



MODULE 1  
**Microbes**



MODULE 2  
**Medication**



MODULE 3  
**Vaccination**



MODULE 4  
**Antimicrobial  
Resistance**



EUROPEAN NURSE  
**Information and  
Communication  
Guide**  
ON MICROBES

MODULE 5  
**Infection  
Prevention  
and Control**



The European Specialist Nurses Organisation (ESNO) is a non-profit organisation with the goal to facilitate and provide an effective framework for communication and co-operation between the European Specialist Nurses Organisations and its constituent members. ESNO represents the mutual interests and benefits of these organisations to the wider European community in the interest of the public health. Members of ESNO consist of individual European specialist nurses member organizations and associates, both institutional and individual.

The organisation focusses on enhancing the capacity and capability of specialists nurses to deliver high quality healthcare by raising and harmonise specialist nursing education standards and actively contribute to health themes and threats, providing the best possible expertise, both national and in European cross border context.

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This publication  
is made possible

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Vaccines Europe



# This guide is endorsed by

EUPHA / EUPHA SECTION HEALTH WORKFORCE RESEARCH (HWR)

ELLEN  
KUHLMANN



**This response to major global health challenges with a comprehensive teaching guide for Europe is a milestone not only for nursing science. Indeed, this is what we need to strengthen public health and to support the implementation of the SDGs in all European countries.**

## HEALTH FIRST EUROPE

Nurses are the frontline of our healthcare systems and the first comfort for each patient in the world. Therefore, Health First Europe welcomes this publication developed by nurses as evidence that a joint effort is necessary to ensure the highest standards of care. Nurses have a key role in antimicrobial stewardship teams. These teams have been shown to improve patient outcomes and reduce antimicrobial consumption, consequently reducing the risk of AMR. Fostering collaboration between all healthcare professionals to share knowledge and good practices is essential to reduce antibiotic consumption and prevention of health care-associated infections (HAIs), particularly those caused by multidrug-resistant organisms (MDROs).

## THE DUTCH INFLUENZA FOUNDATION (NIS)

The Dutch Influenza Foundation (NIS) aims to improve seasonal influenza prevention practices to reduce the annual disease burden associated with influenza infections. The NIS recognises the critical role of physicians and nurses to counsel vulnerable patients about the importance of an annual influenza immunization. The impact of annual influenza epidemics and the benefits of influenza immunizations are not always easy to appreciate due to the variable nature of the influenza viruses, the disease burden and the benefits of an immunization. However, the facts are clearly documented in the literature and prevention policies, as advocated by WHO and other Health Authorities, are evidence-based. The NIS applauds the initiative of this guide for nursing professionals. We trust that this guide will offer support to the nursing professionals with knowledge and understanding of influenza and its prevention. We expect that individuals at risk for influenza infections and their potential complications, will benefit from this initiative by ESNO.

MR TED **VAN ESSEN**

Chair of the Dutch Influenza Foundation (NIS)

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# INTRODUCTION

MARTIN SEYCHELL

Microbiology is founded on the discovery of the first single-cell micro-organisms in the 1670s and 1680s by Antonie van Leeuwenhoek (Figure 1), a Dutch businessman. Health professionals are key for the successful implementation of any health policy initiative. They are the ones patients –and population in general- trust. They are the ones that are in contact with the practical aspects once something in a paper needs to be applied to a patient.

This contact with the population implies a huge burden and responsibility. Science, techniques, tools, advance and continuous education is not only a recommendation, but a real need.

Antimicrobial resistance is one of the biggest health threats for humanity. In less than one century we have made the trip from hope, with the discovery of antibiotics that could save us from the most important diseases at the time, to despair with many antibiotics being useless and not having the right ones. Bad use, abuse, and the always evolving nature, have driven us to this situation that is being discussed even in non-health political fora, such as the United Nations.

And, at the same time, we have useful tools, such as vaccinations, that are one of the most effective methods to fight infectious diseases, that are put in question and not always recognized by their enormous preventive value.

This inconsistency, not valorising what we have and abusing other tools, needs to be redressed.

Nobody is better placed than the nurses. The nurses are the health professionals more in contact with patients and citizens. They are in contact with other health professionals. They are felt as more approachable. They are invaluable to educate everybody. For that, they need to be kept in the frontline of the continuous education, always updated, always trained.

This manual addresses all the issues. It focus on the cycle of microbes, antibiotics, vaccination, AMR, infection prevention and control. It will support nurses on better action and also on communication towards their patients and families.

I want to congratulate ESNO for its work. The organisation is part of the EU Coalition of health workers for vaccination and has been supporting all EU policies for the better health of EU citizens.



MARTIN  
SEYCHELL

Deputy Director-General for Health  
and Food Safety DG SANTE  
Departments. Health and Food Safety.



# GUIDANCE DOCUMENT

## A TRIBUTE TO FLORENCE NIGHTINGALE

When a child is born, they get a very precious gift in the very first seconds of life – a gift of their mother’s bacteria. These bacteria help to populate the healthy bacteria in the gut, on the skin and throughout the body, as well as train the immune system. The development of the immune system takes about four years.

The first edition of the Nurses Guide on Microbes: Vaccination, Antimicrobial Resistance and Infection Prevention and Control is a result of a project started three years ago. This was as a response to a number of calls to health professionals to get engaged with urgent health threats related to microbes and specifically to vaccination, antimicrobial resistance and infections. Nurses receive education and training related to microbes, but this is often only at the start of their study and may not be in depth. The fundamental understanding of the balance between health and infection was first best understood by Florence Nightingale. The editors are pleased to publish this in 2020, the ‘Year of the Nurse and Midwife’ in tribute to Florence Nightingale, born in 12th May 1820.

### FLORENCE NIGHTINGALE



**Wise and humane management of the patient is the best safeguard against infection**



Florence Nightingale made amazing achievements in terms of infection prevention amongst her patients; she was one of the very first infection control champions. While she did not have the modern day understanding of infection control, she managed to introduce the concept of the importance of hospital sanitation. She strongly believed in hospital cleanliness including pure air and water. Florence Nightingale was a true patient advocate as she tried to spread her message to all corners of the world. If Florence Nightingale was alive today, she would perhaps be disappointed by the levels of knowledge and competencies related to infections, prevention, vaccination and preventable healthcare-associated infections, despite the best equipment, staff and facilities.

With this guide -created by nurses- we aim provide nurses and all those interested, with accessible information and education materials to increase their ability to understand microbes and deal with the subject and stay competent professionals. ESNO strongly believe that this information needs to be include in education activities including Continuing Professional Development projects and Life Long Learning throughout career span.

**BER OOMEN** Executive Director

# INTRODUCTION TO THE GUIDE

Nurses with first-line responsibility for hygiene and infection control are familiar with bacteria, viruses and other microbes. However, there may not always be enough information about this in education and professional development for nurses with general and specialist responsibilities.

This guide aims to provide a compact and comprehensive guide tailored to nurses that includes relevant resources such as communication tools, examples, and frequently asked question with answers.

The increasing levels of antimicrobial resistance (AMR) worldwide are one of the motivations behind this guide. Now and in the future, infections with antimicrobial resistant microbes pose a major threat to the treatment of infections, and will have an impact on the workload of nurses and the health of patients. Combined with increasing vaccine hesitancy, the future for preventing and treating infectious diseases looks challenging. Nurses can play an important role in educating healthcare professionals, ancillary staff, patients and citizens in an overall understanding of microbes, the safe and sustainable use of antibiotics, and the role of vaccinations in preventing microbial infections.

This guide to antimicrobial resistance and vaccination for nurses will cover the essential information about microbial infections and the methods of treatment, as well as issues around AMR. The guide will provide information and support optimal communication around topics such as vaccination and infection prevention and control.





## MODULE 1

An introduction to microbes such as bacteria, viruses, fungi, yeasts, parasites, and prions highlights where patients are most at risk of infection.



## MODULE 2

On medication begins with an overview of antibiotics and other antimicrobials and the different ways in which they work. Antibiotics are only effective against bacterial infections, and this can be an education and communication challenge.



## MODULE 3

Takes a closer focus on infections and preventable measures by vaccination, exploring the different types of vaccines, their role in infection prevention, and their storage and handling. Vaccines are used to prevent both bacterial and viral infections. Vaccines are also in development against fungi and parasites. One of the arguments often used by people hesitant to use vaccines relates to their safety and effectiveness. This module covers the monitoring mechanisms for vaccine safety, and discusses ways to improve people's confidence in vaccines.



## MODULE 4

Outlines the issues of AMR, how it develops and spreads, and includes a number of case studies. The module discusses how patients with AMR infections should be treated. It also looks at prevention and containment of AMR, including the role of the One Health approach, which co-ordinates actions across sectors, including veterinary health, agriculture and environmental health. Module four closes with an overview of stewardship programs, and the engagement in European Union initiatives and international health organisations of specialist nurses.



## MODULE 5

Provides an overview of infection prevention and control, and how this can be put in place within healthcare settings. It introduces the chain of infection, and then discusses the principles of hygiene. These begin with hand hygiene and personal protective equipment, and continue with the role of aseptic no-touch techniques to safeguard both patients and healthcare professionals. Nurses play a critical role in infection control, both through practical roles, and as educators for healthcare professionals, patients and carers.

# MODULE 1

# Microbes





**After reading Module 1,** you will understand the basics of microorganisms. This will include the wide variety of bacteria, viruses, fungi, yeasts and parasites, and their characteristics such as growth, and replication. You will also know more about the diseases caused by microorganisms and their diagnosis, and will be able to communicate these to colleagues and patients.

FLORENCE  
**NIGHTINGALE**

”

**The most important practical lesson that can be given to nurses is to teach them to observe**

# 1 The development of microbiology

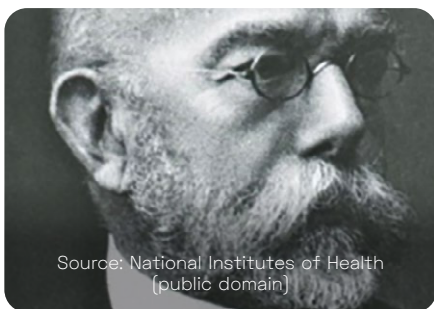
Microbiology is founded on the discovery of the first single-cell micro-organisms in the 1670s and 1680s by Antonie van Leeuwenhoek (Figure 1), a Dutch businessman.



Source:  
Delft Rijksmuseum (public domain)

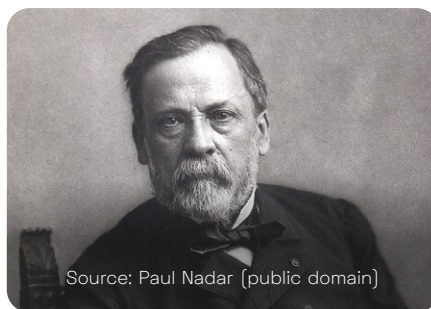
**FIGURE 1: ANTONIE VAN LEEUWENHOEK (1632-1723)**

Modern understanding of bacteriology began with the German doctor Robert Koch (Figure 2), the French biologist, chemist and microbiologist Louis Pasteur (Figure 3), and the German biologist Ferdinand Cohn (Figure 4). In a presentation to the Berlin Physiological Society in 1882, Koch made the connection between single-celled organisms and the development of certain diseases [1]. Research carried out by Pasteur, in the second half of the 19th century, supported the germ theory of disease, and the development of prophylactic vaccines [2]. Cohn's work was in applied microbiology, including understanding the classification and physiology of bacteria [3].



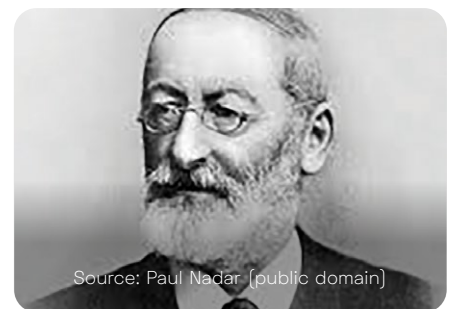
Source: National Institutes of Health (public domain)

**FIGURE 2: ROBERT KOCH (1843-1910)**



Source: Paul Nadar (public domain)

**FIGURE 3: LOUIS PASTEUR (1822-1895)**



Source: Paul Nadar (public domain)

**FIGURE 4: FERDINAND COHN (1828-1898)**

Through their work, and the work of others, it became increasingly clear that infectious diseases were mostly caused by bacteria and viruses, and that bacterial infections and viral infections needed to be treated differently – for example, antibiotics do not work for viral infections. For nurses such knowledge is essential for the prevention and treatment of bacterial and viral infections, and for the control of the development of antibiotic resistance, the adaptation of microbes to medication.

## 2 An introduction to microbes

### 2.1 “Meet your Microbes”

Nurses are familiar with the body systems and vital organs in our bodies, but their training may overlook the normal human microbiota [4]. This is the population of microorganisms that naturally live on our skin, and in our respiratory, digestive and reproductive systems, and are part of our healthy daily life. When you eat a cheese sandwich, you can digest it not only because of the digestive enzymes, but also thanks to the almost 1.5 kilos of intestinal bacteria. When you defecate, half of this is bacteria. When you wash, a few million microbes get rinsed away, but soon get replaced.

The right balance of microorganisms of all forms and shapes, more than one hundred thousand billion or 14,000 times the number of people on earth, play a key role. Everyone has their unique set of microbes, and the majority of these protect us and help us to stay healthy. This is known as the microbiota.

For more information, go to the NIH Human Microbiome Project website (QR code 1).

These microbes do not normally cause disease in healthy people. However, in people with a weakened immune system, or a disrupted gut microbiota, some of the microbes (opportunistic pathogens) can cause disease.

Some microbes are always pathogenic, and the immune system acts to keep these under control. When these are no longer controlled by the immune system, they cause an infection. Symptoms vary per infection, but generally include:

- Redness
- Swelling
- Fever
- Pain

Infections can range from a minor illness to systemic and life-threatening disease. Typical pathogens include: *Salmonella typhi*, *Mycobacterium tuberculosis*, *Clostridioides tetani*, Influenza viruses, Poliomyelitis viruses, *Aspergillus niger* and many others.

Infectious microorganisms can spread through water, food, insect bites, shaking hands, sneezing and coughing, blood, wounds or sexual contact. People can also be carriers of potentially harmful bacteria, without becoming ill themselves. They may spread these through their stools, urine, blood and saliva.

## 3 Bacteria

Bacteria are real survivors. They were here before humanity appeared on the earth and will remain when we have gone. Certain bacteria can survive in extreme conditions, for example in sulphuric acid, boiling or freezing water, and under extremely high pressure. For example, *Deinococcus radiodurans* withstands extreme cold, drought and acid, and even lives in the walls of nuclear reactors.

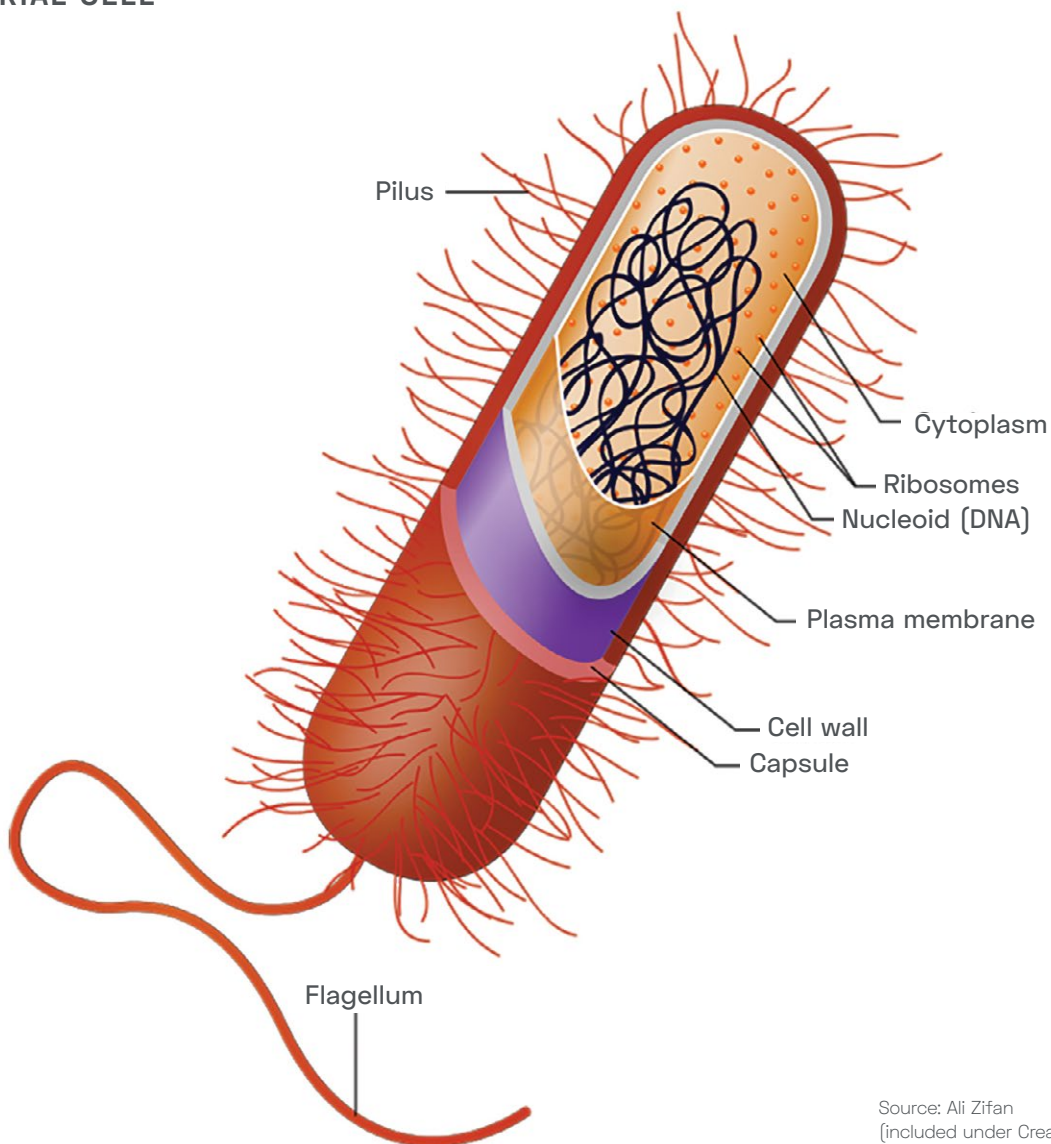


SCAN ME  
[QR code 1]

## 3.1 Structure

Bacteria are single cells, typically around 0.5-4-5  $\mu\text{m}$  (Figure 5). Bacteria are simpler than mammalian (including human) cells (Figure 6), and do not have mitochondria, endoplasmic reticulum, or nuclear membranes. The bacterium is typically made up of cytoplasm and DNA surrounded by a cell membrane.

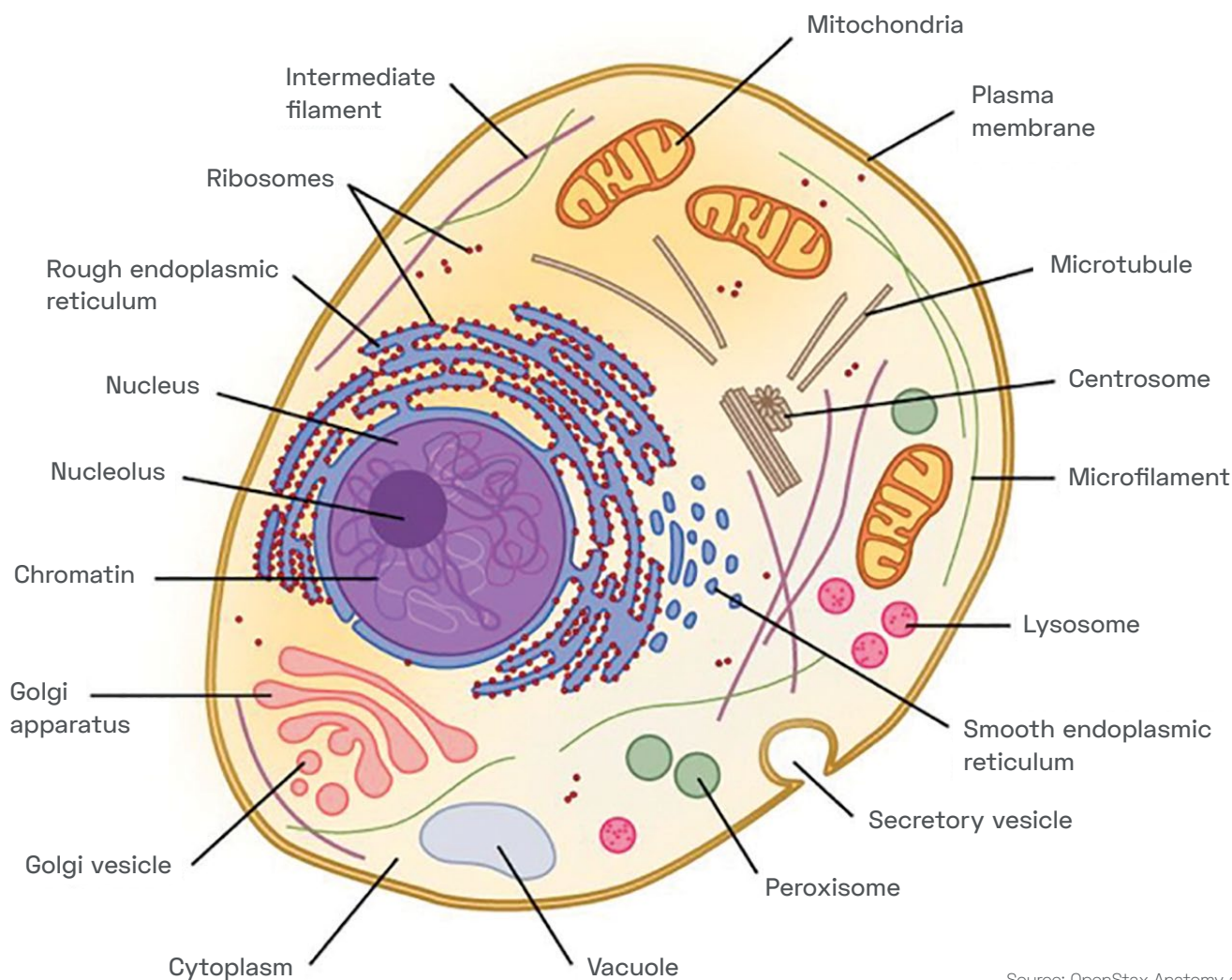
**FIGURE 5: STRUCTURE AND CONTENTS OF AN EXAMPLE OF A GRAM-POSITIVE BACTERIAL CELL**



Source: Ali Zifan  
(included under Creative Commons licence)

Bacteria have a peptidoglycan (protein and sugar) cell wall around the membrane, and some also have an additional slime layer or cell envelope. Bacteria may also have protrusions, known as flagella and pili. The cell membrane is used as a target by researchers developing antimicrobial medications, looking to exploit weak spots and neutralise defence mechanisms.

FIGURE 6: STRUCTURE AND CONTENTS OF A TYPICAL MAMMALIAN CELL



Source: OpenStax Anatomy and Physiology (included under Creative Commons licence)

### 3.1.1 Shape and form

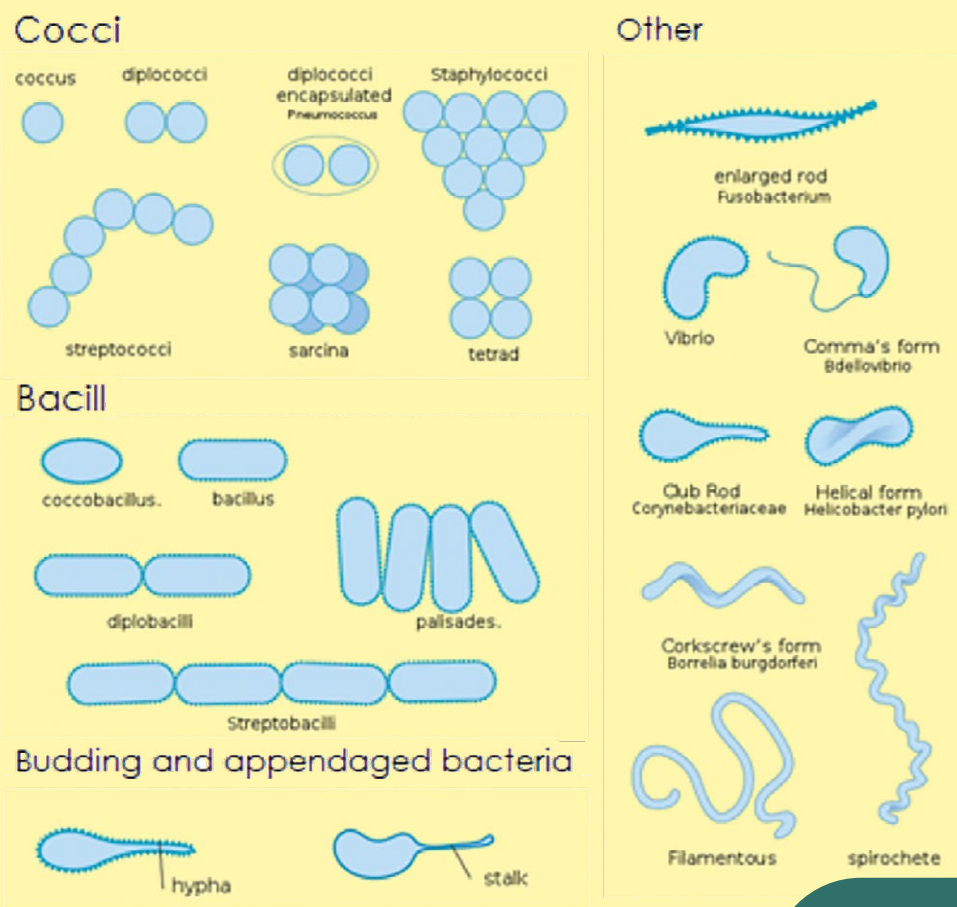
The shape of bacteria is used for systematic classification, and to show relationships. The forms that the bacteria create as they multiply can also be used to identify them (Figure 7).

- **Cocci (sphere)**
  - > Streptococci form chains
  - > Staphylococci form grape-like clusters
- **Bacilli (rods)**
  - > Some bacilli, for example *Bacillus* species, form spores
  - > The plague-causing bacterium *Yersinia pestis* forms a slime layer



- **Vibrio (commas or curved rods)**
  - > Vibrio bacteria are motile, and move around using flagella
- **Spirillum (spiral-shaped rods)**
  - > Some spirillum have flagella

FIGURE 7: SHAPES AND TYPES OF BACTERIA

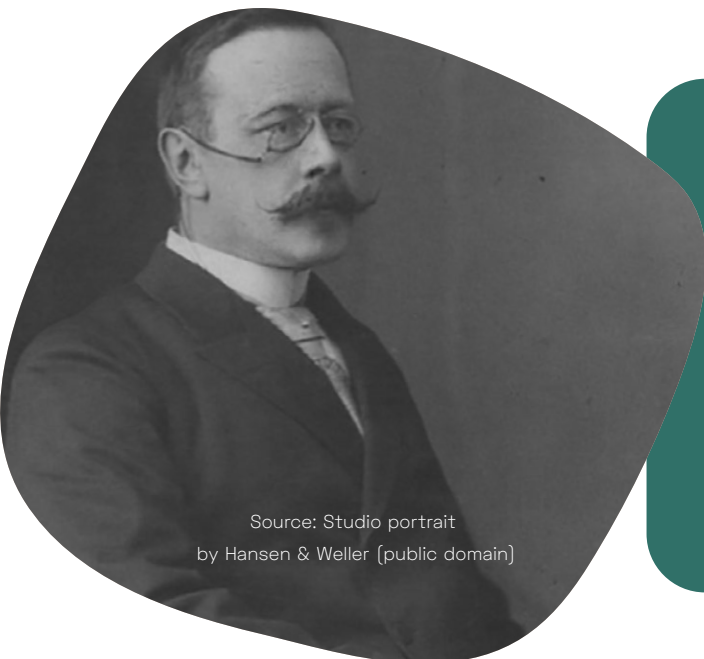


Source: Mariana Ruiz [LadyofHats] (public domain)

Actinobacteria, once thought to be fungi, are rod-shaped bacteria that create fungal-like forms. Actinobacteria are the source of many drugs, including antibiotics.

### 3.1.2 Gram-positive and Gram-negative bacteria

Bacteria are divided into Gram-positive and Gram-negative, and this is all about colours. The Gram method is named after its inventor, the Danish scientist Hans Christian Gram (Figure 8).

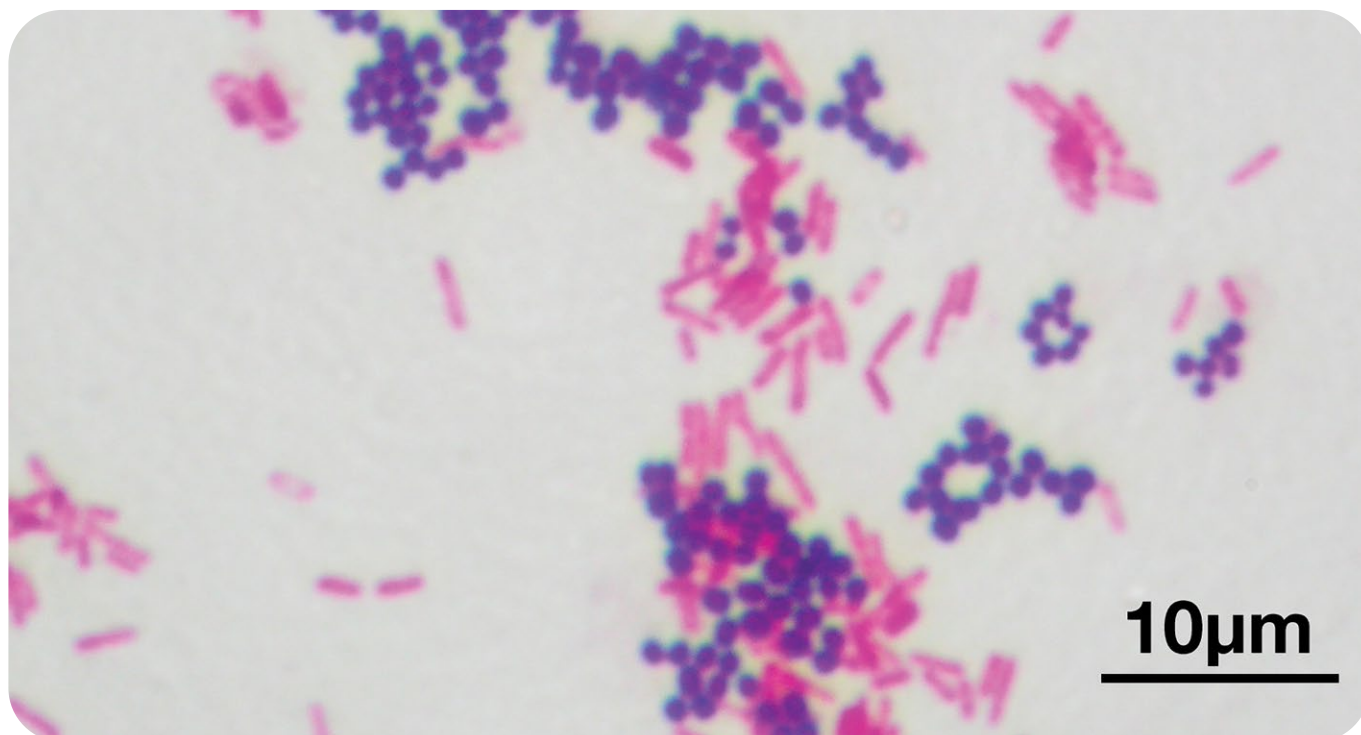


Source: Studio portrait  
by Hansen & Weller [public domain]

**FIGURE 8: HANS CHRISTIAN JOACHIM GRAM (1853-1938)**

Gram developed a technique to identify bacteria based on their cell wall. Gram staining is used to show the thickness of the peptidoglycan cell wall in bacteria (Figure 9 and Table 1). Gram-staining is used in the classification and identification of bacteria, and helps to support antibiotic treatment decisions.

**FIGURE 9: GRAM STAIN OF GRAM-POSITIVE COCCI AND GRAM-NEGATIVE BACILLI**



Note: Gram-positive – *Staphylococcus aureus*, purple; Gram-negative – *Escherichia coli*, pink Source: Y tambe (GNU Free Documentation License)

TABLE 1: GRAM STAINING

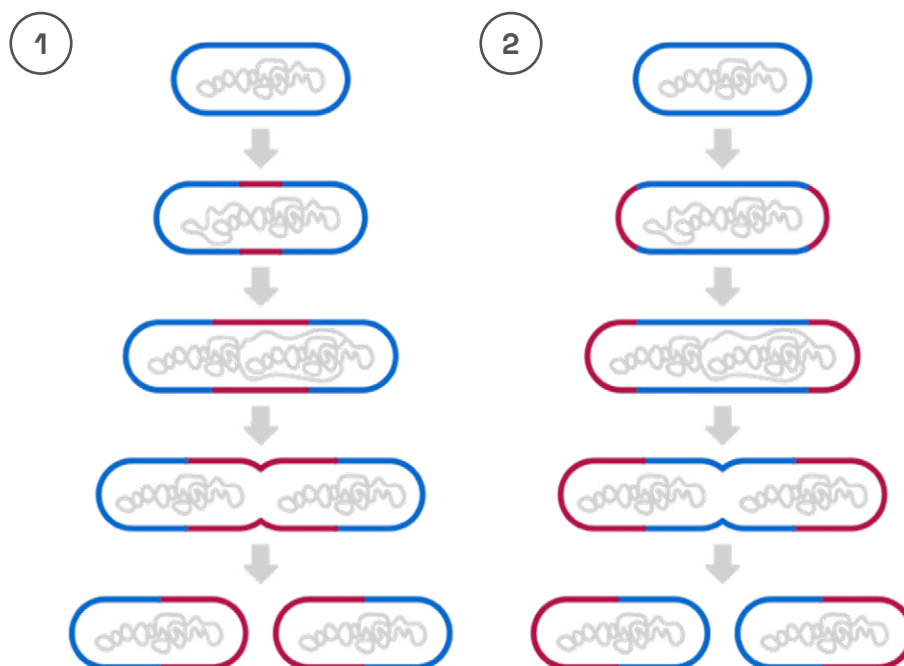
Gram-positive	Gram-negative
Bacteria with a thick wall of peptidoglycan take up both the crystal violet primary stain and the pink fuchsin counterstain in the gram stain, and so are stained blue-purple	In bacteria with a thin wall of peptidoglycan, the crystal violet is washed out, leaving the bacteria stained pink with the counterstain
Most gram-positive bacteria do not have an extra layer outside of the cell wall casing	

Source: Beveridge [5]

### 3.2 Reproduction

Bacteria reproduce through binary fission. The bacterium divides into two cells (Figure 10), and the cell content of each of the new 'daughter' cells is the same as the original 'mother' cell. Some bacteria, such as Escherichia coli, can divide every 20 minutes in the right conditions.

FIGURE 10: ELONGATION AND BINARY FISSION OF BACILLI



Notes: Blue and red lines indicate old and newly generated bacterial cell wall, respectively. (1) growth at the centre of the bacterial body. e.g. Bacillus subtilis, E. coli, and others. (2) apical growth. e.g. Corynebacterium diphtheriae Source: Y tambe (Creative Commons)

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## 3.3 Bacteria classification

Bacteria can be classified in a number of different ways to help distinguish between different types and strains [6].

### 3.3.1 Nutrition

Bacteria can be heterotrophic (which means they cannot produce their own food), or autotrophic, which can produce complex organic compounds, such as carbohydrates, fats, and proteins.

#### Heterotrophic bacteria

Heterotrophic bacteria need organic nutrients (nutrients derived from living or dead things). Bacteria that get their nutrients from living things are called parasites or pathogens. Bacteria that extract their nutrients from dead material are called saprophytes (sapro = rotten).

#### Autotrophic bacteria

Autotrophic bacteria can produce their own organic materials. They can be classified according to their energy source, for example photoautotrophic bacteria get their energy from sunlight through photosynthesis, and chemoautotrophic bacteria convert materials from inorganic materials such as sulphur compounds, carbon dioxide and water.

### 3.3.2 Temperature

Different bacteria grow best at different temperatures, and this can be used for classification.

- **Psychrophilic bacteria or psychrophiles [7]**
  - > Temperature range of -20 °C to +12 °C
  - > Can spoil refrigerated foods
- **Mesophilic bacteria or mesophiles [8]**
  - > Temperature range of +20 °C to +45 °C
  - > Includes most bacteria that are human pathogens, which grow at +35 °C to +37 °C
- **Thermophilic bacteria [8]**
  - > Temperature range of +41 °C to +122 °C
  - > Found in hot springs, peat bogs and compost

### 3.3.3 pH

The pH measures how acidic or alkaline a substance is, on a scale from 0 to 14. Anything above 7 is alkaline, and anything below 7 is acid. Water has a pH level of 7. Most bacteria grow at a neutral pH of 7, and can tolerate a pH range of 5 to 8. An acidogen is a micro-organism that can form acids from food sources, which then lowers the pH.

Bacteria can be classified by pH (acidity or alkalinity).

- **Acidophilic bacteria or acidophiles [9]**
  - > Can grow at a low pH (2.0 or below; acid environment)
- **Alkaliphile**
  - > Can grow at a high pH (9-11; alkaline environment) [10]

### 3.3.4 Oxygen levels

Bacteria are subdivided into four groups according to their sensitivity to oxygen:

- **Aerobe – survives and grows in the presence of oxygen**
  - > Obligate aerobe – requires oxygen
  - > Microaerophile – needs oxygen, but at low levels
- **Anaerobe – does not require oxygen for survival or growth**
  - > Obligate anaerobe – harmed by oxygen
  - > Aerotolerant anaerobe – cannot use oxygen for growth, but tolerates it
  - > Facultative anaerobe – can live with or without oxygen; uses oxygen if present

## 3.4 Bacterial survival strategies

Bacteria have many different strategies for survival. In unfavourable conditions, some bacteria, for example the Firmicutes, can form endospores. These dormant capsules contain the essential part of the bacterium and are like spores or seeds. Endospores can reproduce after freezing, boiling, drying out, treating with disinfectants or ultraviolet radiation.

Bacteria, such as *Azotobacter* species, can form cysts, where the entire bacterium encapsulates. These are resistant, but not as resistant as endospores.

## 3.5 Selected pathogenic bacteria

The body is home to many types of bacteria and most of the time these do not cause any problems. These microbes do not normally cause disease in healthy people. However, in people with a weakened immune system, or a disrupted gut microbiota, opportunistic pathogens can cause disease.

Some microbes are always pathogenic, and the immune system acts to keep these under control. When these are no longer controlled by the immune system, they cause an infection. Certain bacteria can produce harmful toxins, in diseases such as cholera, plague, or tetanus.

## 3.6 Brief review of some of the most important bacteria in human diseases

The tables in this section give examples of some of the most significant disease-causing bacteria, and some of the diseases that these may cause.



TABLE 2: AEROBIC GRAM-POSITIVE COCCI

Genus	Species	Diseases include:
Staphylococcus	S. aureus	Skin infections, respiratory infections, food poisoning, bone, joint and wound infections, infective endocarditis, sepsis, medical implant infections
	Coagulase-negative staphylococci (CoNS)	Infective endocarditis, catheter-associated infection
Streptococcus	S. pyogenes	Pharyngitis, scarlet fever, severe soft-tissue infection, rheumatic fever, glomerulonephritis
	S. pneumoniae	Pneumonia, sinusitis, otitis media, meningitis
	Viridans-streptococci	Infective endocarditis
Enterococcus	E. faecalis	Urinary tract infection (UTI), peritonitis, infective endocarditis, wound infection, sepsis

TABLE 3: AEROBIC GRAM-POSITIVE RODS

Genus	Species	Diseases include:
Corynebacterium	C. diphtheriae	Diphtheria
	C. diphtheroides	UTI, sepsis, wound infection
Listeria	L. monocytogenes	Listeriosis (gastro-enteritis; meningitis, infective endocarditis, severe neo-natal burden)
Bacillus	B. anthracis	Anthrax: particularly dangerous disease (PDD) - type A in CDC classification (skin, gastro-intestinal, pneumonia, sepsis)
	B. cereus	Gastro-enteritis

Other important Gram-positive rods include Mycobacteria. M. tuberculosis causes tuberculosis; the pulmonary form is the most frequent. Diseases caused by non-tuberculosis Mycobacteria include pneumonia and wound infections.

TABLE 4: AEROBIC GRAM-NEGATIVE COCCI AND COCCO-BACILLI

Genus	Species	Diseases include:
Neisseria	N. gonorrhoeae	Gonorrhoea
	N. meningitidis	Meningitis
Haemophilus	H. influenzae	Pneumonia, sinusitis, otitis media, meningitis
Bordetella	B. pertussis	Pertussis

TABLE 5: AEROBIC GRAM-NEGATIVE RODS (FERMENTATIVE) – ENTEROBACTEREALES

Genus	Species	Diseases include:
Escherichia	E. coli	UTI, sepsis, wound-, gastro-intestinal-infection
Klebsiella	K. pneumoniae	UTI, hospital-acquired pneumonia (HAP), wound-, gastro-intestinal- infection, sepsis
Enterobacter	E. cloacae	UTI, wound-, gastro-intestinal-infection, sepsis
Serratia	S. marcescens	UTI, wound-, gastro-intestinal-infection, sepsis
Proteus	P. mirabilis	UTI, wound-, gastro-intestinal-infection, sepsis
	P. vulgaris	
	M. morgannii	
	P. rettgeri	
Citrobacter	C. freundii	UTI, wound-, gastro-intestinal-infection, sepsis
Salmonella	S. typhi	Abdominal typhus
	S. enterica spp	Salmonellosis
Shigella	S. dysenteriae	Dysentery
	S. flexneri	Dysentery
	S. boydii	Dysentery
	S. sonnei	Dysentery
Yersinia	Y. pestis	Plague
	Y. enterocolitica	Gastro-enteritis

Another infection from Gram-negative rods, but comma-shaped, is cholera (*Vibrio cholerae*). This is an example of a particularly pathogenic bacterium.

TABLE 6: AEROBIC NON-FERMENTATIVE GRAM-NEGATIVE RODS

Genus	Species	Diseases include:
<b>Pseudomonas</b>	<i>P. aeruginosa</i>	Wound infection, HAP, muco-viscidosis, hospital acquired UTI, sepsis
<b>Acinetobacter</b>	<i>A. baumannii</i>	Wound infection, HAP, hospital acquired UTI, sepsis

TABLE 7: ANAEROBIC SPORE-FORMING BACTERIA

Genus	Species	Diseases include:
<b>Clostridioides</b>	<i>C. perfringens</i>	Gas gangrene, necrotizing fasciitis, mixed wound infections
	<i>C. tetani</i>	Tetanus
	<i>C. botulinum</i>	Botulism, PDD caused by botulin exotoxin
	<i>C. difficile</i>	<i>C. difficile</i> -associated diarrhoea – after antibiotic therapy

TABLE 8: ANAEROBIC NON-SPORE-FORMING BACTERIA

Genus	Species	Diseases include:
<b>Bacteroides (Gr (-) rods)</b>	<i>B. fragilis</i>	Gastro-intestinal, peritonitis, mixed wound infection, deep organ abscesses sepsis
<b>Fusobacterium (gr (-) rods)</b>	<i>F. nucleatum</i>	Periodontal disease, wound infection
<b>Peptostreptococcus (Gr (+) cocci)</b>	<i>P. anaerobius</i>	Deep organ abscesses, obstetric and gynaecological sepsis, intraoral infections
<b>Propionibacterium (Gr (+) rods)</b>	<i>P. acnes</i>	Skin infections, acne
<b>Actinomyces (Gr (+) rods)</b>	<i>A. israeli</i>	Actinomycosis: wound infections, deep organ abscess

TABLE 9: SPIRAL-SHAPED BACTERIA

Genus	Species	Diseases include:
<b>Campylobacter</b>	<i>C. jejuni</i>	Gastro-enteritis
<b>Helicobacter</b>	<i>H. pylori</i>	Gastritis, peptic ulcer, gastric carcinoma

TABLE 10: SPIROCHETES (HELICAL-SHAPED BACTERIA)

Genus	Species	Diseases include:
<b>Treponema</b>	<i>T. pallidum</i>	Syphilis
<b>Borrelia</b>	<i>B. burgdorferi</i>	Lyme disease
<b>Leptospira</b>	<i>L. interrogans</i>	Leptospirosis

TABLE 11: INTRACELLULAR BACTERIA, INCL. CHLAMYDIA

Genus	Species	Diseases include:
<b>Rickettsia</b>	<i>R. provazeki</i>	Epidemic recurrent typhus
	<i>R. conorii</i>	Marseilles fever
<b>Coxiella</b>	<i>C. burnetii</i>	Q fever
	<i>C. pneumoniae</i>	Atypical pneumonia
<b>Chlamydomphila</b>	<i>C. psittaci</i>	Psittacosis
	<i>C. trachomatis</i>	Trachoma, conjunctivitis, urogenital chlamydiosis, lymphogranuloma venereum

Genus *Mycoplasma* are also intracellular pathogens. *M. pneumoniae* causes atypical pneumonia, while *M. hominis* and *M. genitalium* are the causative agents in uro-genital mycoplasma infections.

## 4 Viruses

The impact of viral infections can be underestimated, but infections such as influenza can have significant impacts on individuals and society. Nurses need to remain up to date on the treatment and prevention of viral infections.

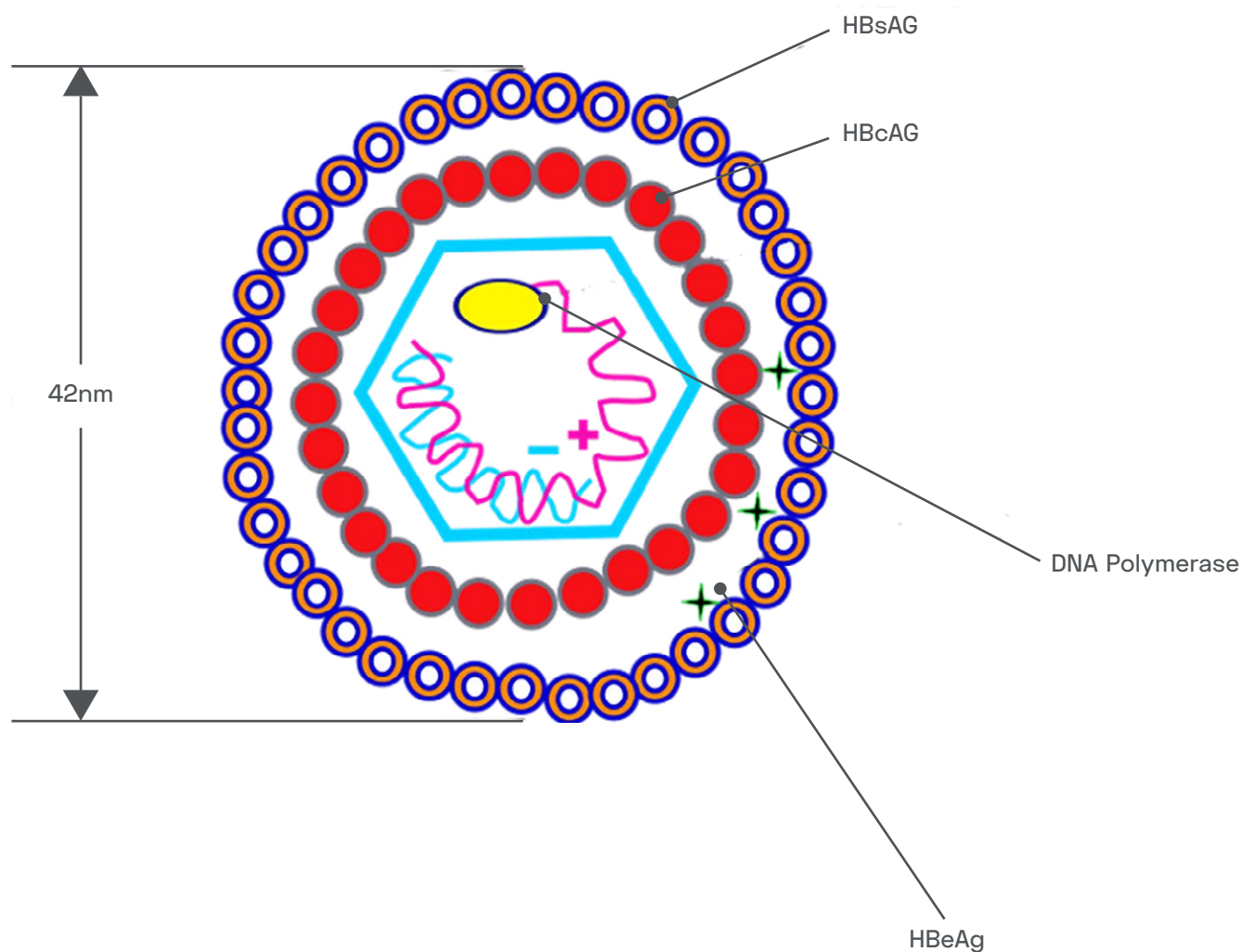
Viruses are infectious agents that do not have their own reproductive mechanism and metabolism, and so are completely dependent on other organisms. Viruses can infect all living organisms, from microbes to humans, and are likely to have existed since the first living cells. Antibiotics do not work on viral infections.

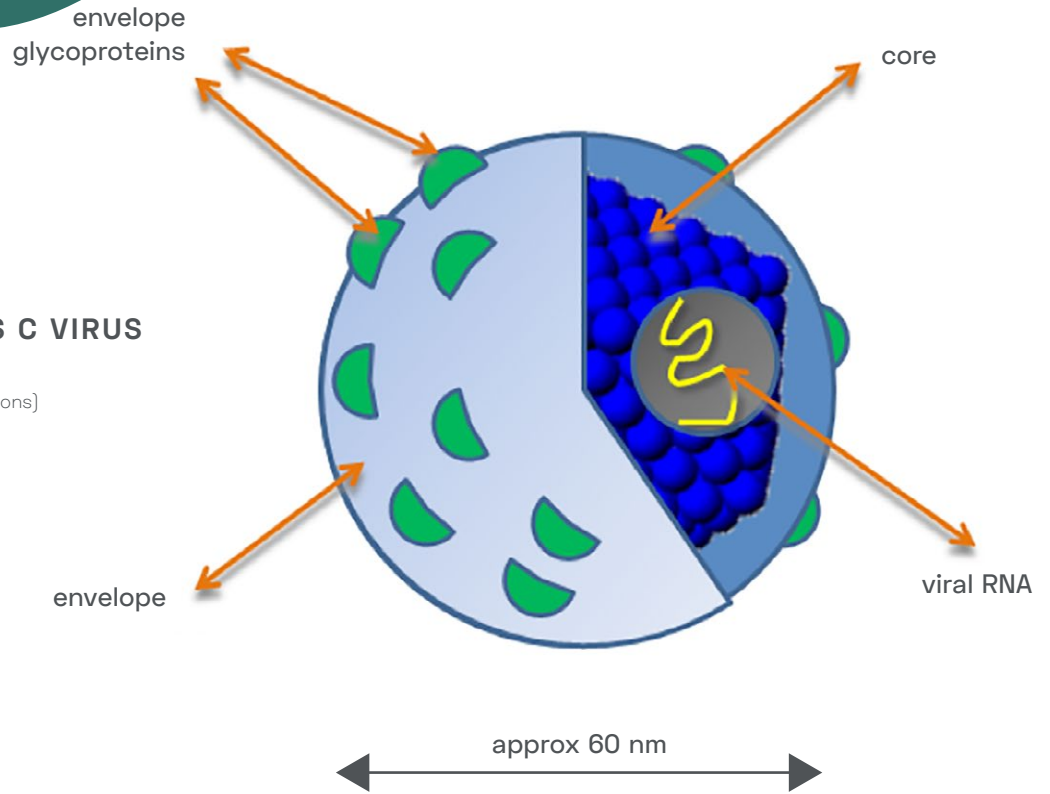
### 4.1 Structure

Viruses are much smaller (from 20 nm to 400 nm) than bacteria, and have a simpler structure. Some viruses can change from generation to generation, making them difficult to tackle using antiviral agents. Viruses come in a variety of shapes – see Figure 11, Figure 12 and Figure 13 for examples.

**FIGURE 11: HEPATITIS B VIRUS**

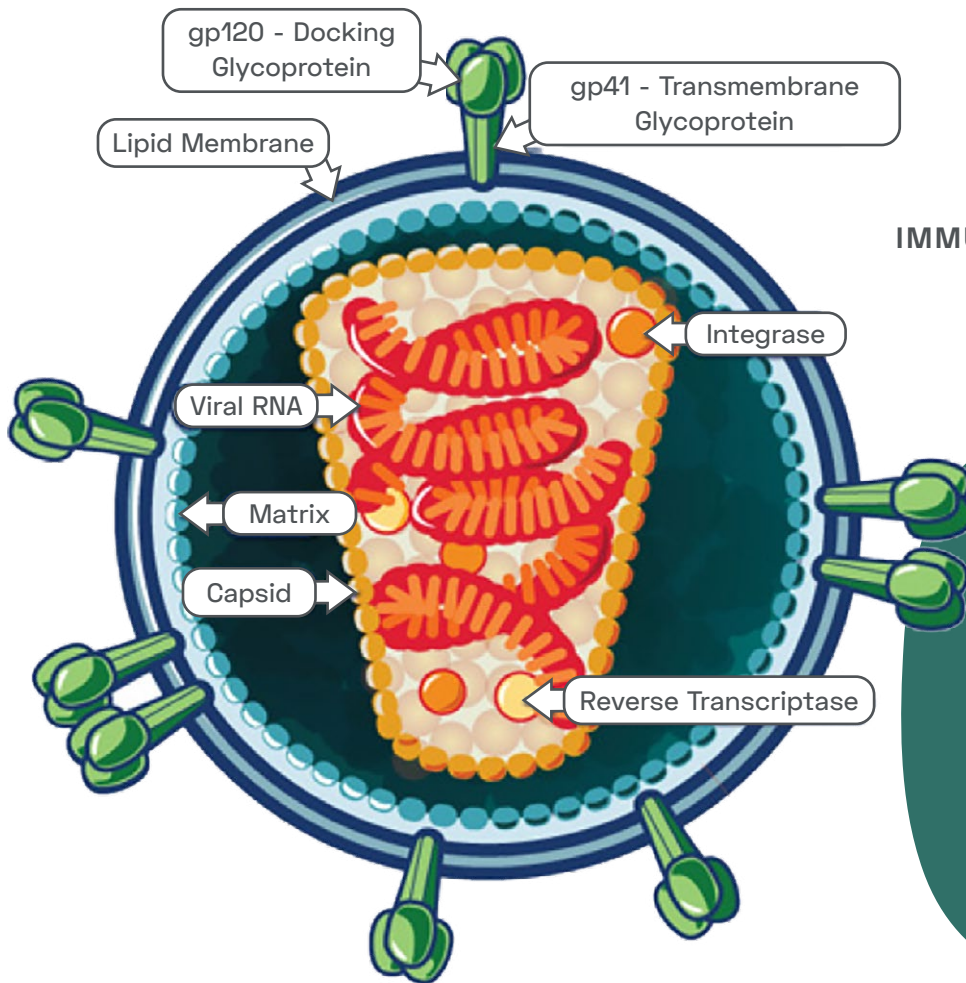
Source: GrahamColm (public domain)





**FIGURE 12: HEPATITIS C VIRUS**

Source: GrahamColm (Creative Commons)



**FIGURE 13: HUMAN IMMUNODEFICIENCY VIRUS (HIV)**

Source: NIAID (Creative Commons)

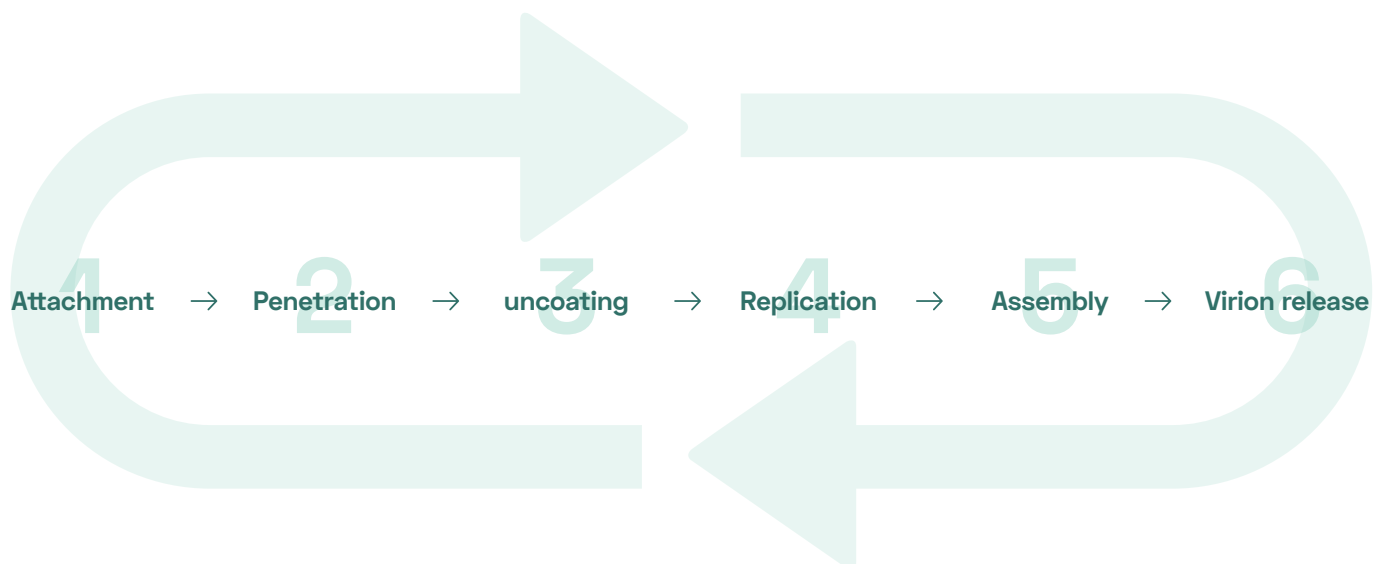
Viruses have a viral genome – only DNA (deoxyribonucleic acid) or RNA (ribonucleic acid), contained within a protein capsule/capsid, consisting of capsomers – this structure is called nucleocapsid.



## 4.2 Reproduction

Viruses use the workings of the host cell to replicate. Virus life cycles differ widely, but there are six basic steps (Figure 14):

**FIGURE 14: THE VIRAL REPLICATION CYCLE**



A virus connects to a cell by attaching to specific receptors on the cell surface. The protein coat of the virus and antigens on the cell mean that the virus attaches to a specific host cell.

The virus penetrates the cell by injecting its own genetic material or merging with the cell. Some viral enzymes may be introduced into the cell. These, or host enzymes, degrade the virus coating, releasing the genetic material.

Inside the host cell, the genetic material of the virus gives the order to make new viruses. A virus can only multiply if it is in a host cell. The new viruses are then released.

Viral replication can be lytic or lysogenic:

- **Lytic reproduction**
  - > The host cell typically creates new viruses and then dies
- **Lysogenic reproduction**
  - > The virus remains in the host cell
  - > The virus does not cause the death of the host cell, and causes symptoms virus when the immune system is weakened, or as a response to UV radiation or chemicals. An example is process is seen with the herpes virus, which causes cold sores.

In 2016, the International Committee on Taxonomy of Viruses distinguished 4404 species of viruses in 735 genera, 122 families and 8 orders [11].

## 4.3 Selected pathogenic viruses

TABLE 12: SELECTED PATHOGENIC VIRUSES

	Structure	Family	Some important members
<b>DNA VIRUSES</b>	Ds, brick or ovoid shaped, (+) envelope	Poxviridae	Smallpoxvirus (variola)
	Ds, icosahedral, (+) envelope	Herpesviridae	Herpes simplex virus 1,2 (HSV-1, HSV-2) Varicella-Zoster virus (VZV) Epstein-Barr virus (EBV) Cytomegalovirus (CMV) Hepatitis B virus (aHBV)
	Ds, spherical, (+) envelope	Hepadnaviridae	Adenovirus
	Ds, icosahedral, (-) envelope	Adenoviridae Papillomaviridae Polyomaviridae	Human papillomavirus JC virus BK virus
	Ss, icosahedral, (-) envelope	Poxviridae	Parvovirus B 19
<b>RNA VIRUSES</b>	Ds, icosahedral, (-) envelope	Reoviridae	Rotavirus
	Ss, bullet-shaped, (-) envelope	Rhabdoviridae	Rabies virus
	Ss, filamentous, (+) envelope	Filoviridae	Ebola virus
	Ss, icosahedral, (-) envelope	Picornaviridae	Polio-viruses ECHO-viruses Coxsackie – viruses Hepatitis A virus Rhino-viruses Norovirus
	Ss, icosahedral, (+) envelope	Calciviridae	Rubella virus
	Ss, spherical, (+) envelope	Togaviridae	Influenza viruses
		Orthomyxoviridae	Parainfluenza viruses
		Paramyxoviridae	Respiratory syncytial virus (RSV) Measles virus Mumps virus Human metapneumovirus Human coronavirus
		Coronaviridae	SARS-CoV MERS-CoV
		Retroviridae	Human immunodeficiency viruses (HIV) Dengue virus
	Flaviviridae	West Nile virus Zika virus Hepatitis C virus	

TABLE 13: HUMAN HERPESVIRUSES

Type	Name	Pathophysiology
HHV-1	Herpes simplex virus-1 (HSV-1)	Oral and/or genital herpes (for example cold source) (mainly orofacial)
HHV-2	Herpes simplex virus-2 (HSV-2)	Oral and /or genital (mainly genital)
HHV-3	Varicella zoster virus (VZV)	Chicken-pox and shingles
HHV-4	Epstein-Barr virus (EBV), lymphocryptovirus	Mononucleosis infections, Burkitt's lymphomas, lymphoma of the nerve system, post transplantation lymphoproliferative syndrome, nasopharyngeal carcinoma
HHV-5	Cytomegalovirus (CMV)	Mononucleosis infections, retinitis, hepatitis, pneumonia, pancreatitis, nephritis, myocarditis
HHV-6, -7	Roseolavirus	Roseola
HHV-8	Kaposi's sarcoma associated herpesvirus (KSHV), human herpesvirus 8, rhadinovirus	Kaposi's sarcoma, primary effusion lymphoma, and multicentric Castleman's disease

Source: viruSITE

### 4.3.1 Rabies

Rabies is a serious condition caused by an infection with the Rabies lyssavirus. It is passed on through a bite or scratch from a rabid animal, such as a dog, fox, bat or cat. Symptoms include headache, fever, weakness, numbness, muscle spasms, seizure and fear of water. Once symptoms appear, rabies is almost always fatal.

Nurses need to remain vigilant for cases of rabies when people with bites or scratches attend healthcare services. They need to ask where the bite happened, and if they have travelled from areas where rabies is endemic.

## 5 Other microbes

### 5.1 Clinically important fungi

Fungi are more complex than bacteria and viruses, and have a rigid cell wall. As with bacteria, many fungi naturally live on the body as part of the microbiota.

## 5.1.1 Different types of fungi

There are two kinds of clinically important fungi.

- Yeasts, which exist as unicellular form and replicate asexually
- Moulds, multicellular filamentous organisms which replicate sexually or asexually. They consist of filaments called hyphae and form budding forms, called spores.

Most fungi exist in one of these forms, however some clinically important fungi can exist in both forms – they are called dimorphic fungi.

### FUNGAL FACT

We have around 150 species of fungi on our feet: About 80 species on our heels, about 60 on our nails and about 40 between our toes. The first response might be, 'get rid of it' but bear in mind, when in right balance, these protect us against harmful microbes

## 5.2 Fungal infections

When things get out of balance, fungi can cause superficial and invasive infections. These range from mild to life-threatening.

### 5.2.1 Superficial fungal infections

Fungi, most commonly *Trichophyton* and *Microsporum*, can cause skin and nail infections.

**TABLE 14: FORMS OF TINEA (RINGWORM)**

Name	Area of infection
Tinea pedis (athlete's foot)	Feet
Tinea unguium (onychomycosis)	Fingernails, toenails, and the nail bed
Tinea corporis (ringworm)	Arms, legs, and trunk
Tinea cruris (jock itch)	Groin area
Tinea manuum (ringworm of the hands)	Hands and palm
Tinea capitis (ringworm of the scalp)	Scalp and hair
Tinea faciei (ringworm of the face)	Face
Tinea barbae (beard ringworm)	Facial hair
Tinea Gladiatorum or tinea corporis gladiatorum (RINGWORM IN WRESTLERS)	Head, neck and arms

Source: Ely [12]

TABLE 15: SUPERFICIAL FUNGAL INFECTIONS

Infection type	Pityriasis versicolor	Dermatophytoses	Onychomycosis	Mycotic keratitis	Lymphocutaneous sporotrichosis
Cause	Malassezia furfur	Microsporum spp. Trichophyton spp. Epidermophyton floccosum	Candida spp Aspergillus spp. Trichosporon spp. Geotrichum spp.	Fusarium spp. Aspergillus spp. Candida spp.	Sporothrix schenckii

Source: Kidd [13]

## 5.2.2 Invasive fungal infections

Fungal infections of the vagina and other mucous membranes are relatively harmless, but a fungus can also penetrate deeper into the body, infecting the bloodstream, lungs, brain, kidneys or liver. These invasive fungal infections are rare and usually occur in people who are seriously ill, have a reduced immunity for example following a solid organ transplant or cancer chemotherapy, or have been treated with antibiotics [14].

### Symptoms of invasive fungal infections

Symptoms depend on where the infection is located, for example, a fungal infection in the lungs can lead to coughing and shortness of breath. The symptoms are not specific to a fungal infection and can also be caused by another disease [14].

### Most common invasive fungal infections

#### Aspergillus species

Aspergillosis is most commonly caused by *Aspergillus fumigatus*, *Aspergillus niger* and *Aspergillus flavus*. While people may inhale thousands of *Aspergillus* spores daily, these are generally dealt with by the immune system. *Aspergillus* is ubiquitous. In the hospital environment it is in the air, showerheads, potted plants, and water-storage tanks. Levels increase during building work.

*Aspergillus* infections can cause a 'fungus ball'. This may be asymptomatic, or cause cough, fever, chest pain, coughing up blood and problems with breathing. The infection can also spread through the blood. A serious infection leads to fever, chills, shock, delirium, seizures, blood clots and organ failure, and can be fatal, especially in patients with compromised immune systems.

#### Candida species

The infection is called candidiasis. Apart from the most common *C. albicans*, infection can be due to other species as *C. guilliermondi*, *C. tropicalis*, *C. krizei*, *C. glabrata*, *C. parapsilosis*, *C. dubliniensis*, *C. auris*. Some of them are more resistant to antifungal agents, and especially *C. auris*.

Systemic candidiasis or candidaemia is not the same as Candida syndrome, also known as Candida hypersensitivity syndrome. Candida syndrome symptoms are claimed to include abdominal pain, fatigue and depression. However, no epidemiological or therapeutic studies have shown evidence for the existence of this syndrome. [15].

### Cryptococci

The infection is called cryptococcosis. *Cryptococcus neoformans*, the main pathogens, are spherical yeasts surrounded by a polysaccharide capsule. Infection is frequent in persons living with HIV due to an impaired cell immunity. Initially, the infection develops in the lungs and is followed by a meningitis.

The opportunistic fungus *Pneumocystis jirovecii* (previously known as *Pneumocystis carinii*) causes pneumonia in immunosuppressed patients, including those with AIDS resulting from HIV infection.

### Histoplasma

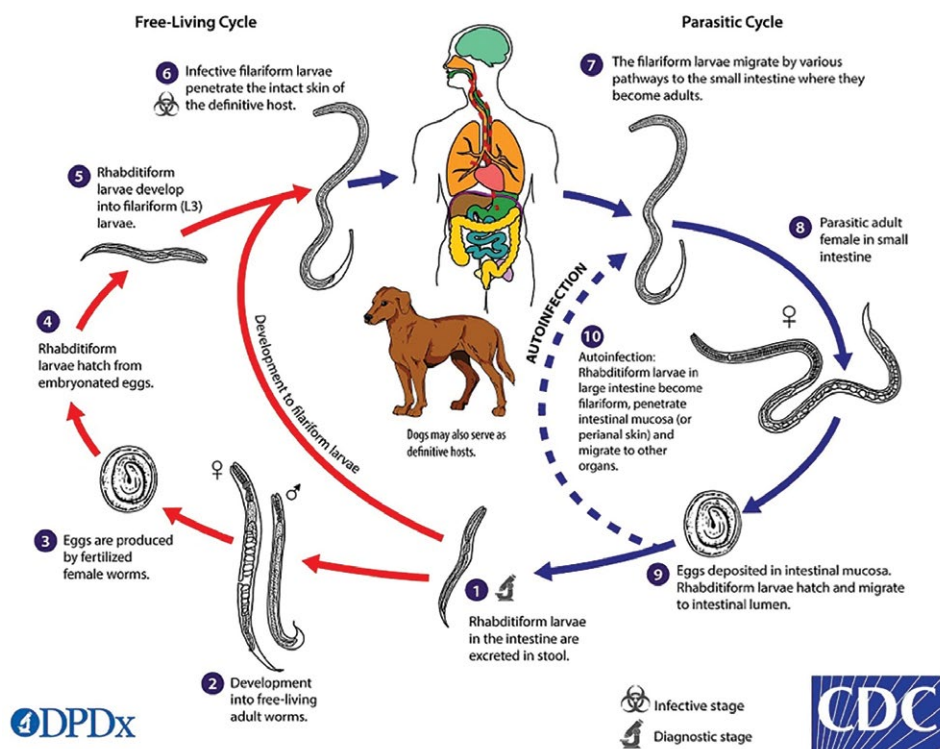
Histoplasmosis, caused by *Histoplasma capsulatum*, includes pneumonia and skin and bone lesions.

## 5.3 Parasites

A parasite is an organism that lives within or on another organism (host). The parasite uses the host's resources to maintain itself and support its life cycle. Parasites vary widely. Around 70% are not visible to the human eye, such as the malarial parasite, but some worm parasites can reach over 30 meters in length. Different parasites have different effects.

**Endoparasites** live inside the host. They include heartworms, tapeworms, roundworms and flatworms – see Figure 15 for an example. An **intercellular parasite** lives inside the host's cells, and includes bacteria and viruses. Endoparasites rely on a third organism, known as the vector, or carrier. The vector transmits the endoparasite to the host. The mosquito is a vector for many parasites, including *Plasmodium*, a protozoan that causes malaria.

**FIGURE 15: STRONGYLOIDES STERCORALIS (ROUNDWORM) LIFE CYCLE**



Source: CDC [public domain]



**Epiparasites** feed on other parasites in a relationship known as hyper-parasitism. A flea lives on a dog, but the flea may have a protozoan in its digestive tract. The protozoan is the hyper-parasite.

There are three main types of parasites.

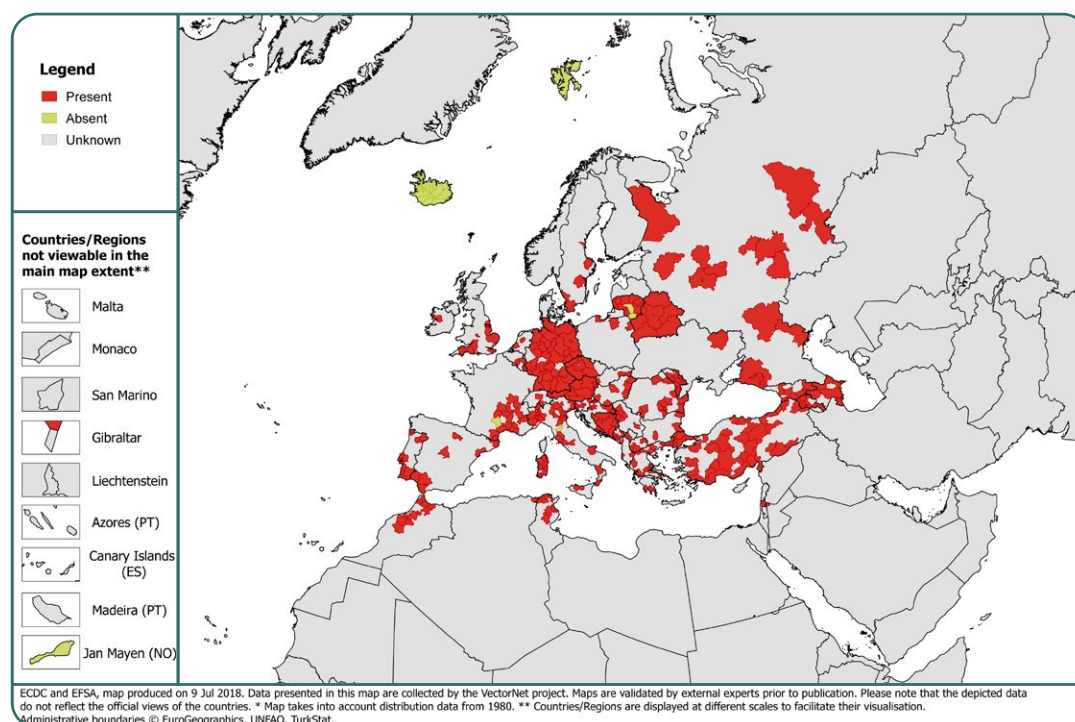
- Protozoa: Examples include Plasmodium, a single-celled organism. Protozoa can only multiply within the host.
- Helminths: These are worm parasites, and examples include roundworm, pinworm, trichina spiralis, tapeworm, and fluke.
- Ectoparasites: These live on, rather than in their hosts, and examples include lice and fleas.

### 5.3.1 Babesiosis

Babesiosis, also called tick fever or piroplasmiasis, is an infection caused by the Babesia parasite (*Theileria microti*). Babesiosis is transmitted by the *Dermacentor reticulatus* tick. It can also be passed on through a blood transfusion. Many people have no symptoms. If symptoms occur, these are flu-like and develop between a week and a few months. Babesia lives in red blood cells and can destroy them, leading to haemolytic anaemia, which may be life-threatening.

### 5.3.2 Malaria

Global travel now means that diseases previously described as tropical, such as malaria, are now present in Europe. These cases are either transmitted by local *Anopheles* mosquitoes infected by a returning traveller (introduced malaria) or by an infected mosquito transported by aircraft from a malaria-endemic country (airport malaria). Introduced mosquitoes are also more likely to survive longer because of climate change. For an example of European mosquito distribution, see Figure 16.



**FIGURE 16:  
ANOPHELES  
MACULIPENNIS  
S.L. COMPLEX  
- CURRENT  
KNOWN  
DISTRIBUTION,  
JULY 2018**

Source: European Centre for Disease Prevention and Control

Nurses need to remain vigilant for cases of malaria when people with fevers attend healthcare services, and ask if people have travelled from areas where malaria is endemic. Nurses also need to remain aware that, because of climate change, cases of malaria can be picked up locally and not just from outside of Europe.

The Eurosurveillance website provides information on communicable disease surveillance, prevention and control (QR code 2).

For more information about parasitic diseases, go to the CDC website (QR code 3).

## 5.4 Creutzfeldt-Jakob disease

Prions and proteinaceous infectious particles are cellular proteins that are wrongly folded. Prion diseases are rare, affecting around 1-1.5:1,000,000 people each year. Creutzfeldt-Jakob disease (CJD) is the most common human prion disease, and most cases arise sporadically in middle or old age (sCJD; 80-95% of prion diseases), or are genetic (familial), occurring in younger people (fCJD; 10-15% of prion diseases).

Bovine spongiform encephalopathy (BSE) or 'mad cow disease' is a neurodegenerative disease seen in cattle, where they have weight loss, signs of pain, problems walking, and odd behaviour such as aggression and anxiety. It was first seen in the UK in the 1980s, and is transmitted when the animals eat food made from infected animals, such as feed made from sheep with the prion infection scrapie. BSE peaked around 1992-1993, and was controlled by the early 2000s.

Variant CJD (vCJD), which was first seen in the United Kingdom in 1994-1995, makes up less than 1% of all cases of prion disease. It is the only prion disease that is transmitted from animals to humans, and is linked with eating meat from cows with BSE. Cases of vCJD have declined since 2000, and there have been no new cases since 2012. Symptoms begin with dementia and dysesthesia (an unpleasant feeling when touched), with involuntary movements developing a few months later. People live for an average of 14 months after developing vCJD.

There is no cure for CJD and other human prion diseases, and symptoms should be treated to make patients more comfortable, for example anti-anxiety drugs, antidepressants and anticonvulsants.

Prion diseases, including CJD, can be passed on through contaminated human growth hormone, dura mater and corneal grafts, neurosurgical instruments or blood products. Prions cannot be destroyed by usual methods of disinfection and sterilization, such as formalin, alcohol, heat and radiation.

Where possible, autoclave instruments at 134 °C for 1 hour. All disposable instruments, materials, and wastes that come in contact with high infectivity tissues (brain, spinal cord, and eyes) and low infectivity tissues (cerebrospinal fluid, kidneys, liver, lungs, lymph nodes, spleen, and placenta) of suspected or confirmed patients should be incinerated [16-18].



SCAN ME  
(QR code 2)



SCAN ME  
(QR code 3)

## 5.5 Emerging microbial infections

Because of the increasing ease of global transport, added to migration and climate change, diseases previously only seen in tropical countries are spreading worldwide.

### 5.5.1 West Nile virus fever

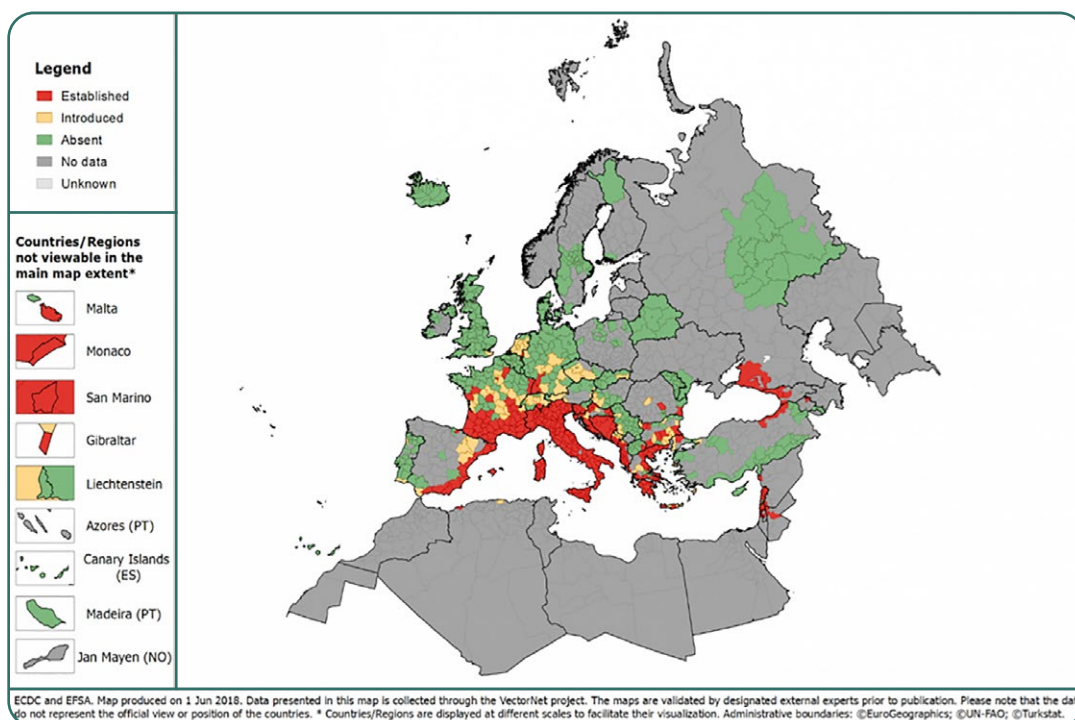
West Nile virus (WNV), a member of the Flavivirus family, is transmitted by mosquitoes. Most people infected do not develop symptoms; for example, fever and other symptoms such as headache, vomiting, or a rash are only seen in around 20% of patients. Further, only 1 in 150 persons infected develops a serious CNS illness such as an encephalitis or meningitis. There is no vaccine or specific antiviral treatment for West Nile virus infection. In severe cases, patients need to be hospitalized to receive supportive treatment, such as intravenous fluids, analgesia, and skilled nursing care.

### 5.5.2 Zika virus infection

Zika virus (ZIKV) is a member of the Flavivirus family, and is transmitted primarily through the bite of an infected *Aedes* species mosquito, such as *Aedes albopictus* (see Figure 17). Nonhuman and human primates are the main reservoirs of the virus. Other transmission routes include perinatal, in utero, and sexual, as well as transfusion and transplantation.

#### FIGURE 17: DISTRIBUTION OF THE AEDES ALBOPICTUS MOSQUITO AS OF JUNE 2018

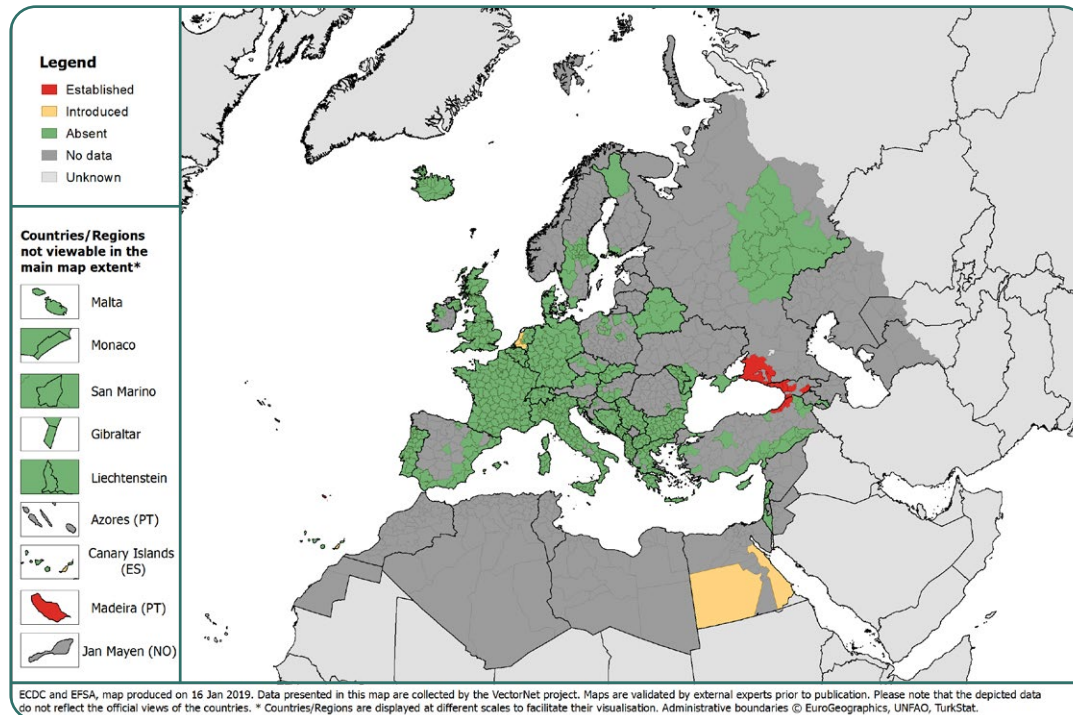
Source: European Centre  
for Disease Prevention  
and Control



Most cases are asymptomatic, but some patients develop fever, rash, arthralgia, and conjunctivitis. Other symptoms are myalgia and headache. These symptoms are usually mild and last for several days to a week. Some patients may develop a Guillain-Barré syndrome (an immune attack to the nerves, causing muscle weakness). However, during pregnancy, Zika virus infection is a cause of microcephaly and other severe foetal brain defects. There is no vaccine or specific antiviral treatment for Zika virus infection.

### 5.5.3 Dengue

Dengue virus, a member of the Flavivirus family, is transmitted by the mosquito *Aedes aegypti* (see Figure 18). Most cases are asymptomatic (40% - 80%). Other patients present with a fever, headache, vomiting, muscle and joint pains. In severe forms, around 5% progress to bleeding, with haemorrhagic fever and shock. The fatality rate of severe dengue has reduced with proper medical care and is now below 1%. There are no specific antiviral drugs available, and treatment involves hydration (including intravenous fluids if required), fever reducers and painkillers such as paracetamol. NSAIDs (non-steroidal anti-inflammatory drugs), such as ibuprofen and aspirin should be avoided [19].



**FIGURE 18:**  
DISTRIBUTION  
OF THE AEGES  
AEGYPTI  
MOSQUITO AS  
OF JANUARY  
2019

Source: European Centre  
for Disease Prevention  
and Control

The incidence of dengue fever is growing, and around half of the world's population is at risk [19].

### 5.5.4 Ebola virus haemorrhagic fever

Ebola virus belongs to the Filoviridae family. It is responsible for haemorrhagic fever with an average fatality rate of 50, ranging from 25% to 90%. Ebola viruses have caused outbreaks in the past, mostly in sub-Saharan Africa. People are initially infected with Ebola virus through contact with an infected animal (fruit bat, ape or monkey). The virus then spreads from person to person through direct contact (broken skin or mucous membranes in the eyes, nose, or mouth): via blood or body fluids (urine, saliva, sweat, faeces, vomit, breast milk, and semen) of an infected person or who has died from Ebola virus disease (EVD). The infection is also spread by needles and syringes contaminated with the body fluids, and even from the semen of male patients following recovery from EVD. The disease typically develops after an incubation period of 2 to 21 days, and with symptoms such as fever, severe headache, muscle pain, diarrhoea, vomiting, abdominal pain, and haemorrhages. Recovery from EVD depends on good supportive clinical care and the patient's immune response. All activities should be performed at the 4th level of biological security and in full biological personal protective equipment. There is not a specific treatment, but supportive care includes rehydration with oral and intravenous fluids, and treatment of specific symptoms. A vaccine has now been approved, and the first-ever multi-drug randomized control trial began during the 2018/2019 Ebola outbreak in the Democratic Republic of Congo [20].



### 5.5.5 Lyme disease

Lyme disease or Lyme borreliosis is an infection caused by the *Borrelia* bacterium. The bacteria is spread by *Ixodes* ticks (Table 16). It is the most common tick-borne infection in temperate parts of Europe, North America and Asia, and its reach around the world is increasing [21].

**TABLE 16: TICKS AND BACTERIA LINKED WITH LYME DISEASE**

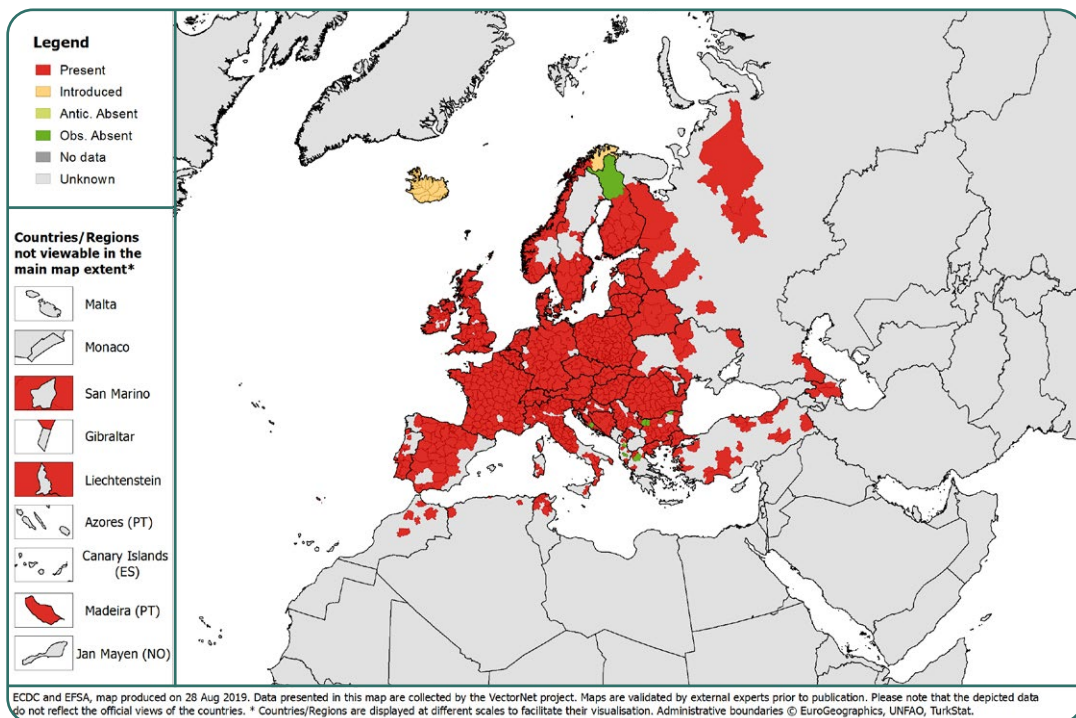
Region	Tick	Bacterium
Europe	<i>Ixodes ricinus</i>	<i>Borrelia afzelii</i> <i>Borrelia garinii</i> <i>Borrelia burgdorferi</i> <i>Borrelia bavariensis</i> <i>Borrelia spielmanii</i>
North America	<i>Ixodes scapularis</i>	<i>Borrelia burgdorferi</i>

Source: ECDC [21]

The numbers of ticks in Europe are growing, driven by climate change, increasing numbers of deer, and changes in land management [22]. See Figure 19 for European distribution of *Ixodes ricinus* and Figure 20 for an image of the tick.

**FIGURE 19:  
IXODES RICINUS  
- CURRENT  
KNOWN  
DISTRIBUTION:  
JULY 2019**

Source: ECDC [23]





**FIGURE 20: IXODES RICINUS**

Source WWalas [Creative Commons]

In 1883, German doctor Alfred Buchwald described a skin rash, now known as acrodermatitis chronica atrophicans, the third stage of Lyme disease. The neurological complications of Lyme disease were first described in the 1920s and 1930s. Lyme disease has three stages: [24-26].

**Stage 1:** Primary or localised infection, with flu-like symptoms 1-30 days after the bite, and a characteristic expanding rash (erythema migrans; bull’s eye rash) at the site of the tick bite, usually within 7-14 days after the tick is removed. Other symptoms can include tiredness, muscle and joint pain, fever, chills and neck stiffness.

**Stage 2:** Early disseminated disease, weeks to months after the bite as the bacteria spread through the body

- Fever and malaise, blurred vision, eye pain
- Nervous system disorders (neuroborreliosis): Symptoms include painful inflammation of the nerves of the spine (Bannwarth syndrome), facial paralysis (Bell’s palsy), meningitis, and encephalopathy, including confusion, memory loss, and issues with concentration, mood and sleep
- Lyme arthritis: Symptoms include swelling and pain in one or a few joints. This most commonly affects the knees, but also includes the ankle, shoulder, elbow, or wrist

**Stage 3:** Chronic neuroborreliosis can set in months or years after infection, and includes central and peripheral nervous system symptoms (chronic neuroborreliosis). There is no consensus among experts on the prevalence of chronic neuroborreliosis.

**FIGURE 21: ERYTHEMA MIGRANS**

Source: Centers for Disease Control and Prevention [public domain]

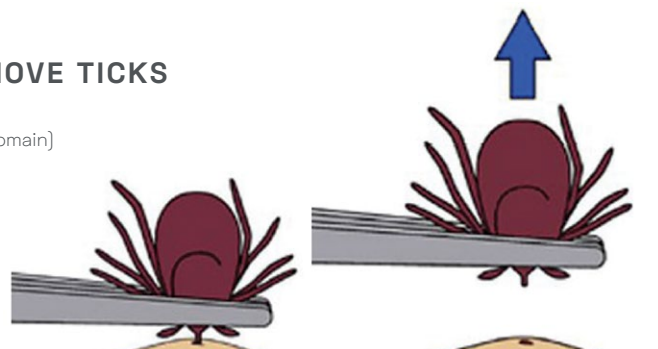


**Treatment**

Ticks should be removed as quickly as possible (Figure 22). Grip the tick as close to the skin surface as possible, pull upwards with steady even pressure, and then clean the skin and hands with soap and water or alcohol. Dispose of the tick by putting it in alcohol, sealing it in a bag, wrapping it in tape, or flushing it down the toilet [27].

**FIGURE 22: HOW TO REMOVE TICKS**

Source: CDC [public domain]





High-risk patients, who have been bitten in an area where disease is highly endemic, and where the tick has been attached for 36 hours or more, may benefit from a preventive single dose of an antibiotic such as doxycycline.

Treatment depends on the disease stage and clinical manifestation. See Table 17 for guidance but also refer to local and national guidelines for further details.

**TABLE 17: CLINICAL PRESENTATION AND THERAPY FOR THE STAGES OF LYME DISEASE**

Disease stage	Clinical manifestations	Treatment route	Duration
<b>Early localized</b>	Erythema migrans	Oral	7-14 days
	Multiple erythema migrans	Oral	14 days
	Isolated cranial nerve palsy	Oral	14-21 days
	Meningoradiculoneuritis	Oral	14-28 days
<b>Early disseminated</b>	Meningitis	Intravenous or oral	14-21 days
	Carditis – ambulatory	Oral	14-21 days
	Carditis – hospitalized	Intravenous followed by oral	14-21 days
	Borrelial lymphocytoma	Oral	14 days
	Arthritis	Oral	days
	Recurrent arthritis after oral therapy	Oral or intravenous	28 days or 14-28 days
<b>Late</b>	Encephalitis	Intravenous	14-28 days
	Acrodermatitis chronica atrophicans	Oral	21-28 days

Source: Meyerhoff [24]

Patients with chronic disease may benefit from long-term antibiotic treatment.

### 5.5.6 Coronavirus 2019-nCoV

In December 2019 and January 2020 there was a cluster of cases of pneumonia in China caused by a novel coronavirus, 2019-nCoV. The first cases were reported in Wuhan City, Hubei province, China on 31

# Source European Commission

## What is the outbreak about?

From what ECDC (European Centre for Disease Prevention and Control), national and international agencies currently know, the outbreak is caused by a novel coronavirus. There are still many unknowns regarding to the virulence and pathogenicity of the virus, the severity of affected patients, its transmission patterns, reservoir and source of infection. Epidemiological analyses available to date are also limited which leads to many uncertainties on the characteristics and the dynamic of the outbreak.

## What are coronaviruses?

Coronaviruses were identified in the mid-60s and are known to infect humans and a variety of animals (including birds and mammals). This family of viruses are known to cause illness in humans ranging from the common cold to more severe or even fatal diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS).

There is currently limited information about the epidemiological and clinical characteristics of the infection caused by COVID-19. Although the data available to ECDC is currently very scarce (see e.g. open source platform nextstrain.org which visualises phylogenetic analysis and relation between the nCoV and SARS and other beta-coronaviruses). This novel coronavirus seems genetically closely related to the 2003 SARS virus and appears to have similar epidemiological characteristics.

## What are the symptoms and treatment options?

Even if severe and fatal infections have been observed, human infections with common coronaviruses are mostly mild and asymptomatic, resembling those of a common cold (cough, fever, runny nose, etc.). These viruses are able to cause lower respiratory tract infections and pneumonia in humans.

## Are vaccines and treatments available?

There are currently no vaccines against coronaviruses. There is not specific treatment for this disease so the clinical approach is symptomatic-based on the patient's clinical condition. Moreover, supportive care (e.g. supportive therapy and monitoring – oxygen therapy, fluid management, empiric antimicrobials) for infected persons can be highly effective.

Since there is no specific treatment for this disease, the clinical approach is based on the symptoms of the clinical condition of the patient.



WHO ON  
#COVID

December 2019, with links to a wholesale fish and live animal market selling different animal species. By 30 January 2020, there were cases in 18 countries outside of China, with confirmed human-to-human transmission.

Coronaviruses were first identified in the 1960s, and cause infections in humans and animals. Two coronaviruses have crossed over from animals to humans: SARS-CoV (2002) and MERS-CoV (2012). These were both likely to have originated in bats, and spread to Himalayan palm civets, Chinese ferret badgers and raccoon dogs sold for food. The origin of the coronavirus 2019-nCoV is not yet clear. Symptoms of the coronavirus 2019-nCoV include fever, cough, muscle pain and tiredness [28,29]. The WHO website [QR code 4] has up to date information.



SCAN ME  
[QR code 4]

### NOTE FROM THE EDITOR:

During the preparation of this guide, the CORONA-19 virus infection became a pandemic. Because of changing advice, we are not able to include all available information but refer you to aspects of Infection Prevention Control in Module 5. In the second edition we will provide more information, with implications for clinical practice.

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## MODULE 2

# Medication

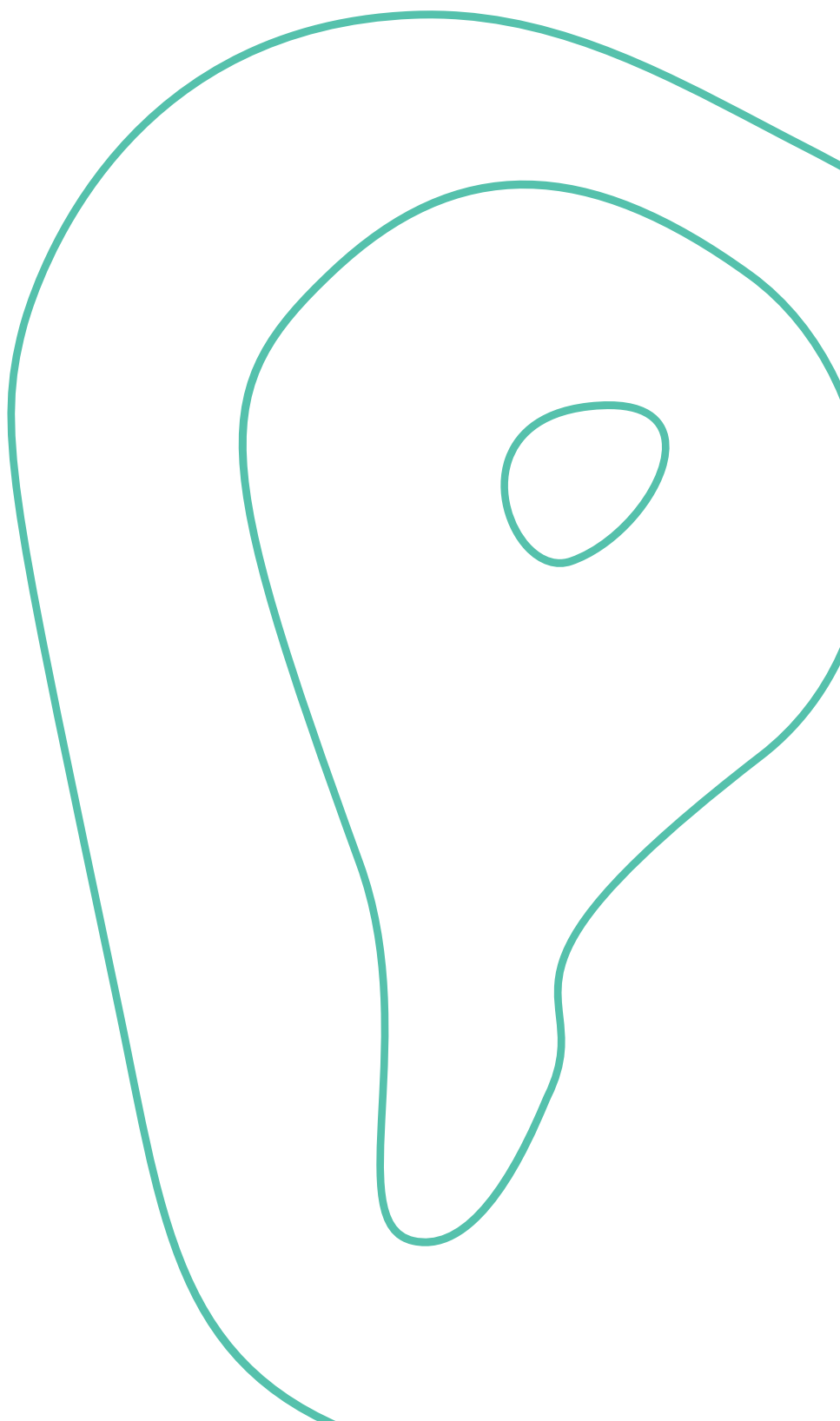


**After reading Module 2,** you will understand the essentials of how vaccines, antibiotics and other antimicrobials work. You will know more about how vaccines are used to prevent infectious disease caused by bacteria and viruses, and that there are vaccines in development against fungi and parasites. You will be able to educate patients about antibiotics, including that they are not effective against viruses. You will be better at communicating and discussing the responsibilities of nurses, nurse specialists and physicians.

## HIPPOCRATES

”

**The greatest  
medicine of all is  
teaching people  
how not to need it**





## 7 An introduction to antimicrobial medication

From the days of Florence Nightingale, distributing medication has been a key responsibility for nurses. As medications have become more complex, nurses' roles have grown to include more than just distribution (Figure 23).

**FIGURE 23: NURSES' ROLES IN ANTIMICROBIAL MEDICATION**



For work in infection, it is crucial that nurses have a working knowledge of microbiology, and understand the mechanisms of action of medications used in its prevention and treatment.

This module will use antimicrobials as a word to cover the drugs used against bacterial, viral, fungal, parasitic and other infections, and antibiotics to describe the drugs specifically used against bacterial infections.

### 7.1 Developing medications

There are many different medications available for a huge variety of diseases, from high blood pressure to depression, and from cancer to infection. In the 1960s, there were only a few hundred medications available in Europe; today there are thousands. Some of these medications are for common diseases, others for very rare conditions.

Drugs are assessed in clinical trials, and then approved for use in patients after careful evaluation by the European Medicine Agency (EMA), a coalition of national institutes that look at the efficacy and safety of medication. The EMA is supported by working groups that involve patients and health professionals, including specialist nurses.

## 7.2 Naming medications

Medications have three different names:

- **Chemical name:**
  - > The scientific name that describes the molecule and its structure; for example, **N-methyl-3-phenyl-3-[4-(trifluoromethyl) phenoxy]propane-1-amine**
- **Generic name:**
  - > The International Non-proprietary Name (INN) for the drug; for example, **fluoxetine**
  - > This remains the same, even if the drug is made by different manufacturers. This makes communication more precise, and helps to avoid prescribing errors.
  - > Generic names may have a suffix that shows they belong to a certain class, for example -cidin for naturally occurring antibiotics or -cillin for derivatives of penicillin.
  - > Where two medicines are combined into a single dose, their generic names may be joined by a hyphen or slash, for example suspensions combining trimethoprim and sulfamethoxazole may be described as trimethoprim-sulfamethoxazole or co-trimoxazole.
- **Trade name:**
  - > The name given by the pharmaceutical company; for example, **Prozac**.
  - > Many drugs have multiple trade names, reflecting marketing in different countries, manufacture by different companies, or both.

# 8 Antibiotics and how they work

## 8.1 Antibiotic essentials

The European Centre for Disease Prevention and Control definition is: [1]

Antibiotics, also known as antimicrobial drugs, are medicines that can kill or inhibit the growth of bacteria to cure infections in people, animals and sometimes plants. Antibiotics are medicines for bacterial infections (such as pneumococcal pneumonia or staphylococcal bloodstream infections); antimicrobial drugs that are effective against viruses are usually called antiviral drugs (such as those for influenza, HIV and herpes).

This section covers both bactericidal antibiotics (kill bacteria directly), and bacteriostatic antibiotics (stop bacteria from growing).

For example:

- **Bactericidal:** The antibiotic polymyxin B **damages the plasma membrane of bacteria**, upsetting the balance of salts on both sides of the plasma membrane. Polymyxin B also lets other important molecules, like DNA and RNA, leak out, so the bacterium is destroyed.
- **Bacteriostatic:** Tetracycline antibiotics stop bacteria from growing by **preventing them from making proteins**. When bacteria run out of the proteins they need, they can no longer replicate. Other bacteriostatic antibiotics interfere with DNA replication or other metabolic processes in the bacteria.

A limited number of antibiotics also possess antiprotozoal activity such as malaria.

## 8.2 The evolution of antibiotics



Source: Imperial War Museums  
(public domain)

**FIGURE 24: PROFESSOR ALEXANDER FLEMING IN HIS LABORATORY AT ST MARY'S, PADDINGTON, LONDON (1943)**

Alexander Fleming (Figure 24) is credited with the discovery of the first antibiotic. In 1928, he saw that a fungus (*Penicillium chrysogenum*), that had accidentally ended up in a bacterial culture, inhibited the growth of *Staphylococcus aureus*. That was the start of penicillin, leading to the subsequent development of many antibiotics, but was also the start of the race against antimicrobial resistance [2].

The discovery of penicillin, however, built on a number of different breakthroughs, from the invention of the microscope by van Leeuwenhoek, to Rudolf Virchow's cell theory, Claude Bernard's understanding of the importance of balance within the organism, and Louis Pasteur and Robert Koch's development of germ theory, showing that microorganisms cause diseases and infections.

Following Fleming's discovery, Paul Ehrlich and Sahachiro Hata developed Salvarsan (arsphenamine, also called compound 606) at the beginning of the 20th century. This was the first effective treatment for syphilis, and began the era of effective antimicrobials [3].

## 8.3 How antibiotics work

Different antibiotics work against different bacteria. Their main ways of attack are by targeting the bacterial cell wall, or the cell's protein or nucleic acid synthesis.

The reason that antibiotics do not work against viruses and virus infections is quite simple: the targets for antibiotics are missing in viruses. **Viruses do not have a cell wall or machinery for protein synthesis:** they multiply via human cells. **So, flu and the cold cannot be treated with antibiotics.**

### 8.3.1 Antibiotics that target the cell wall

Bacteria, except *Mycoplasma*, have a cell wall. The building blocks for the bacterial cell wall and the machinery in the bacterial cell to make the cell wall – cell wall synthesis – are targets for antibiotics. This allows them to kill bacteria without affecting human cells. For example, beta-lactams target and affect the structure of the bacterial cell wall.

### 8.3.2 Antibiotics that target protein synthesis

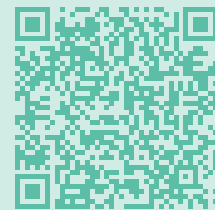
Aminoglycosides, macrolides, lincosamides, streptogramins, tetracyclines, and chloramphenicol inhibit protein synthesis so that bacteria can no longer make the proteins or enzymes they need to survive.

### 8.3.3 Antibiotics that target bacterial DNA/nucleic acid synthesis

Quinolones, co-trimoxazole and rifampicin target bacterial DNA and affect how the bacteria multiply.

**IMPORTANT:** All antibiotics have side effects, and it's important to know what these might be.

Quinolones, such as moxifloxacin, ciprofloxacin and levofloxacin can have severe side effects. Because of this, the EMA advises that quinolones should not be used as first line antibacterial medication. See more on the European Medicines Agency website **[QR code 5]**.



**S C A N M E**  
[QR code 5]

### 8.3.4 Antibiotics that target the surface outer membrane of Gram-negative bacteria

Polymyxins, for example colistin, act as surface inhibitors and disrupt the outer membrane of Gram-negative bacteria.

## 8.4 Routes of administration

- **Oral**
  - > Most common, especially for short term treatment of less severe systemic infections
  - > Advantages: Simple, can be administered at home
  - > Disadvantages: Can irritate the stomach
- **Topical**
  - > For local infections, for example skin, eye, ear, surgical site infections
  - > Advantages: Simple, can be administered at home; provides high and sustained concentration of antibiotic at the site of infection; reduces systemic absorption and decreases toxicity; reduces the overall dose required
  - > Disadvantages: Some systemic absorption may occur; accurate dosing is difficult; local hypersensitivity reactions or contact dermatitis may occur; antimicrobial resistance can occur rapidly with topical antibiotics
- **Intravenous**
  - > For deep-seated systemic infections
  - > May be continuous or in separate infusions
  - > Advantages: Allows use of antibiotics that may not be available orally
  - > Disadvantages: Can usually only be administered in hospital; requires IV access
- **Intramuscular**
  - > For short-term courses of antibiotics when oral administration is not possible
- **Special routes**
  - > Intravesical administration of gentamicin in chronic urinary tract infections (UTIs)
  - > Inhaled administration of tobramycin, colistin or aztreonam in pulmonary infections
  - > Intrathecal administration of colistin, vancomycin or amikacin in meningitis
  - > Gentamicin, tobramycin or cefuroxime in bone cement in osteomyelitis

### ANTIBIOTIC SWITCHING IN THE NETHERLANDS

For some antibiotics the tissue concentrations obtained by intravenous and oral administration are the same. This allows patients to switch as their clinical situation improves, so that they can continue their treatment at home.

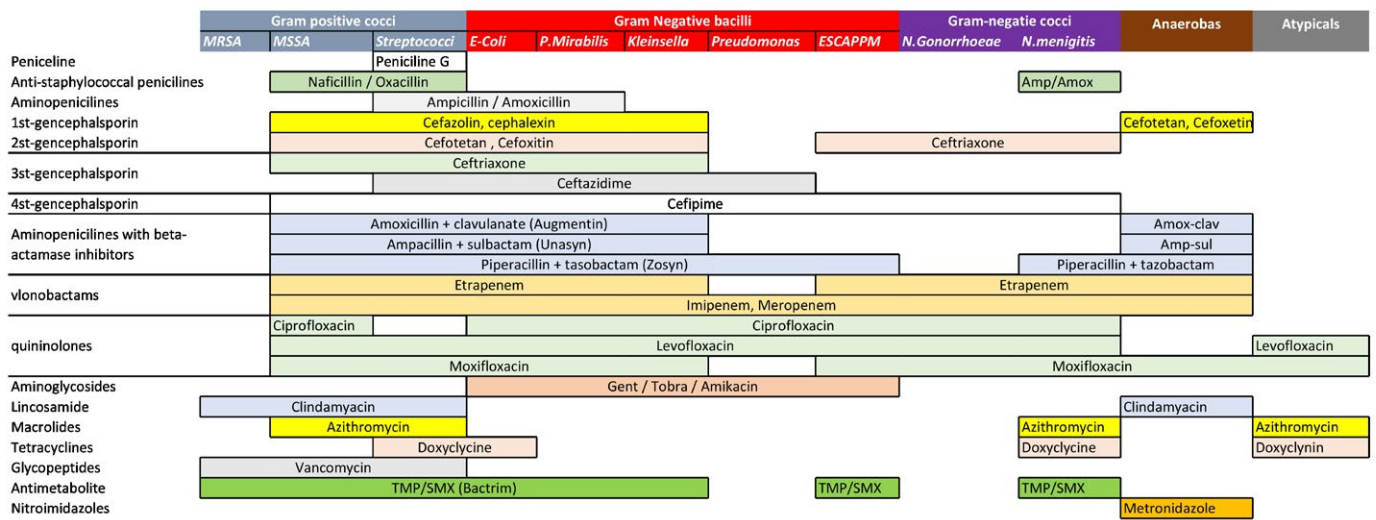
In the Netherlands each hospital has an antibiotic stewardship group. This team monitors the use of intravenous antibiotics daily in order to see when patients can be taken off the antibiotics or switched to an oral dose (see also section 31).

## 8.5 Broad- and narrow-spectrum antibiotics

### 8.5.1 Broad-spectrum, what makes it such and when to use it

A broad-spectrum antibiotic acts on a wide variety of bacteria, including Gram-positive and Gram-negative infections (Figure 25).

**FIGURE 25: ANTIBIOGRAM**



See [www.github.com/aetherist/antibiogram](http://www.github.com/aetherist/antibiogram) for details. For educational purposes only. TMP/SMX = Trimethoprim-sulfamethoxazole, MRSA = Methicillin-resistant *Staphylococcus aureus*. MSSA = Methicillin-sensitive *Staphylococcus aureus*. ESCAPPM = *Enterobacter spp.*, *Serratia spp.*, *Citrobacter freundii*, *Aeromonas spp.*, *Proteus spp.*, *Providencia spp.* and *Morganella morganii*

Broad-spectrum antibiotics are used:

- When the causative organism is unknown, but delays in treatment would lead to worsening infection or spread of bacteria to other parts of the body
  - > For example, in meningitis, where the patient can become fatally ill within hours if treatment is not initiated.
- For drug-resistant bacteria that do not respond to narrow-spectrum antibiotics.
- In the case of superinfections, where there are multiple types of bacteria causing the infection
- For prophylaxis in order to prevent bacterial infections occurring
  - > For example, this can occur before surgery, to prevent infection during the operation, or for patients with immunosuppression who are at high-risk for dangerous bacterial infections.



## 8.5.2 Narrow-spectrum, what makes it such and when to use it

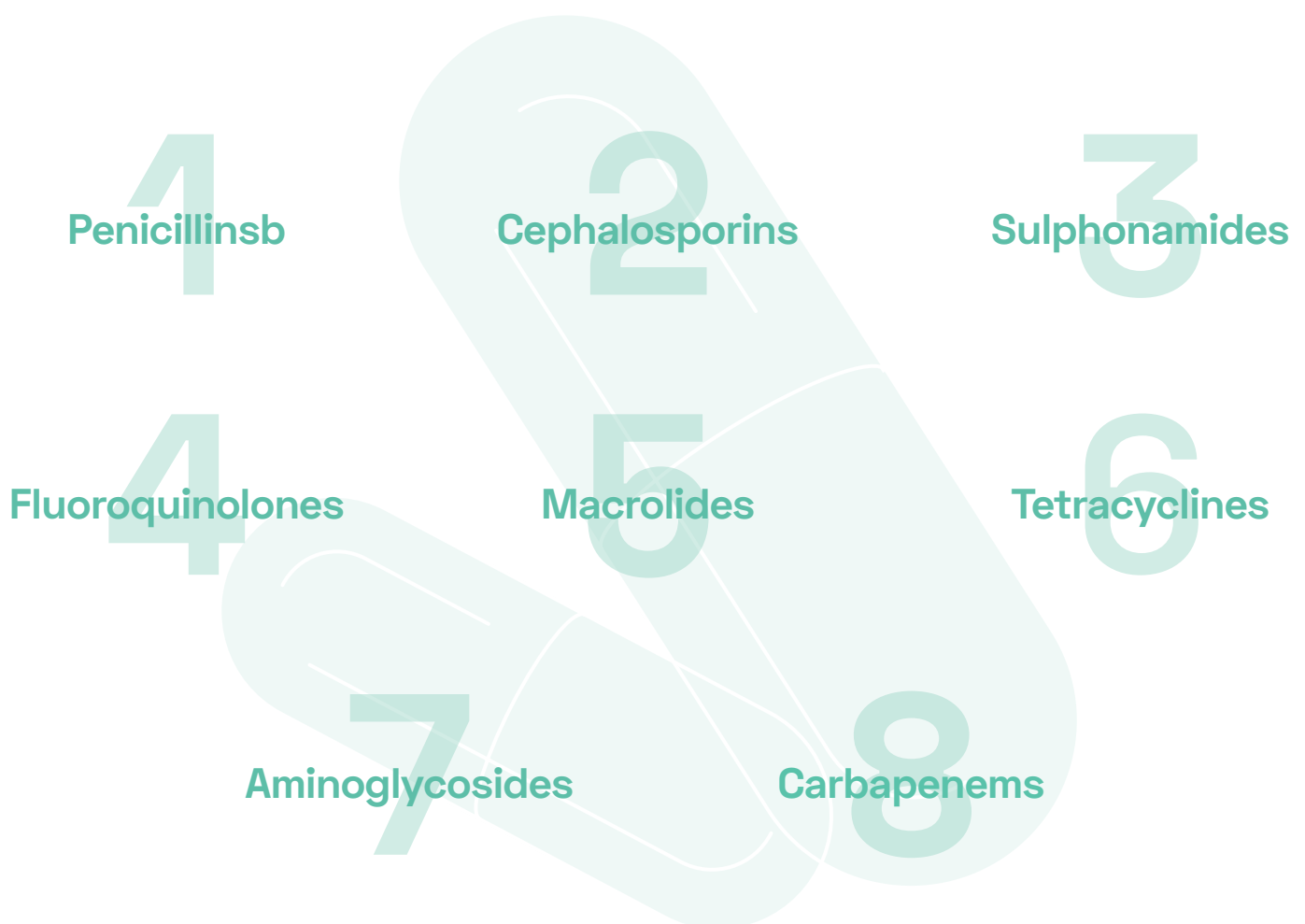
Narrow-spectrum antibiotics are only effective against those bacterial species that are unwanted (i.e. causing disease). This reduces the impact on beneficial bacteria.

Before patients can be treated with a narrow-spectrum antibiotic, it's essential to know which bacterium is causing the illness. Patients may be treated with antibiotics on a trial and error process until results come back. It's expected that in the future new technologies can be used for a quicker determination and to select medication.

## 9 Overview of eight groups of antibiotics

There are dozens of different types of antibiotics, grouped into different classes. The following section includes eight of the most common classes (Figure 26), what they are generally used for and some of the potential side effects.

**FIGURE 26: CLASSES OF ANTIBIOTICS**





This section does not cover all of the antibiotics in each class, and prescribing will depend on antibiotic and disease guidelines.

While many of these antibiotics are similar in structure and usage, there are differences that can affect how effective they are for each individual. Side effects will also vary depending on the individual taking them and their dosage levels.

People with non-severe infections are treated initially with commonly used antibiotics, alone or in combination, ideally following microbiological investigation. For severe infections, antibiotics are given based on observation and then tailored following microbiological investigation.

Antibiotics should be given in combinations that are not known to cause cross-resistance. If all of these fail, patients are treated with an antibiotic of last resort. These are used only in these situations to reduce the chance of resistance developing.

## 9.1 Penicillins

Penicillins, such as amoxicillin, ampicillin, nafcillin, piperacillin and penicillin G, can treat a wide variety of bacterial infections. Because they act specifically on the cell wall of bacteria, they have a wide therapeutic window, and can be administered during pregnancy and to newborn babies.

Penicillin is the most widely prescribed of all antibiotics, usually as amoxicillin. It is usually the first choice for patients with infections such as pneumonia, tonsillitis and dental abscesses. Other common bacterial infections treated with penicillins include strep throat and UTIs. The most common side effects are gastrointestinal, including nausea, vomiting, bloating and diarrhoea, and black hairy tongue.

Benzylpenicillin has a narrow spectrum of activity, mainly against Gram-positive bacteria. It must be given by injection (IM or IV). It is effective against pneumococcal, streptococcal, meningococcal and leptospiral infections.

Flucloxacillin is effective in infections caused by penicillinase-producing penicillin resistant Staphylococci, only used in infections with these bacteria (hospital acquired staphylococcal infections). It can be given orally, but in severe infections it should be given by injection.

Ampicillin and amoxicillin are broad-spectrum antibiotics and active against non-beta-lactamase-producing Gram-positive bacteria. They diffuse into Gram-negative bacteria and are also active against strains of *E. coli*, *Haemophilus influenzae* and *Salmonella*. For oral administration, amoxicillin is the drug of choice. Penicillins are inactivated by penicillinase-producing bacteria. Many bacterial beta-lactamases are inhibited by clavulanic acid. A mixture of this inhibitor with amoxicillin results in being active in penicillinase-producing bacteria. Co-amoxiclav is indicated in respiratory and urinary infections.

Hypersensitivity is the most important side-effect, including rashes and rarely anaphylactic reactions that are fatal in about 10% of cases.

## 9.2 Cephalosporins

Cephalosporins were first discovered and isolated in 1945. There are five generations of cephalosporins. The first generation of these antibiotics is usually used for infections that are easier to treat. The latter generations are for more serious bacterial infections.

Cephalosporins are often used for strep throat, meningitis, pneumonia, UTIs and ear infections. The cephalosporins that are primarily prescribed include cephalexin, cefaclor and ceftriaxone (as an injection). Cefazolin, cefuroxime and ceftiofur are not used as often and normally prescribed for individuals with cystic fibrosis or those undergoing dialysis. The fifth-generation cephalosporin, ceftaroline, is used for antibiotic-resistant infections such as MRSA.

Side effects are similar to those experienced with penicillin. These include nausea, diarrhoea, rash and thrush. If someone is allergic to penicillin it is likely they will be allergic to cephalosporins, since they are similar in molecular structure. Depending on how severe the allergy is, some individuals may be able to still take third, fourth or fifth generation cephalosporins.

## 9.3 Sulphonamides

Sulphonamides (also known as sulphonamides or sulfa/sulpha drugs) were initially developed as early as 1906 but not used for antimicrobial purposes until the 1930s. These are technically antimicrobials rather than antibiotics, and examples include sulfisoxazole and sulfamethoxazole. Sulphonamides are used for general bacterial infections such as bronchitis and UTIs.

There are a variety of potential side effects associated with sulphonamides, including itching and rash. Older adults can be particularly sensitive to sulphonamides and are usually advised to avoid these medications. Pregnant women are also advised to avoid these antibiotics as they can be excreted in breast milk.

There are dozens of medications that have the potential to interact with sulphonamides, making it extremely important for patients to discuss these with their prescribing healthcare worker.

Sulphonamides are rarely used for bacterial infections because of the development of more effective and less toxic antibiotics. Also, many organisms have developed resistance to sulphonamides.

## 9.4 Fluoroquinolones

Fluoroquinolones are divided based on pharmacology and their antimicrobial spectrum. The older group of fluoroquinolone antibiotics includes ofloxacin, norfloxacin and ciprofloxacin. The newer group includes moxifloxacin, levofloxacin, delafloxacin and gemifloxacin. Fluoroquinolones work by destroying the ability of the bacteria to replicate.

Quinolones, such as moxifloxacin, ciprofloxacin and levofloxacin can have severe side effects. Because of this, the European Medicines Agency (EMA) advises that quinolones should not be used as first line antibacterial medication. See more on the EMA website (QR code 5).

It is generally recommended to use these antibiotics only after other courses of treatment have failed. There may be some cases, however, such as when treating severe bacterial pneumonia and abdominal infections, that the potential benefits outweigh the risks.

Ciprofloxacin is effective against both Gram-positive and Gram-negative bacteria, including *E. coli*, *Pseudomonas aeruginosa*, *Salmonella* and *Campylobacter*. Ciprofloxacin is well absorbed orally and intravenously. Side effects are infrequent, and include nausea, vomiting, rashes, dizziness, headache and tendon damage.

## 9.5 Macrolides

These antibiotics were discovered during the 1950s. Specific drugs in this class include roxithromycin, clarithromycin, azithromycin and erythromycin. These antibiotics are often used for specific types of pneumonia, chlamydia and urethritis.

Macrolides are usually given orally, but erythromycin and clarithromycin can be given by IV. They have a narrow spectrum mainly against Gram-positive bacteria, similar as benzylpenicillin. They can be given to penicillin sensitive patients with infections caused by streptococci, staphylococci, pneumococci, and clostridia. They do not penetrate the central nervous system and are therefore ineffective in meningitis. Macrolides are also effective against *Mycoplasma pneumoniae* and Legionnaires' disease. Erythromycin is metabolized by the liver, therefore dosage reduction in renal failure is not necessary, unless severe renal failure.

Macrolides are sometimes prescribed to prevent a bacterial infection. If a person has had their spleen removed or suffers from sickle cell disease, then they may need to use one of these antibiotics on a regular basis to prevent an infection.

Minor side effects can include nausea, diarrhoea and ringing in the ears. Macrolides are often a good alternative for individuals that are allergic to penicillin or cephalosporins. However, potential complications regarding these antibiotics include some drug interaction concerns that could lead to serious heart complications.

## 9.6 Tetracyclines

Tetracyclines were discovered in 1945 and first prescribed in 1948. In 1953, the drug was patented but was not commercially used until 1978. Tetracyclines are usually given orally but may be given by injection. Absorption in the gut is reduced by calcium ions (milk), magnesium ions (antacids), food and iron preparations.

Tetracyclines are broad spectrum antibiotics, but because of increasing resistance their use is limited. They are the drug of choice to treat infections caused by intracellular organisms because they penetrate macrophages, e.g. *Chlamydia*, *Rickettsia* (Q fever) and *Borrelia burgdorferi* (Lyme disease). They have also been used for acne and in combination with other medication for stomach ulcers caused by *Helicobacter pylori*.

Because tetracyclines bind to calcium in growing bones and teeth, and can cause discoloration of the teeth in the young, they should be avoided in children up to 8 years, and in pregnant and lactating women. Tetracyclines are active against MRSA pathogens and Vancomycin-resistant enterococci.

While many of these antibiotics have similar side effects to those in other classes, tetracyclines may also inhibit appetite. The most common side effects may include nausea, diarrhoea, swollen tongue, troubling swallowing and soreness or swelling in the genital area. A rare but potential serious side effect is possible blindness due to intracranial hypertension.

## 9.7 Aminoglycosides

In 1943, streptomycin (the first aminoglycoside) was discovered. These antibiotics, unlike most others, are usually administered intramuscularly or intravenously in a clinical setting.

Aminoglycosides are bactericidal and active against Gram-negative bacteria and some Gram-positive bacteria. They kill bacteria directly and are often used for conditions that are difficult to treat. A few types of aminoglycosides can be taken as ear drops, eye drops or orally.

They have a narrow therapeutic index and potentially toxic. They are excreted by the kidney, renal impairment results in accumulation and greater toxic side effects. One of the most important side effects is the damage to the VIII cranial nerve (ototoxicity), as well as kidney damage. Aminoglycosides may impair neuromuscular transmission and are contraindicated in patients with myasthenia gravis. Resistance to aminoglycosides arises from production of enzymes that inactivate the drug. Other mechanisms are alteration of the envelope to prevent drug access.

Gentamicin is the most important aminoglycoside, and its main use being in the empirical treatment of life-threatening Gram-negative infections (*Pseudomonas aeruginosa*) in hospitals. Amikacin is less affected by aminoglycoside-inactivating enzymes and is used in infections that are resistant to gentamicin.

## 9.8 Carbapenems

These antibiotics were introduced in the 1980s. They are a class of antibiotics also known as beta lactams. They work by inhibiting synthesis of the bacterial cell wall. Carbapenems are often used for serious urinary infections, abdominal infections, blood infections and pneumonia.

The carbapenems doripenem, ertapenem, imipenem and meropenem are usually administered intravenously or injected into a muscle. These drugs are often prescribed for infections that are not easily treated with other antibiotics.

Meropenem is a carbapenem (structure similar to penicillin) but highly resistant to most  $\beta$ -lactamases. It has a wide spectrum and is bactericidal against most Gram-negative and Gram-positive pathogenic bacteria. It is given by injection.

Carbapenems are similar to penicillin. General side effects include nausea, diarrhoea and headache.

## 9.9 Others

Trimethoprim is an inhibitor of dihydrofolate reductase. It is selectively toxic for the bacterial enzyme. It is widely used in UTIs and in combination with sulfamethoxazole (co-trimoxazole) may produce a synergetic action and increase activity against certain bacteria. It has an important use in the treatment of *Pneumocystis jirovecii* pneumonia. It is well absorbed orally.

Metronidazole is active against most anaerobic bacteria including *Bacteroides* species. It is a first choice in certain protozoal infections, i.e. *Entamoeba histolytica*, *Giardia lamblia*, *Trichomonas vaginalis*. It is well absorbed orally and can be given by IV. It is often used as prophylaxis in gut surgery. Side effects include gastrointestinal disturbance. Tinidazole has similar action to metronidazole but has longer duration of action.

Vancomycin is a bactericidal antibiotic that is not absorbed orally. It acts by inhibiting peptidoglycan formation and is active against most Gram-positive bacteria. IV delivery is important for treatment of septicaemia or endocarditis caused by MRSA. It is given orally for antibiotic associated pseudomembranous colitis (superinfection of the bowel by *Clostridioides difficile*). Rarely, vancomycin can cause renal failure or hearing loss.

Nitrofurantoin concentrates in the urinary tract and is used in UTIs. The blood levels remain low and it seems to trigger little resistance. It is used long-term to prevent UTIs.

# 10 Adverse issues with antibiotics

There are three areas of adverse issues of antibiotics; side effects, interactions and antibiotic resistance.

## 10.1 Antibiotic side effects

Side effects are classified as very common ( $\geq 1/10$ ); common ( $\geq 1/100$ ,  $< 1/10$ ); uncommon ( $\geq 1/1,000$  to  $< 1/100$ ); rare ( $\geq 1/10,000$ ,  $< 1/1,000$ ); very rare ( $< 1/10,000$ ). The most **common side effects of antibiotics**, affecting around one in 10 people, are gastrointestinal. There are generally mild and include: vomiting, nausea, diarrhoea, bloating, indigestion, abdominal pain and loss of appetite. These usually subside once the course of treatment is finished. It is therefore important to report all side effects to the prescriber. It is essential to talk to the prescriber about any **additional side effects**, as these can be more serious (see Table 18).

TABLE 18: POTENTIAL SIDE EFFECTS OF ANTIBIOTICS

Group and target	Examples	Mechanism of action	Side effects
Sulphonamides Folic acid inhibitor	Sulfasalazine, sulfadiazine	Bacteriostatic	Nausea, vomiting, headaches, hypersensitivity, bone marrow depression, hepatitis
Trimethoprim Folic acid inhibitor	Trimethoprim	Bacteriostatic	Nausea, vomiting, skin rashes, megaloblastic anaemia (folate deficiency)
Penicillins $\beta$ -lactam	Penicillin, benzylpenicillin, amoxicillin, flucloxacillin	Bactericidal	Hypersensitivity (1-10%), nausea, vomiting, encephalopathy (rare)
Cephalosporins $\beta$ -lactams	Cefuroxime, cephalexin, cefotaxime	Bactericidal	Hypersensitivity, nephrotoxicity, diarrhoea, skin rashes, headache
Monobactam $\beta$ -lactams	Aztreonam	Bactericidal	Skin rashes, occasional abnormal liver function
Carbapenems $\beta$ -lactams	Imipenem	Bactericidal	Hypersensitivity, nausea, vomiting, encephalopathy, neurotoxicity at high doses

<b>Aminoglycosides</b> <b>Protein synthesis inhibitor</b>	Gentamycin, streptomycin, neomycin	Bactericidal	Sensorineural deafness (can also affect the foetus in a pregnant woman), balance
<b>Glycopeptides</b> <b>Cell wall synthesis inhibitor</b>	Vancomycin, teicoplanin	Bactericidal	Nephrotoxicity, rashes, blood disorders, nausea
<b>Macrolides</b> <b>Protein translocation inhibitor</b>	Erythromycin, clarithromycin	Bactericidal/ bacteriostatic	Gastrointestinal effects, hypersensitivity, skin rashes
<b>Lincosamides</b> <b>Protein synthesis inhibitor</b>	Clindamycin	Bactericidal/ bacteriostatic	Nausea, vomiting, rashes, jaundice, neutropoenia, bone marrow suppression
<b>Fusidic acid</b> <b>Protein synthesis inhibitor</b>	Fusidic acid	Bactericidal/ bacteriostatic	Gastrointestinal effects, skin eruptions, jaundice
<b>Quinolones</b> <b>DNA transcription inhibitor</b>	Ciprofloxacin, levofloxacin, ofloxacin	Bactericidal	Gastrointestinal effects, skin rashes, dizziness, headaches. Not to be used with theophylline
<b>Metronidazole</b> <b>DNA synthesis inhibitor, breaks down DNA</b>	Metronidazole, tinidazole	Bactericidal	Nausea, vomiting, metallic taste, intolerance to alcohol, rashes
<b>Nitrofurantoin</b> <b>DNA disruptor</b>	Nitrofurantoin	Bactericidal	Peripheral neuropathy, gastrointestinal effects, lung fibrosis (long term use)
<b>Tetracyclines</b> <b>Protein synthesis inhibitor</b>	Doxycycline, minocycline, oxytetracycline	Bacteriostatic	Nausea, vomiting, diarrhoea, discolouration of teeth in children, intracranial hypertension, photosensitivity
<b>Chloramphenicol</b> <b>Protein synthesis inhibitor</b>	Chloramphenicol	Bacteriostatic	Highly toxic – bone marrow toxicity, neuritis, headache, rashes, grey baby syndrome

Around 1 in 15 people will have an allergic reaction to antibiotics, most commonly to penicillin and cephalosporins. Symptoms include skin rash and itches, as well as coughing, wheezing, and tightness of the throat, which can cause breathing difficulties. The antibiotic should then be stopped, and allergic reactions reported instantly. The reaction may need antihistamines as an urgent intervention.

In rare cases, an antibiotic can cause a severe and potentially life-threatening allergic reaction known as anaphylaxis. **Initial symptoms of anaphylaxis** are often the same as a mild allergic reaction. They include: feeling lightheaded or faint, breathing difficulties such as fast, shallow breathing or wheezing, fast heartbeat, clammy skin, confusion and anxiety, and collapsing or losing consciousness. There may be other allergy symptoms, including an itchy, raised rash (hives), feeling or being sick, swelling (angioedema), or stomach pain.

**Anaphylaxis** is a medical emergency and can be life-threatening. Inside a hospital, follow the hospital procedures; outside of a hospital, dial 112 immediately and ask for an ambulance if think someone is going into anaphylactic shock.

Tetracyclines can make **skin sensitive to sunlight** and artificial sources of light, such as sun lamps and sunbeds. Avoid prolonged exposure to bright light while taking these medicines.

In very rare cases, fluoroquinolone antibiotics can cause disabling, long-lasting or permanent **side effects affecting the joints, muscles and nervous system**. Stop taking fluoroquinolone treatment straight away and tell a doctor if the following occur: tendon, muscle or joint pain, usually in the knee, elbow or shoulder, tingling, numbness or pins and needles.

### 10.1.1 Reporting side effects

In the European Union, reporting side effects of medication is important, and is very straightforward. The EMA is committed to maintaining a strong working relationship with this group and specialist nurses play a key role. There are national routes for reporting side effects, for example the Netherlands Pharmacovigilance Centre (Lareb).

The Pharmacovigilance Risk Assessment Committee (PRAC) is responsible for assessing all aspects of risk management of human medicines, including detection, assessment, minimisation and communication of the risk of adverse reactions, while taking the therapeutic effect of the medicine into account; design and evaluation of post-authorisation safety studies; and pharmacovigilance audit.

## 10.2 Interactions between antibiotics and other medicines

Antibiotics may interact with unrelated nonantibiotic drugs, and the result may be the enhanced or decreased activity of the antibiotic or other drug.

1. delay emergence of resistant organisms
2. treat mixed or undiagnosed infections; or
3. enhance the rate of bactericidal action.

Whether a combination of antibiotics will be synergic, additive, indifferent, or antagonistic frequently is not predictable. In vitro tests are required to determine synergic combinations. Interactions and the mechanisms of these interactions involving antimicrobial agents in humans are reviewed in this communication.



## 10.3 Antibiotic resistance

Some bacteria are naturally insensitive to certain antibiotics, known as intrinsic resistance. Acquired resistance is as a result of selection following mutation and acquisition of genetic material from other bacteria. Bacteria divide very rapidly. With each division there is potential for the introduction of a spontaneous mutation. Many mutations are harmful, and the bacteria do not survive. However, some mutations improve the chance of survival.

Bacteria can, by chance, have mutations that make them antibiotic-resistant. When there is no antibiotic present, this does not improve their chance of survival, and they may die out. If there is an antibiotic present, the mutation **does** increase the chance of survival. While the antibiotic will kill the antibiotic-sensitive bacteria, the antibiotic-resistant bacteria will survive – this is known as selection. The more often an antibiotic is used, the more chance there is that resistant bacteria will be seen.

There are different kinds of AMR. Some bacteria produce enzymes, including beta-lactamases, that break down antibiotics. Others change the makeup of the cell wall, meaning that the antibiotic no longer works.

### 10.3.1 The spread of resistance

People can spread resistant bacteria to each other through person to person transmission, by touching (directly), or by handling an object that someone else has touched (indirectly). This includes people who are ill, or who are otherwise healthy but are carriers of a resistant strain of bacteria. People can be colonised by resistant bacteria and not get ill, but they can still pass on the resistant strain. The resistant bacteria become a serious problem when the infection becomes invasive, and an infection develops. This infection is not treatable by the antibiotic to which it has developed a resistance. As a result of the combination of selection pressure and transfer of bacteria between people, resistance can spread through an entire population.

Resistance can also spread from bacteria to bacteria, when sensitive bacteria acquire the resistance mechanisms of resistant bacteria by exchanging small, ring-shaped DNA molecules known as plasmids. When antibiotics are present in the environment, these resistant bacteria will spread further at the expense of the sensitive bacteria. This mechanism is starting to play an increasingly important role in the spread of resistance. This form of resistance can spread rapidly on a large scale; all the more reason to limit the emergence of resistant organisms so that infections will remain treatable with relatively cheap, effective and safe means.

### 10.3.2 Multidrug-resistant organisms

Sir Alexander Fleming said, «It is not difficult to make microbes resistant to penicillin» and Dr Margaret Chan former Director-General of the World Health Organisation once said «A post-antibiotic era means, in effect, an end to modern medicine as we know it. Things as common as strep throat or a child's scratched knee could once again kill» [4].

The development of multi-drug resistant organisms (MDROs) pose a threat to healthcare. For example, there have been reports of pan-resistant (totally resistant) carbapenem-resistant Enterobacterales initially originating from countries such as India [5]. Unless nurses and other healthcare professionals are vigilant and judicious in the use of antibiotics to treat life-threatening infections, the warning of a post-antibiotic era where even simple infections cannot be treated, and where operations such as joint replacements can no longer be carried out, could become a reality.

Organisms do not respect boundaries between community, primary and secondary care. Patients are discharged from hospital to community with MDROs and then from the community back to hospital.

### 10.3.3 Extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae

Extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae have become important in terms of resistance in Gram-negative bacteria worldwide. ESBL-Enterobacteriaceae bacteraemias carry an increased risk both for mortality and delay in effective treatment. ESBL producers are resistant to all beta-lactam antibiotics except carbapenems and usually resistant to other important antimicrobials such as fluoroquinolones, aminoglycosides and co-trimoxazole [6]. The ESBLs break down penicillins and cephalosporins making them ineffective. ESBL-producers are resistant to all beta-lactam antibiotics. Examples include *Escherichia coli* and *Klebsiella* species.

### 10.3.4 Carbapenem-resistant Gram-negative bacteria

Carbapenems are effective against gram-negative bacteria, but resistant organisms produce carbapenemases that make carbapenems ineffective [7].

Carbapenem-resistant Enterobacteriaceae (CRE), *Acinetobacter baumannii* (CRAB), and *Pseudomonas aeruginosa* (CRPA) are becoming a major challenge for treatment. To make matters worse, countries in the EU are reporting pan-resistant strains, which cannot be treated by any antibiotics [8-12]. Patients who become positive for CRE remain persistent carriers for up to 1 year [13,14]. These factors create a major challenge for controlling the spread and treating the patient with a clinical infection.

### 10.3.5 Resistant strains of *Staphylococcus aureus*

The first cases of Methicillin-resistant *Staphylococcus aureus* (MRSA) were reported in the late 1960s. The rates of MRSA continued to increase worldwide causing major outbreaks. The incidence of mortality and morbidity increased significantly in the early 2000s both in the US and the UK [15]. According to data from the ECDC, the levels of MRSA are falling [16].

MRSA is transmitted through direct contact with patients who are either colonised or infected, or through equipment and their environment. MRSA is found in the skin, axilla and perineum [17], with the main reservoir in the nose. It is a major problem in hospitals, long-term care facilities and nursing homes, mainly spread through direct skin contact. In addition, MRSA also occurs in various animal species and can be therefore transmitted from animal to human. Patients admitted from hospitals in other countries, or who are routinely in contact with animals, should be checked for MRSA carrier status. Carriers however are less likely to pass on MRSA than people with an active infection.

Management of MRSA infection requires good hand hygiene and good wound care. MRSA cannot be treated with methicillin and other beta-lactam antibiotics. In empiric therapy for staphylococci if possibility of MRSA is low, a penicillinase-resistant penicillin such as flucloxacillin should be used as first treatment choice (or cephalosporins of first/second generation). But MRSA cases should be treated with linezolid, vancomycin or daptomycin according to the site of infection and the antimicrobial susceptibility.

For infections where toxins play an important role, such as toxic shock syndrome (TSS), clindamycin should be added to block toxin production at an early stage.

Nasal *S. aureus* can be eliminated by short treatments with antimicrobial nasal ointment (Mupirocin 2% 3 times for 5 days). This can be used preoperatively, and to prevent infections in dialysis patients.

Prophylaxis before surgery, such as mupirocin or fusidic acid in combination with a disinfectant soap (chlorhexidine), may be useful for patients with skin infections, such as furunculosis. However, relapses occur relatively often following treatment.

Vancomycin-resistant *Staphylococcus aureus* (VRSA) is resistant to the antibiotic of last resort, vancomycin, which is used against MRSA, methicillin-resistant *Staphylococcus epidermidis* (MRSE) and methicillin-resistant *Clostridioides difficile*. All cases of MRSA or VRSA need to be reported to the relevant national public health or AMR institute, which will follow up with European institutes.

### 10.3.6 The fight against resistance

The antimicrobial resistance (AMR) crisis facing hospitals globally is driven by the ESKAPE pathogens (Gram-negatives *Klebsiella pneumoniae*, *Enterobacter cloacae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, and Gram-positives *Enterococcus faecium*, and *Staphylococcus aureus*). These are responsible for the majority of infections in hospital patients that are difficult to manage with antimicrobial therapy.

Resistant forms of these bacteria:

1. Cause frequent and serious illness
2. Have a form of acquired resistance that makes it impossible to treat the patient with the usual antibiotics.
3. Are able to spread if no additional measures are taken, such as isolating a patient.

The ESKAPE pathogens do not include bacteria such as *Staphylococcus epidermidis*. Even though there is extensive resistance, *S. epidermidis* is present on everyone's skin and mucous membranes, and almost never leads to disease in healthy people. Infections only occur in specific circumstances, such as patients who have a catheter or implant that allows the bacteria to enter the body. Preventing the spread of this bacterium is difficult and would not be a cost-effective approach. That is why in this case we opt for preventive measures aimed at preventing contamination during, for example, the insertion of catheters.

## 11 Antibiotics in veterinary use and effect on humans

For almost seven decades, antibiotics have been routinely fed to food animals such as pigs; almost as long as people have taken antibiotics. And for just about as long, it has been clear that those antibiotics have been fostering drug-resistant bacteria that can be transmitted from animals to make humans sick.

### 11.1 Veterinary antibiotics

Giving antibiotics to animals as growth promoters has had a great impact in the environment. Antibiotic-resistant bacteria are in the water, in animals and in food, leading to a global spread of bacteria that are not sensitive to antibiotics. This can only be addressed with the co-operation of governments worldwide. This has led to the World Health Organisation's introduction of the One Health approach.

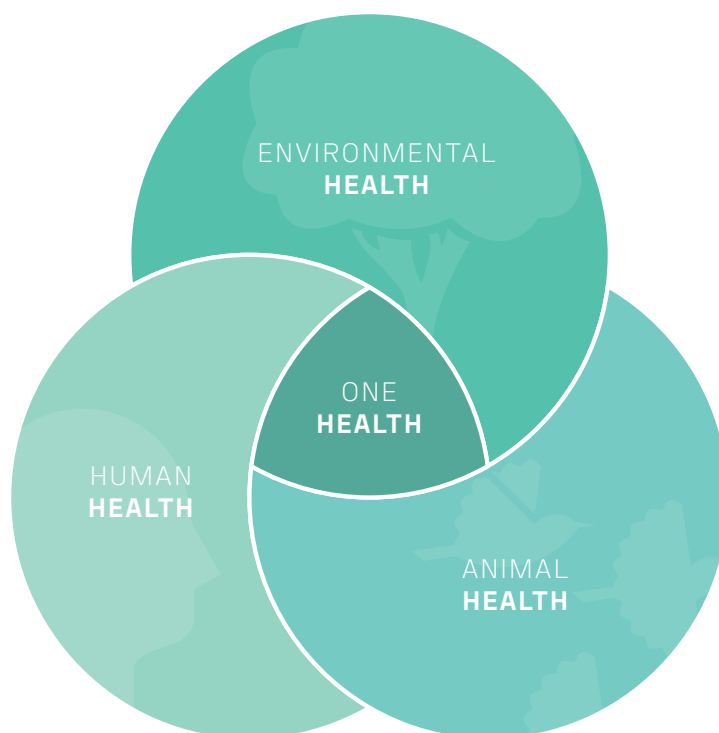
## HUMAN HEALTH THREATS RELATED TO VETERINARY USE OF ANTIBIOTICS.

The first outbreaks of drug-resistant foodborne illness were spotted as early as the mid-1950s, when an epidemic of resistant Salmonella swept through south-eastern England. That was the first of waves of outbreaks that occurred over decades, some small and some very large and widespread. One of the largest foodborne outbreaks in US history, which made 634 people in 29 states and Puerto Rico sick in 2013-14, was tracked back to chickens that had been given antibiotics in their feed. Europe has now banned the use of antibiotics as growth promoters.

## 11.2 One Health

Whereas in the past, health was addressed in silos, with the environment, humans and animals each in their own domain, the One-Health concept brings a wider approach (Figure 27).

FIGURE 27: ONE HEALTH



### 11.2.1 What is 'One Health'?

'One Health' is an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. The One Health approach includes food safety, the control of zoonoses (diseases that can spread between animals and humans, such as flu, rabies and Rift Valley Fever), and combatting antibiotic resistance (when bacteria change after being exposed to antibiotics and become more difficult to treat).

# 12 Other antimicrobials and how they work

## 12.1 Antivirals

Viral diseases are treated using antivirals, which reduce the ability of viruses to multiply. These work by:

- Blocking the virus from entering the cell
- Stopping the virus from releasing its contents into the cell
- Preventing the cell from building new viruses
- Inhibiting the release of the new viruses.

Viruses are constantly mutating and changing, and this can make them resistant to antiviral medication. As with antibiotics, if antiviral medications do not completely clear the viral infection, a resistant form of the virus can take over [18].

Vaccines are used to prevent infections, by triggering immunity against a specific virus (see 18: Vaccines and how they work).

## 12.2 Antifungals

Antifungal medicines are used to treat fungal infections, which most commonly affect skin, hair and nails, but can also affect the lung or brain. Antifungal medicines are often available 'over the counter' pharmacist. Antifungal medicines kill fungal cells by affecting a substance in the cell walls, causing the contents of the fungal cells to leak out and the cells to die, or by preventing fungal cells growing and reproducing. Antifungal medicines are available as:

- topical antifungals – a cream, gel, ointment or sprayed directly to skin, scalp or nails
- oral antifungals – a capsule, tablet or liquid medicine that is swallowed
- intravenous antifungals – an injection into an arm, usually given in hospital
- intravaginal antifungal pessaries – small, soft tablets inserted into the vagina

Infections commonly treated with antifungals include ringworm, athlete's foot, fungal nail infections, vaginal thrush and some kinds of severe dandruff.

Less commonly, there are also more serious fungal infections that develop deep inside the body tissues, such as aspergillosis, which affects the lungs, and fungal meningitis, which affects the brain. These may need to be treated in hospital. People who have a weakened immune system, through illness or because they are taking drugs to suppress their immune systems, are more at risk of getting one of these more serious fungal infections. Often treatment must start before results are known because fungal infections are very dangerous, and time is crucial. In cases of resistance, another antifungal agent can be added, or treatment can be combined with an agent that makes the immune system stronger (immunotherapy).

One of the last resorts is surgery, where the infection is removed. Antifungals may be prescribed as a precaution for example, in people with acute leukaemia who receive chemotherapy, or in persons living with HIV who have a weakened immune.

Resistance to antifungals occurs naturally, but is also driven by inappropriate use of antifungals, and by use of antifungals in agriculture. Antibiotics may also add to antifungal resistance. There are increasing numbers of *Candida* infections resistant to fluconazole, and resistance to echinocandins is emerging. Patients infected with *Candida* resistant to both fluconazole and an echinocandin have few treatment options [19].

## 12.3 Anti-parasitics

Symptoms of parasitic infections vary widely. Antiparasitic medications target the parasites and destroy them or inhibit their growth. They are given orally, intravenously or topically.

# 13 Prescribing responsibility of the nurse specialist and physician

The role of nurses in prescribing varies across Europe. In some European countries, nurses have a very marginal role related to medication, for example they may not even be allowed to vaccinate in clinical practice. In other countries, they are able to prescribe, often after an academic education program and certification, for example nurse practitioners, nurse specialists or clinical nurse specialists.

## 13.1 Authorization to prescribe

As in any other area of practice, nurses need to act within their competence and scope of practice where prescribing is concerned. Not all nurses are able to prescribe.

- **Formal prescribing:**  
within national legislative structure and the boundaries of the nurse's competence. Prescribing may be general or from a range of medications within a particular specialisation. Prescribing can be an independent competence, or under supervision or consultation with another professional such as a general practitioner or family doctor, or a hospital specialist.
- **Informal prescribing:**  
nurses with specialist knowledge and experience may provide prescribing advice for other colleagues, medical specialists or physicians in training. This provides support for prescribers and helps to improve patient safety.

## 13.2 Other responsibilities for nurses

Nurses spend a lot of time with patients and have a responsibility in observing patients for medication responses and side effects, especially with antibiotics.

They are responsible for:

- The correct and timely administration of antibiotics
- Observing patients' condition and reporting changes to the physician
- Taking patients' specimens for investigation and informing physicians about the results
- Understand the significance of infection control measures in hospitals
- Understand the value of vaccination.

Nurses also have a responsibility to educate patients:

- What antibiotics are and why they are taking them
- What side effects can be expected
- What antimicrobial resistance is, and how it can affect them

Nurses are in the best place to be supporters and advisors to patients, and they play a really important and significant role in influencing society and improving antibiotic use. Nurses can also play a role as advisors to medication committees, pharmaceutical companies and EMA.

## 14 Medicine and market

### 14.1 Shortage

Medication shortages can affect patients, nurses, pharmacists, and physicians. The main three causes are: shortage of ingredients; problems in manufacturing; and market dynamics.

The causes behind these include:

1. Companies stopping manufacturing because use of a particular drug is declining
  - > Medications are developed for certain treatment and often prescribed based on guidelines, but when the insights on a disease changes or a guideline, then the manufacturer may stop production.
2. Competition forcing the price of a drug down, meaning manufacturers drop out
  - > This occurs when a product has become so cheap that companies decide to stop producing. When there is a change in the market, it often takes a longer time to start up processing.
3. Shortage of raw materials to make medication.
4. Companies not being able to keep up with demand
5. Pharmacists choosing not to stock cheaper drugs because profit margin is too narrow.



## 6. Manufacturing issues

- > Over the past years, some manufactures have been able to build a monopoly position and in some cases a factory had a major incident leading to stop all activities

## 7. Political sanctions

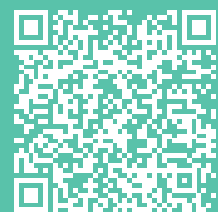
- > This is most common in politically sensitive regions where there is a ban on delivering products, trade bans or unresolved trade relations and this can lead to shortage.

## 8. Theft and corruption

In most European countries, patients, nurses and other healthcare professionals can report medication shortages to their national authorities **(QR code 6)**

Medication shortages can be very worrying for patients, and can put their health at risk. Nurses and pharmacists are often on the frontline when shortages occur. Their responsibility is to communicate with the patients and help them to remain on course with their treatments.

At times of shortage, patients may try to buy medications online. However, much of this is falsified. Falsified medicines do not meet the efficacy, safety and quality standards required under EU law. Falsified medicines appear to be genuine, but may be contaminated, may contain incorrect ingredients, or may contain the correct ingredients at an incorrect dose. It is of vital importance that nurses are aware of this.



**S C A N M E**  
[QR code 6]

## MORE INFORMATION ON MEDICATION SHORTAGE

Position statement on Medication Shortage European Association of Hospital Pharmacists (EAHP)  
European Medicine Agency (EMA) 'Availability on Medicines'

An example on falsified medication was on a medication related to rheumatism. The products not available any more in regular market, it was for sale on the internet. The source was a Mediterranean country, but the product was made in Asia. The fact it was a counterfeit medication was discovered month later after serious relapse of patients with very problematic consequences.

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MODULE 3

# Vaccination

**After reading Module 3,** you will understand the important role of vaccines in viral infections. You will know more about the different types of vaccines, their role in infection prevention, and their storage and handling. One of the arguments often used in vaccine hesitancy is the safety and effectiveness of vaccines. This module will help you to respond, as it covers the monitoring mechanisms for vaccine, safety, and also discusses ways to improve people's confidence in vaccines. It closes with your role in education, advice and administration, including the importance of leading by example.

WILLIAM  
FOEGE

”

**Vaccines are  
the tugboats of  
preventive health**

# 16 Principles of vaccination

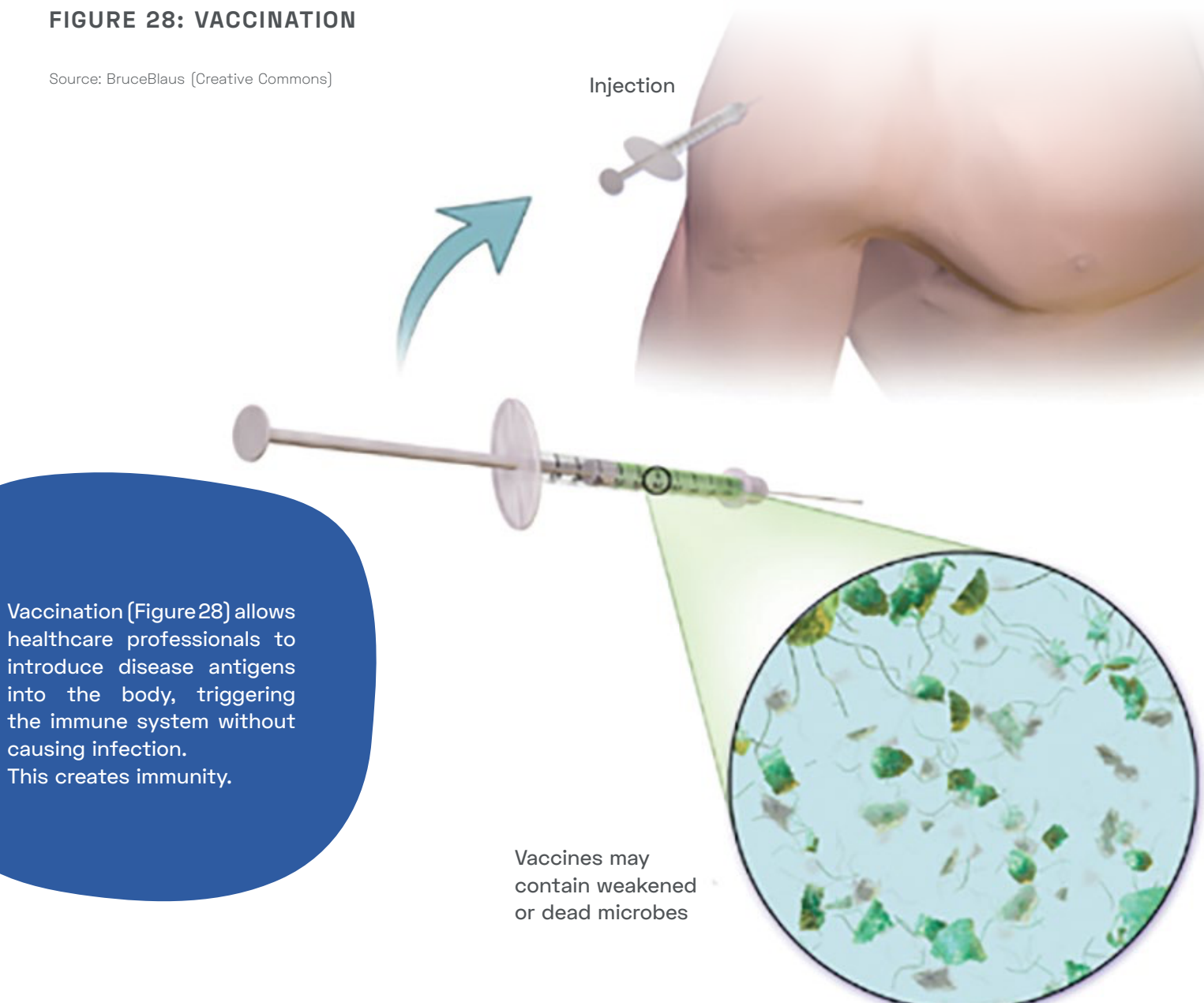
## 16.1 Principle of immunity and vaccination

The human immune system protects against diseases by recognizing germs entering and identifying them as foreign invaders through the antigens – short for ‘antibody generator’ – on their surface. When antigens invade the human body, the immune system responds by producing proteins called antibodies (humoral immunity) and highly specific cells (cellular immunity). The humoral and cellular immune systems are closely connected, and these two arms of the immune system both fight the invading germs, which may be bacteria, viruses, parasites or fungi.

Immunity is the body’s successful defence against a pathogen. When the body has produced enough antibodies or specific cells to fight the disease, immunity results. This provides protection against the disease for many months, years or even for a lifetime. When a person comes into contact with that same pathogen, the immune system quickly produces the same type of antibodies, preventing re-infection. This is also called ‘immunological memory’, and this system can recognize and combat thousands or even millions of different organisms.

### FIGURE 28: VACCINATION

Source: BruceBlaus (Creative Commons)



Vaccines may contain weakened or dead microbes

## MY PATIENT ASKED: IS NATURAL IMMUNITY BETTER THAN VACCINE IMMUNITY?

It is true that natural infection almost always causes better immunity than vaccines. Whereas immunity from disease often follows a single natural infection, immunity from vaccines usually occurs only after several doses. However, the difference between vaccination and natural infection is the price paid for immunity.

As examples, among others, the price paid for immunity after natural infection might be pneumonia from chickenpox, intellectual disability from *Haemophilus influenzae* type b (Hib), pneumonia from pneumococcus, birth defects from rubella, liver cancer from hepatitis B virus, or death or immune system amnesia from measles.

# 17 The role of vaccination

There is a lot of evidence confirming that immunization is the most important public health intervention to reduce child morbidity and mortality and provide lifelong protection against disease. Each nation in Europe has its own goals, established by governments, which protect both individuals and those who cannot be or have not yet been immunized. The challenge is to translate European and national goals into local implementation.

Vaccination is a concern for all European nations, and the EU has put in place a European Vaccine Action Plan 2015–2020 (EVAP). This was drafted to complement, regionally interpret and adapt the Global Vaccine Action Plan in harmony with key regional health strategies and policies.

EVAP sets a course through a regional vision and goals for immunization and control of vaccine-preventable diseases from 2015 to 2020 and beyond, by defining objectives, priority action areas and indicators, considering the specific needs and challenges of WHO European Region Member States.

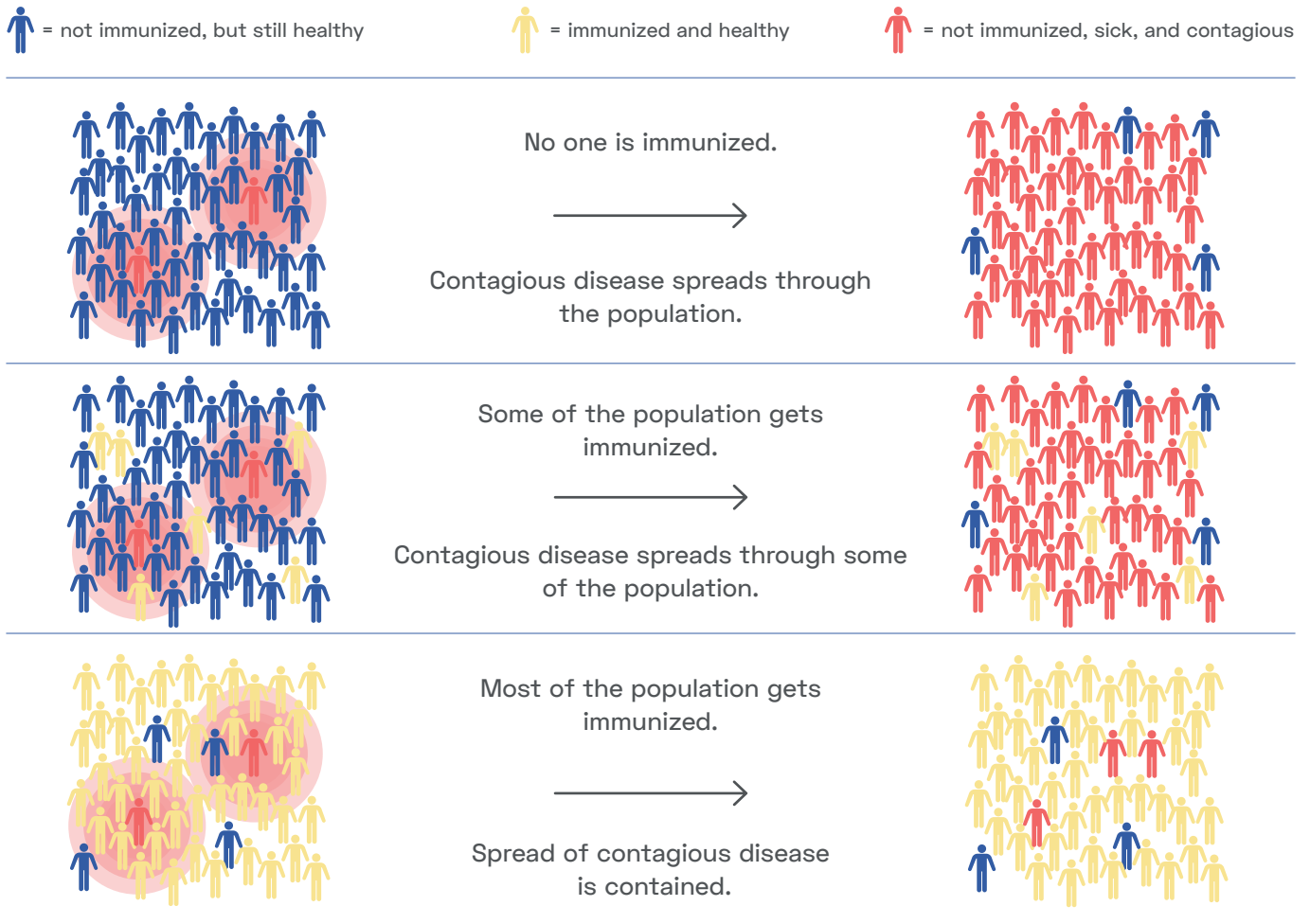
## 17.1 Community immunity effect (herd immunity)

The principle of community or herd immunity is that if the majority of a population is immune to an infectious disease, spread of the infection from person to person within the community is much less likely, and those that are not immune are protected from infection.

Reaching a high coverage of vaccination leads to herd immunity, protecting those individuals who cannot be or who are yet to be vaccinated, such as newborn babies, and children or adults with chronic illnesses or immune systems that are not working properly. This is known as herd immunity (Figure 29).



**FIGURE 29: HERD IMMUNITY**



Source: Tkarcher (Creative Commons)

The proportion of vaccinated individuals needed to provide herd immunity is high and specific for each disease. For example, 95% of the population need to receive two doses of measles vaccines to avoid outbreaks. Herd immunity is crucial for the success of vaccination programmes, and vaccine hesitancy, which decreases vaccination coverage, compromises the herd immunity effect, leading to the resurgence of certain infectious diseases.

The lack of coverage of vaccines may be because of vaccine hesitancy, for example in certain religious groups, or in people who do not trust medicine or the pharmaceutical industry. Lack of access to healthcare, specifically preventive healthcare, also causes gaps in vaccine coverage.

If enough people in a population are immune to a viral infection, transmission of the infectious disease in that population will stop. This is known as elimination of the infection, and is achieved on a regional basis through a vaccination program. The next step is global eradication, which has only been achieved for smallpox and rinderpest. To get to eradication, elimination in all world regions must be achieved.

**Key message: Herd immunity**

Herd immunity describes how a population is protected from a disease after vaccination by stopping the germ responsible for the infection being transmitted between people. In this way even people who cannot be vaccinated can be protected.

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# 18 Vaccines and how they work

There is a lot of evidence confirming that immunization is the most important public health intervention to reduce child morbidity and mortality and provide lifelong protection against disease. Each nation in Europe has its own goals, established by governments, which protect both individuals and those who cannot be or have not yet been immunized. The challenge is to translate European and national goals into local implementation.

Vaccination is a concern for all European nations, and the EU has put in place a European Vaccine Action Plan 2015–2020 (EVAP). This was drafted to complement, regionally interpret and adapt the Global Vaccine Action Plan in harmony with key regional health strategies and policies.

## 18.1 Key vaccine-preventable diseases

TABLE 19: TEN KEY VACCINE-PREVENTABLE DISEASES

Common name	Cause	Symptoms	How it spreads	Impact
<b>Measles</b>	Viral infection – measles morbillivirus	Fever, cough, runny nose and rash	Airborne through coughs and sneezes, can last for up to two hours on surfaces; 90% of people without immunity to the virus will catch it if exposed	Pneumonia, brain swelling, and death  Subacute sclerosing panencephalitis (SSPE) is a rare complication, developing years after an infection  Before the vaccine, there were around 2.6 million deaths worldwide each year
<b>Whooping cough, 100-day cough (pertussis)</b>	Bacterial infection – Bordetella pertussis	Cough	Airborne through coughs and sneezes	Pneumonia, seizures, and slowed or stopped breathing; particularly dangerous in babies
<b>Influenza (flu)</b>	Viral infection – type A, B or C influenza virus  Virus mutates constantly	Cough, sore throat, fever, muscle pain, headache	Airborne through coughs and sneezes; droplets spread up to 2 metres.	Pneumonia, bronchitis  15,000–70,000 people die in Europe every year as a result of influenza
<b>Poliomyelitis (polio)</b>	Viral infection – poliovirus	No symptoms or flu-like symptoms initially	Infection is passed on by coming into contact with a sick person's faeces	Brain infection, paralysis, and death  Vaccination has reduced cases, but the disease has not yet been eradicated

## Non-invasive pneumococcal disease

Bacterial infection – Streptococcus pneumonia

Depend on site of infection but include: cough, pain, swelling and tenderness

Spreads through contact with an infected person's mucus or saliva

Ear infection, bronchitis, sinusitis

## Invasive pneumococcal disease

Depend on site of infection but include: Fever, chills, headache, cough, problems breathing

Pneumonia, sepsis (blood infection), meningitis. Pneumonia caused by pneumococcal disease is especially serious in people older than 65. Meningitis and blood infections can be life-changing or life-threatening.

10% of invasive streptococcal infections are fatal

## Tetanus (lockjaw)

Bacterial infection – Clostridioides tetani

Breathing problems, muscle spasms

Bacteria is found in soil, dust, and manure, and can enter the body through a cut or open sore

Paralysis and death  
Up to 10% to 20% of tetanus cases are fatal. Deaths are more common in people who are older than 60 or who have diabetes

## Meningococcal disease

Bacterial infection – Neisseria meningitidis

Fever that starts suddenly, headache, and stiff neck

The bacteria live in the nose and throat, and can spread through saliva, or through close, prolonged contact

Meningitis (swelling of the brain and spinal cord), and blood infections

In 2016, there were 3,280 confirmed cases and 304 deaths in Europe; fatality is 8-15%

## Hepatitis B

Viral infection – hepatitis B virus

Initially, few or no symptoms

The hepatitis B virus is in blood and other body fluids, and is spread through sex or sharing needles. A pregnant woman can pass it to her baby

Liver cancer, chronic liver disease

## Mumps

Viral infection – mumps rubulavirus

Fever, headache, pain, swelling of parotid (salivary) glands

Airborne through coughs and sneezes

Male sterility, encephalitis (brain inflammation), ovarian inflammation, meningitis, pancreatitis, hearing loss

## Haemophilus influenzae type B (Hib)

Bacterial infection – Haemophilus influenzae type B

Depend on site of infection

Airborne infection; some people have Hib bacteria in their nose or throat but are not ill

Pneumonia, sepsis, meningitis, epiglottitis, septic arthritis, cellulitis, otitis media, and purulent pericarditis (heart valve infection)

Around 5% of people with Hib meningitis will die, and 15-20% will have deafness, behavioural and learning difficulties, and speech and language problems



## 18.2 How vaccines work

When external invaders such as bacteria or viruses enter the body, immune cells called lymphocytes respond by producing protein molecules called antibodies. These recognise antigens on the microorganism's surface and protect against infection. A healthy individual can produce millions of antibodies a day, fighting infection so efficiently that people never even know they were exposed to an antigen. Unfortunately, the first time the body faces a particular invader, it can take several days to ramp up this antibody response. For really nasty antigens like the measles virus or whooping cough bacteria, a few days is too long. The infection can spread and kill the person before the immune system can fight back. That's where vaccines come in. They can't cause an infection, but the immune system still sees them as an enemy and produces antibodies in response.

### Memory:

After the threat has passed, many of the antibodies will break down, but immune cells called memory cells remain in the body. When the body encounters that antigen again, the memory cells produce antibodies fast and strike down the invader before it's too late. This is why people get infections such as rubella or whooping cough only once. Vaccinations also create memory cells. Measles infections can cause 'immune amnesia', wiping the immune system of its memory of infections.

### Vaccine boosters:

Some vaccines need an initial (prime) dose followed by a booster dose, to increase the immune response to protective levels. If for certain vaccines there are no follow ups, there is no effect at all. The first shots are an introduction to the body where as the final vaccination is the main medication. When only half is taken, then the first dose alone may not have the full impact.

### The community effect:

Vaccines also work on a community level. Some people are very vulnerable to infection, including babies too young to be vaccinated, elderly people, and people with damaged immune systems. If everyone around them is vaccinated, unvaccinated people are protected by something called **herd immunity**. In other words, they're unlikely to even come in contact with the disease, so they probably won't get sick. When it comes to vaccines, sometimes it can pay to follow the crowd.

#### Measles is more than just a childhood disease

Measles causes long-term damage to the immune system, leaving children who have had it vulnerable to other infections long after the initial illness has passed, research has revealed. "We've found really strong evidence that the measles virus is actually destroying the immune system," said Prof Stephen Elledge, a geneticist at Harvard Medical School and co-author of one of the papers. "The threat measles poses to people is much greater than we previously imagined" [1-3]

## 18.3 Most used vaccines

TABLE 20: EXAMPLES OF VIRAL AND BACTERIAL VACCINES

	Live attenuated	Killed inactivated	Subunit
<b>Viral</b>	Vaccinia Polio (OPV) Yellow fever Measles Mumps Rubella Influenza Rotavirus	Polio (IPV) Rabies Influenza Hepatitis A	Hepatitis B (HepB-surface antigen) Human papilloma virus (HPV)
<b>Bacterial</b>	BCG (tuberculosis) Salmonella typhi (oral)	Bordetella pertussis (whole cell) Cholera Bacillus anthracis	Tetanus (toxoid) Diphtheria (toxoid) Neisseria meningitidis (polysaccharide) Bordetella pertussis (acellular) Streptococcus pneumoniae, 23 valent (polysaccharide) Haemophilus influenzae, type b (Hib) (polysaccharide) Neisseria meningitidis (polysaccharide conjugate) Streptococcus pneumoniae, heptavalent (conjugate polysaccharides) Salmonella typhi Vi (capsular polysaccharide)

Source: Nascimento [4]

TABLE 21: COMMON CHILDHOOD VACCINES

Vaccine	Diseases targeted
HepB	Hepatitis B infection (liver disease)
RV	Rotavirus (major cause of diarrhoea)
DTaP	Diphtheria, tetanus, and pertussis (whooping cough)
Hib	Haemophilus influenzae type b (bacterial meningitis)
PCV	Pneumococcal disease, including pneumonia
IPV	Polio
Flu	Influenza
MMR	Measles, mumps, and rubella (German measles)
Varicella	Varicella (chickenpox)
HepA	Hepatitis A infection (liver disease)

Source: ECDC vaccine scheduler (QR code 8)

TABLE 22: COMMON VACCINES IN ADOLESCENCE AND ADULTHOOD

Vaccine	Diseases targeted
Flu	Influenza
TDaP	Diphtheria, tetanus, and pertussis (whooping cough)
HZV	Herpes zoster (shingles)
PCV	Pneumococcal disease, including pneumonia
HPV	Herpes papillomavirus (cervical and other cancers, genital warts)

Source: ECDC vaccine scheduler (QR code 8)

Other vaccines offered to adolescents and adults include meningococcal disease, hepatitis A, hepatitis B, chickenpox, measles, mumps, and rubella.

Different vaccines schedules operate in different countries across Europe – see the ECDC vaccine scheduler (QR code 8) or refer to your local schedules for further information.

## 19 Types of vaccines

Vaccine designs depend on the disease-causing agent, how it infects the cell and how the immune system responds. Vaccines can be divided into two basic groups; live attenuated and inactivated.

### 19.1 Live attenuated vaccines

Live attenuated vaccines are produced by weakening a disease-producing ('wild-type') virus or bacterium in the laboratory. The modified strains are able to multiply within the body and trigger a strong immune response. Live attenuated vaccines are generally given in one or two doses.

A live weakened vaccine very rarely causes disease in people with healthy immune systems; however, if it does, it is likely to be a much milder form. Sometimes the side effects of vaccines can also appear like the symptoms of the infection they are preventing.

However, live attenuated vaccines should be not generally be used in people with weakened immune systems, for example with diseases such as leukaemia or HIV/AIDS, who have had an organ transplant, or who are having cancer chemotherapy or other treatments that affect the immune system. In this group of people, live attenuated vaccines can lead to infection as a result of uncontrolled replication of the virus or bacterium.

Active immunity from a live weakened vaccine may not develop because of interference from circulating antibodies to the vaccine virus. This includes antibodies from blood transfusions, or antibodies that have crossed the placenta from mother to child. This leads to poor or no response to the vaccine, and is known as 'vaccine failure'.



SCAN ME  
(QR code 8)

Examples include:

- varicella-zoster (chickenpox)
- oral poliovirus (OPV)
- yellow fever virus
- measles, mumps, and rubella (MMR)

## 19.2 Inactivated vaccines

Inactivated vaccines are produced by growing bacteria or viruses in culture media, then inactivating them with heat and/ or chemicals, usually formalin. Inactivated vaccines are either whole or fractional. Inactivated vaccines cannot cause disease from infection, even in immunodeficient people. Inactivated antigens are less affected by circulating antibody than live vaccines.

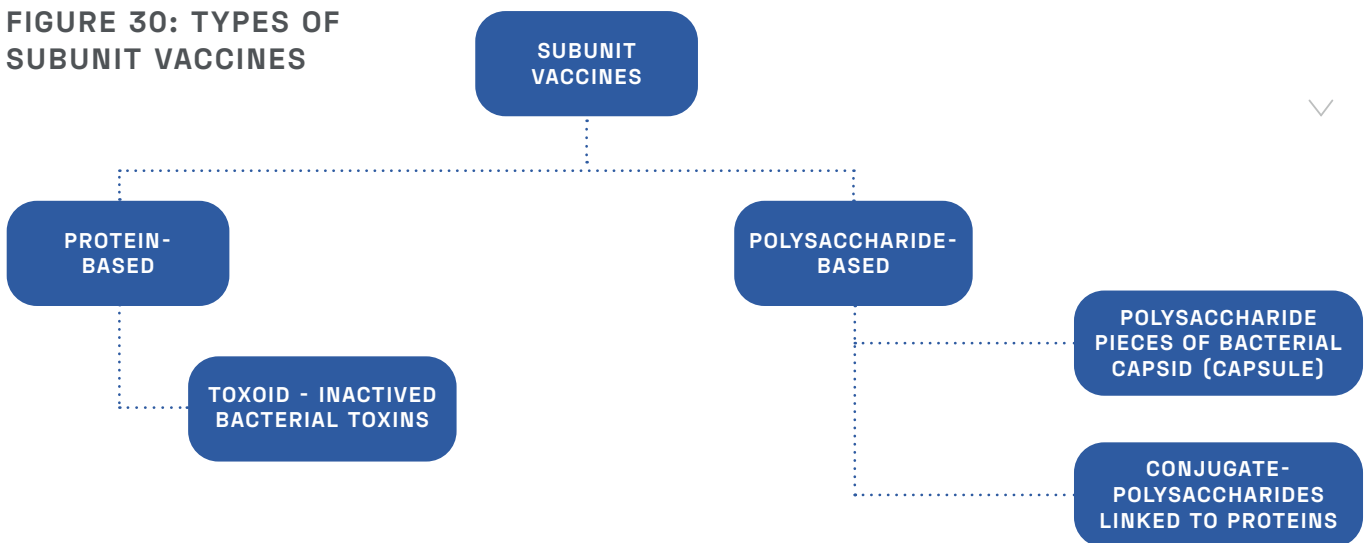
Most inactivated vaccines trigger a weaker immune system response than live vaccines, and always require multiple doses. In general, the first dose does not produce protective immunity, but ‘primes’ the immune system. A ‘real’ protective immune response develops after the second or third dose.

In contrast to live vaccines, in which the immune response closely resembles natural infection, the immune response to an inactivated vaccine is mostly humoral. Little or no cellular immunity results. Antibody titres against inactivated antigens diminish with time. As a result, some inactivated vaccines may require booster doses to increase antibody titres. The proteins in conjugate vaccines boost the immune response.

## 19.3 Subunit vaccines

Subunit vaccines do not attack the entire microbe but address only important parts of it: those antigens that best stimulate the immune system. In some cases, these vaccines use epitopes—the very specific parts of the antigen that antibodies or T cells recognize and bind. Because subunit vaccines contain only the essential antigens make the chances of adverse reactions much lower. Figure 30 shows a number of types of sub-unit vaccines

**FIGURE 30: TYPES OF SUBUNIT VACCINES**



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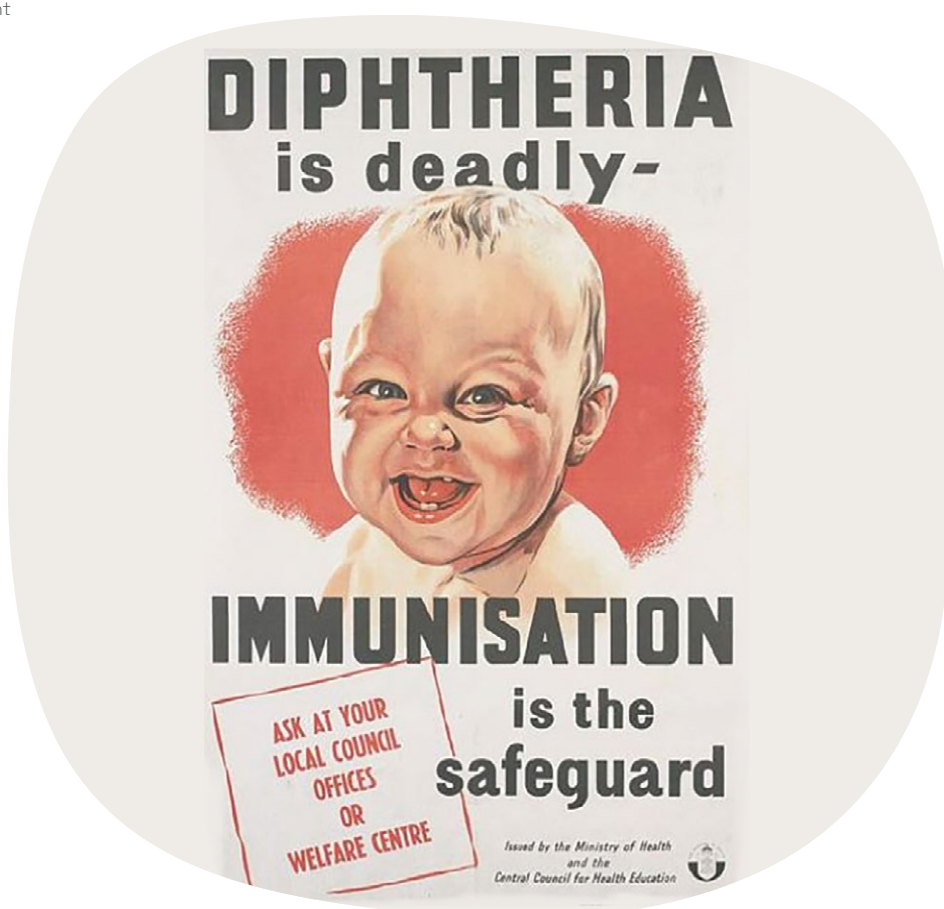


## 19.4 Toxoid vaccines

Toxoid vaccines teach the immune system to fight off the natural toxin. These vaccines are used when a bacterial toxin is identified as cause of illness. The toxins are inactivated using formalin, a solution of formaldehyde and sterilized water. These detoxified toxins, or toxoids, can then be safely used in vaccines. When the immune system receives a vaccine containing a harmless toxoid, it learns how to fight off the natural toxin. Examples of toxoid vaccines include diphtheria and tetanus in diphtheria, tetanus and pertussis (DTaP) (Figure 31).

**FIGURE 31: 1940S DIPHTHERIA POSTER**

Source: UK Government  
(public domain)



## 19.5 Polysaccharide and conjugate vaccines

Polysaccharide and conjugate vaccines have been developed to target bacteria with capsids (capsules) made up of long chains of sugar, known as polysaccharides. Pure polysaccharide vaccines are available for three diseases: pneumococcal disease, meningococcal disease, and typhoid fever.

Polysaccharide vaccines are inactivated subunit vaccines composed of long chains of sugar molecules that make up the surface capsule of certain bacteria. Pure polysaccharide vaccines are available for three diseases: pneumococcal disease, meningococcal disease, and typhoid fever.

Young children do not respond consistently to polysaccharide antigens, probably because of immaturity of the immune system. In the late 1980s, it was discovered that those problems could be overcome through conjugation, in which the polysaccharide is chemically combined with a protein molecule. Conjugation changes the immune response from T-cell independent to T-cell dependent, leading to immune memory, increased immunogenicity in infants and antibody booster response to multiple doses of vaccine.

The polysaccharide coatings can disguise the antigens, making it hard to trigger an immune response, particularly in young children with immature immune systems. This can be overcome by conjugation, where polysaccharides are chemically combined with a protein molecule. This improves the immune response and immune memory, increases immunogenicity in infants, and boosts the antibody response to multiple doses of vaccine.

**TABLE 23: VIRAL AND BACTERIAL VACCINES**

	Live attenuated	Inactivated	Subunit
<b>Viral</b>	Vaccinia Polio (OPV) Yellow fever Measles Mumps Rubella Influenza Rotavirus	Polio (IPV) Rabies Influenza Hepatitis A	Hepatitis B (HepB-surface antigen) Human papilloma virus (HPV)
<b>Bacterial</b>	BCG (tuberculosis) Salmonella typhi (oral)	Bordetella pertussis (whole cell) Cholera Bacillus anthracis	Tetanus (toxoid) Diphtheria (toxoid) Neisseria meningitidis (polysaccharide) Bordetella pertussis (acellular) Streptococcus pneumoniae, 23 valent (polysaccharide) Haemophilus influenzae, type b (Hib) (polysaccharide) Neisseria meningitidis (polysaccharide conjugate) Streptococcus pneumoniae, heptavalent (conjugate polysaccharides) Salmonella typhi Vi (capsular polysaccharide)



Source: Nascimento & Leite [4]; CDC Understanding how Vaccines work (QR code 9)

## 19.6 Recombinant vaccines

Vaccine antigens may also be produced by genetic technology. Hepatitis B vaccines are produced by insertion of a segment of the hepatitis B virus gene into the gene of an animal or a yeast cell. The modified cell produces pure hepatitis B surface antigen when it grows.

## 19.7 Vaccine adjuvants and other additives

Adjuvants are added to vaccines to improve the immune response. The adjuvants most commonly used in Europe are the alum (aluminium salt) adjuvants.

These compounds bind to the antigens in the vaccine, helping to retain them at the site of injection, and deliver them to the lymph nodes, where antigen immune responses are initiated. Slowing the release of antigens to tissue around the injection site and improving the delivery of antigens to the lymph nodes can produce a stronger antibody response than the antigen alone. Alum adjuvants are also taken up by immune cells in the blood, supporting the immune response.

In addition to adjuvants, vaccines may contain antibiotics to prevent bacterial contamination during manufacturing, preservatives to keep multi-dose vials of vaccine sterile after they are opened, or stabilizers to maintain a vaccine's potency when stored in less-than-optimal temperatures

## 19.8 Combination vaccines

Combination vaccines combine two or more vaccines into a single injection. Getting a number of vaccines at the same time has been confirmed to be safe. If a number of vaccines are administered by injection at the same time, these should be at different sites on the body, and location recorded in medical records.

### 19.8.1 Subunit vaccines

Subunit vaccines do not attack the entire microbe but just target the antigens that best stimulate the immune system. In some cases, these vaccines use epitopes – subsections of the antigens that are recognised by antibodies or immune cells. Because subunit vaccines contain only the essential antigens, the chance of adverse reactions is much lower.

### 19.8.2 Adjuvants and other ingredients

Adjuvants are added to a vaccine to improve the immune response. The most commonly used adjuvants in use in Europe are the alum adjuvants, which are aluminium salts. These compounds bind to the antigens in the vaccine, slow the release of the antigens from the site of infection, and help deliver antigens to the lymph nodes, where immune responses to the antigens are initiated. The slowed release of antigens to tissue around the injection site and the improved delivery of antigens to the lymph nodes help to produce a stronger antibody response than the antigen alone. Alum adjuvants are also taken up by cells such as macrophages and improve the presentation of antigens to the lymphocytes.

Vaccines may also contain **antibiotics to prevent bacterial contamination during manufacturing**, preservatives to keep multi-dose vials of vaccine sterile after they are opened, or stabilizers to maintain a vaccine's potency at less-than-optimal temperatures.

## 20 Vaccine administration and handling

For administration, follow the instructions given in the product leaflets, as administration may differ between vaccines, even those for the same infection.

### 20.1 Routes of administration

There are five possible routes for vaccine administration:

- IM (intramuscular)
- SC (subcutaneous)
- ID (intradermal)
- Oral (mouth)
- Nasal (nose)

The appropriate route will depend on the manufacturer's recommendation, and on outcomes of clinical trials. Using a different route may reduce vaccine efficacy or even increase adverse reactions. For example, IM vaccines containing adjuvants can cause local irritation, induration, skin discoloration, inflammation and even granuloma formation when given SC or ID.

Choosing injection sites for IM, SC and ID injection will depend on manufacturer's recommendations, and on an individual's tissues. The location should be chosen to avoid local, neural, vascular, or tissue injury. For IM administration, injection technique is the most important parameter to ensure efficient intramuscular vaccine delivery. Appropriate needle length depends on age and body mass. Longer needles are associated with less redness or swelling. In infants and children, distraction, pain relief, sweet liquids (including breastmilk), swaddling and swaying can help to reduce pain and distress.

Oral delivery is easier for patients but more challenging for manufacturers, requiring formulations to overcome the harsh gastrointestinal (GI) environment. Rotavirus, adenovirus, cholera vaccine, and oral typhoid vaccines are the only vaccines administered orally in Europe.

#### HINTS AND TIPS

Some single-dose manufacturer-filled vaccines come with an air pocket in the syringe chamber. Do we need to expel the air pocket before vaccinating?

No. You do not need to expel the air pocket. The air will be absorbed. This is not true for syringes that you fill yourself; you should expel air bubbles from these syringes prior to vaccination to the extent that you can do so.

## 20.2 Managing pain

Childhood vaccinations are part of routine care, but the pain associated with vaccines can be upsetting for children and distressing for parents. Untreated pain may also have long-term consequences, increasing anxiety about future medical procedures and health care. This can lead to delayed vaccinations, or avoiding vaccinations all together, so leaving children unprotected.

There are a number of techniques that can help to reduce the distress, for children, adolescent and adult recipients of vaccines, and for their caregivers:

- Healthcare professionals need to explain things clearly, remain calm, be positive, and avoid using any language that triggers anxiety or distrust
- The patient should be in the right position for the vaccine
  - > Infants or younger children should be held on a caregiver's lap
  - > Older children, adolescents and adults should be sitting upright
- The vaccine should be given rapidly
- Topical anaesthetics may help
- Distractions can help
  - > Rubbing or stroking the skin before and during vaccination
  - > Breast or bottle feeding or sweet-tasting solutions for infants
  - > Toys or books
  - > Singing, music, talking, joking, telling stories
  - > Deep breathing for older children, adolescents and adults

## 20.3 Spacing of vaccine administration

Based on guidance from the Advisory Committee on Immunization Practices (ACIP), a committee within of the US Centers for Disease Control and Prevention (CDC) and American Academy of Pediatrics (AAP):

- All vaccines can be administered at the same visit, unless patients are high risk – see vaccine product leaflets for further information
- There is no upper limit for the number of vaccines that can be administered during one visit
- Vaccination should not be deferred because multiple vaccines are needed
- All live vaccines can be given at the same visit if required
  - If live vaccines are not given at the same visit, they should be separated by 4 weeks or more
- Multiple vaccines given in the same visit should be separated by 2.5 cm or more, to avoid local reactions overlapping

**My patient asked: Do vaccines overload the immune system?**

Within hours of birth, a baby's gastrointestinal and respiratory tract are heavily colonised with bacteria. Rather than overwhelming the immune system, vaccines help stimulate and strengthen it. Immune systems need stimulation to develop well: allergies may result from too little immune stimulation in our cleaner environments.

There is no evidence that vaccines can overload the immune system. The immune system is designed to deal with a constant stream of foreign antigens on the surface and inside our bodies.

### 20.3.1 Dosing vaccines outside the approved schedule

In clinical practice, vaccine doses occasionally are administered at shorter than the minimum recommended interval or at ages lower than the minimum recommended age. Doses administered too close together or at too young an age can lead to less of an immune response. However, administering a dose a limited number of days earlier than the minimum interval or age is unlikely to have a substantially negative effect on the immune response to that dose.

See section 21.4 Travel for information on spacing of travel vaccines.

### 20.3.2 Booster doses

For some vaccines, the levels of antibodies in the body can drop over time after the initial dose, leaving people under-protected. Giving a booster shot 'wakes up' the immune system to continue its protection. Because of this, it's important to check whether patients are up to date with their vaccinations and boosters at routine and other appointments. Nurses should encourage patients to keep records of vaccinations for themselves and their family members.

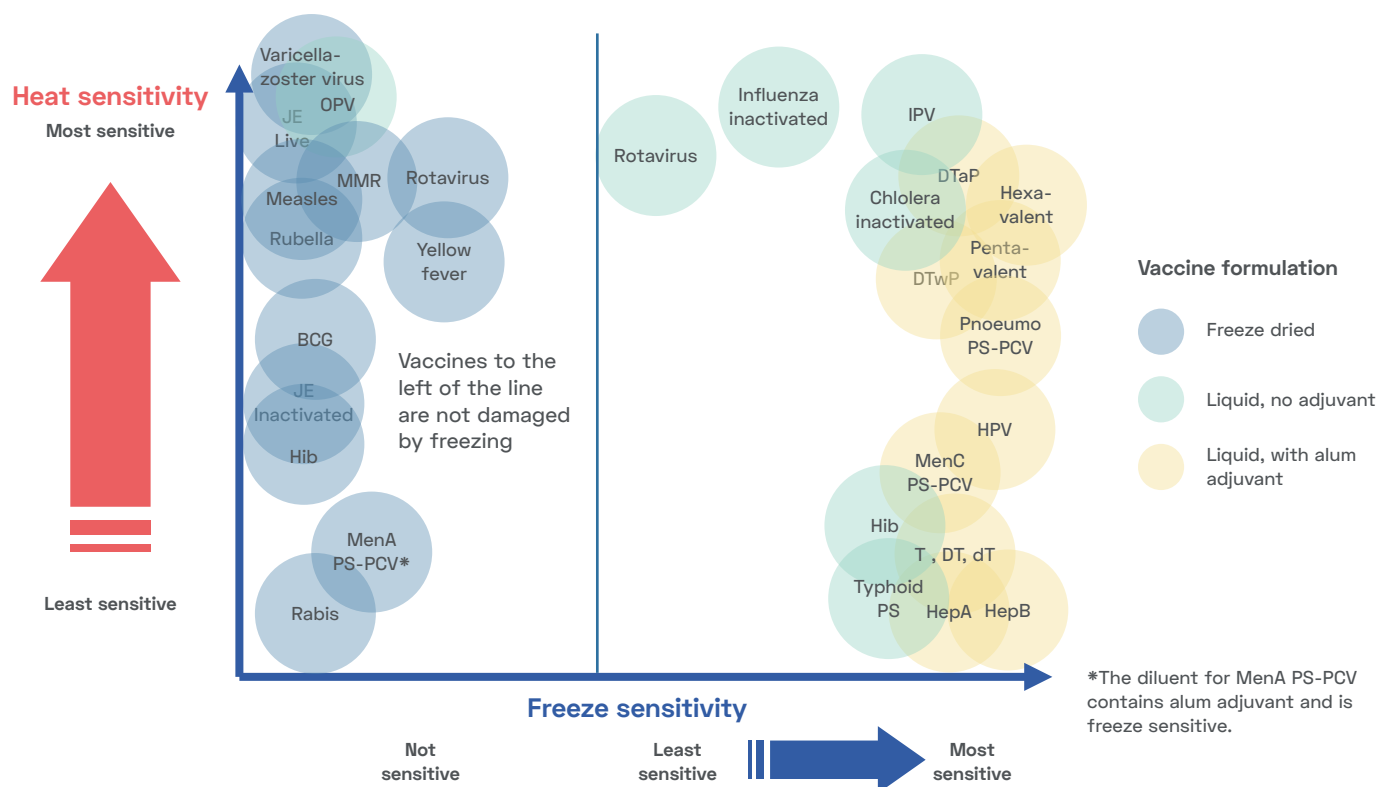
## 20.4 Vaccine storage and handling

Many vaccines are sensitive to heat and cold (Figure 32). To maintain their effectiveness and safety, vaccines must be kept at the correct temperature from the time they are manufactured until they are used.

### 20.4.1 Cold chain

Vaccines must be stored and distributed in a temperature-controlled environment. Known as the 'cold chain', this must be maintained at every stage from the manufacturing plant, through distributors and pharmacists, to the healthcare professionals' clinic.

FIGURE 32: TEMPERATURE SENSITIVITY OF VACCINES



Source: WHO/PATH vaccine stability presentation

The WHO has recommendations for cold chain equipment and monitoring. Manufacturers will provide storage instructions for individual vaccines, and it is important to refer to the product leaflets for individual vaccines.

## 21 Vaccination in special situations

There are a number of factors that can influence the immune response. These include:

- The presence of maternal antibodies
- Nature and dose of antigen
- Route of administration
- Presence of adjuvants
- Age
- Nutritional status
- Genetics
- Coexisting disease.



Some groups of people are at increased risk of vaccine-preventable diseases:

- Preterm infants
- Pregnant women
- Immune-compromised patients
- Travellers

These special populations either cannot be vaccinated, are less responsive to vaccines, or are under-vaccinated. Reasons for under-vaccination include:

- Lack of awareness of vaccine-preventable diseases
- Uncertainty or misconceptions about the safety and efficacy of vaccination among patients, parents and healthcare professionals
- Cost
- Inability of healthcare systems to ensure all patients can receive recommended vaccines

## 21.1 Preterm infants

Infection tends to have more serious consequences in preterm than in full-term infants, mainly because of immaturity of the immune system. Consequently, preterm and low birth weight infants have a higher risk of vaccine-preventable diseases, including those caused by pertussis, *Streptococcus pneumoniae* and rotavirus.

It is generally recommended that preterm infants who are otherwise healthy are immunised according to the vaccination schedule used for full-term infants. To ensure early protection, preterm infants should be vaccinated according to their chronological rather than corrected gestational age and regardless of birth weight. It may be appropriate to administer additional vaccine doses to preterm or extremely low birth weight infants who produce suboptimal vaccine responses, for example hepatitis B in babies under 2 kg.

## 21.2 Pregnant women

The physiological changes associated with pregnancy can weaken the immune system. This can increase the risk of complications for pregnant women; for example, influenza in pregnancy can lead to bronchitis and pneumonia, and mumps can increase the risk of miscarriage.

Infections during pregnancy can also increase risks to the unborn baby:

- Influenza during pregnancy may lead to premature birth and reduced birth weight. Newborns that catch the infection from the mother may become seriously ill.
- Rubella during pregnancy can lead to congenital rubella syndrome, resulting in babies with:
  - > Reduced birth weight
  - > Sight and hearing loss
  - > Damage to the brain, heart, liver and spleen

Newborn babies are vulnerable to pertussis (whooping cough), which remains endemic in much of the world, especially in the early months of life before vaccination, once protective maternal antibody levels have waned. Vaccination of the pregnant woman remains the best strategy to protect babies during their first months of life.

## 21.3 Immune-compromised patients

There are a number of different reasons that people may be immune-compromised:

- People with chronic or immune-compromising medical conditions
- People being treated with immunosuppressants
- Older people

Immunodeficiencies may be primary (hereditary or genetic) or secondary (acquired through illness, disease treatment, malnutrition or aging).

It is important that people who are immunocompromised receive appropriate inactive vaccines to protect them from disease. They may not be given live vaccines (see 19.1: Live attenuated vaccine). People who live with immunocompromised patients can also receive inactivated vaccines.

Not all immunocompromised people will respond to vaccinations, but they can be protected through herd immunity (see 17.1: Community immunity effect (herd immunity)).

## 21.4 Travel

Travel vaccines, also called travel immunizations or travel shots, are given to travellers before visiting certain areas of the world, to help to protect them from serious illnesses. It also avoids bringing diseases back home for which most of the population is not protected.

In some countries, vaccination against certain diseases is compulsory to avoid the reimportation of a disease for which the vector is present, but the disease has been eradicated (for example yellow fever), or to prevent the introduction or spread of different serotypes (for example meningococcal strains).

The WHO emphasizes that all travellers should be up to date with routine vaccinations. Travel is a good opportunity for healthcare professionals to review the immunization status of infants, children, adolescents and adults. Non-immunized or incompletely immunized travellers should be offered the routine vaccinations recommended in their national immunization schedules, in addition to those needed for international travel. Ideally, consultation should be done at least 2 or 3 weeks before travel.

When people travel last minute, they may not be able to complete the full course of vaccines that require multiple doses to induce full protection, for example hepatitis B, Japanese encephalitis, or rabies. Accelerated schedules may be possible, or the traveller could get further doses at their destination. The level of protection may not be complete if the full series of doses isn't given.

Travellers intending to visit friends and relatives (VFRs) are a specific group of travellers who have been identified as having an increased risk of travel-related morbidity. It's both a risk for themselves and for their country of origin, as they may introduce a disease when coming back from their travel for which the population is not protected. This risk is often underestimated.

VFRs should be made aware of their increased risk for travel-related illnesses and how to prevent them. Higher levels of non-immunity to vaccine-preventable disease and increased prevalence of chronic diseases among VFRs should also be addressed. In addition, health care providers should stress the importance of adherence and address potential challenges to achieving it.

## 22 Role of vaccination in the fight against antimicrobial resistance (AMR)

Vaccines against bacterial infections can reduce the prevalence of AMR by reducing the need for antibiotic use. Because people can pass resistant infections to one another, and because bacteria can pass on AMR to other bacteria, vaccination could also reduce the spread of resistance by reducing the number of infections on a population. There is more on AMR at 10.3: Antibiotic resistance.

Vaccines against viruses can also play a role, as some viral infections, such as influenza, make people vulnerable to bacterial infections. Reductions in the number of viral infections could also reduce the numbers of antibiotics that are inappropriately prescribed for viral infections.

These effects may be amplified by herd immunity, extending the protection to unvaccinated persons in the population.

## 23 Vaccine safety and monitoring mechanisms

Adverse events following immunization (AEFIs) should be recorded and reported; this is important for tracking both common and rare AEs, and has been successful in bringing to light serious AEFIs after vaccines have been marketed.

### 23.1 Definition of an adverse event

An adverse effect (AE), also known as a side effect, is defined as:

Any untoward medical occurrence in a patient or clinical investigation subject administered a pharmaceutical product and which does not necessarily have to have a causal relationship with this treatment.

Put more simply, an AE is any undesired effect from a medical treatment or intervention.

AEFIs can be categorised as:

- Vaccine product-related reaction – linked to the properties of the vaccine itself
- Vaccine quality defect-related reaction – caused by manufacturing problems
- Immunization error-related reaction – caused by issues with vaccine storage or administration
  - > Preventable through education of the healthcare professional

- Immunization anxiety-related reaction – caused by stress or anxiety in the patient
  - > Preventable through patient education and support
- Coincidental event – caused by illness or other situations not related to the vaccination
  - > Preventable through patient education and support

Many vaccine product-related AEFIs are minor, for example soreness, fever or redness, and go away within a few days. Some vaccine product related AEFIs are specific to the individual vaccine, and will be listed in the manufacturer's information.

It is important to remember that it is hard to identify whether apparent side effects are caused by a particular vaccine.

### HINTS AND TIPS

- Monitor patients for around 30 minutes after giving a specific vaccine for the first time, if patients have a potential allergy, or if you are concerned about a patient
  - > Use your clinical judgement
  - > Be aware of local guidelines
  - > Be aware of the information in the manufacturer's product information
- If a patient is going to have an anaphylactic reaction, this will be within the first 20 minutes, and is very rare

## 23.2 Main safety surveillance systems

### 23.2.1 European Medicines Agency

The European Medicines Agency (EMA), based in Amsterdam, coordinates and supports the pharmacovigilance system in the European Union (EU). This system monitors the safety of drugs across Europe.

The EMA's Pharmacovigilance Risk Assessment Committee (PRAC) is responsible for assessing and monitoring the safety of human medicines. It is made up of experts in medicines safety from regulatory authorities in member states, as well as scientific experts and representatives of patients and healthcare professionals, including specialist nurses. The EMA shares information with the US Food and Drug Administration (FDA), and the WHO.

Nurses can report any concerns to the EMA using the yellow card system.

### 23.2.2 Vaccine

The Vaccine Safety Datalink (VSD) is one of the largest ongoing networks that is population-based and expressly focused on vaccine safety surveillance. It was started in 1990 as a collaborative research enterprise between the Centers for Disease Control and Prevention (CDC) and four health maintenance organizations (HMOs) to enable studies into serious adverse events following immunization.

### 23.2.3 Vaccine Adverse Events Reporting System (VAERS)

VAERS receives reports of events that are submitted voluntarily by patients or their caregivers.

## 23.3 National and immunization safety surveillance systems

The national regulatory authority (NRA) and the national immunization programme (NIP) are responsible for developing and maintaining a national AEFI surveillance system.

In countries that produce their own vaccines, vaccine manufacturers and national control laboratories may be part of the national AEFI surveillance system.

# 24 The role of healthcare professionals

## 24.1 Nurse training

ESNO strongly recommends training on vaccination and vaccination-preventable diseases for nurses, with an emphasis on regional and local requirements. Being equipped with the right information makes it easier to educate and motivate patients about vaccination. All nurses who administer vaccines should receive competency-based training and education on vaccine administration before providing vaccines to patients.

Training objectives should include:

- Strategies for vaccine communication
- Infection control guidelines
- Vaccine preparation and storage
- Administration routes, sites, and needle sizes
- Pain control techniques
- Vaccine administration in special situations
- Documentation requirements
- Avoiding vaccine administration errors
- Managing adverse events

Providers need to orient new staff to vaccines used in their office and validate nurses' knowledge and skills about vaccine administration with a skills checklist. This needs to include temporary nurses who may be filling in on days when the facility is short staffed or helping during peak times such as flu season.



Senior nurses should be involved at all stages of the creation of education programs:

- Policy
- Composing recommendations
- Program design
- Development of educational material
- Organisation of education and training activities.



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[QR code 10]

For further details on the role of nurses, read 'The Role of Nurses in Immunisation: A snapshot from OECD countries', from the International Council of Nurses (see QR code 10). In the near future, ESNO aims to set out a detailed study on varieties and with recommendations.

## 24.2 Providing education and communication

Nurses are the most important and trusted source of information on protection from vaccine-preventable disease. The personal credibility of nurses and their positions of trust places them in a unique and responsible position to play an important role in education and communication. This needs to be backed up by knowledge, skills and attitude. The nurse should also communicate no vaccine hesitancy or other personal opinions on vaccination, and should ideally be a vaccine advocate. Nurses should remain neutral on compulsory vaccination, as this is a matter of policy set at a national level.

The nurse's role is both before and after vaccination, including discussing after-effects and follow-up. Follow up includes:

- Monitoring adverse reactions
- Remaining available to answer questions following vaccination
- Recording the vaccination (including location) in medical records and personal vaccination records

Nurses should collect information on vaccinations for education for colleagues and patients. Nurses should also ensure that they receive all relevant vaccinations.

### HINTS AND TIPS

- Use positive language when talking about vaccines
- Don't just quote data
- Talk about protection and prevention
  - > Use images like roofs on houses, umbrellas or car seatbelts



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[QR code 11]

## 24.3 Clinical practice on vaccination per specialist nursing

### 24.3.1 Oncology

There are a number of national guidelines for vaccination in oncology, for example the Vaccination guidelines in haematopoietic transplant patients: recommendations from the Transplantation Committee of the Belgian Hematological Society (BHS) Transplant Committee (QR code 11).

### Practice example: Belgian nurse example – Marijke Quaghebeur, Clinical Nurse Specialist, haematology

In the haematology department of University Hospital Ghent, physicians, the clinical nurse specialist and the nurse consultant have access to the professional vaccine government network. This access was requested at the Flemish Vaccinet group in order to provide a comprehensive vaccination program post-stem cell transplantation. Access to and application of the Vaccinet program generally results in better follow-up of vaccinations in patients according to current guidelines and reimbursement conditions.



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[QR code 12]

In the multidisciplinary team of the haematology department, specialized cancer nurses coordinate the vaccination follow up. Apart from the prescription for vaccination, nurses inform, educate about and administrate the necessary vaccine on the right time according the evidence based guidelines. The overall information and education about the post treatment vaccination is provided during a nurse led consultation. All patients and carers receive an overview on the vaccination plan, meaning that patients can be involved in their healthcare management.

The logistic and communication part of the Vaccinet system is completely managed by the clinical nurse specialist and the nurse consultant. Through the Vaccinet system, these specialized nurses ensure that vaccine stocks are always replenished, and that the vaccination status of the patient is up to date. As a result, both hospital and the first line healthcare professionals, e.g. general practitioner, can access the correct vaccination status of the patient at all times.

For more information about vaccination following stem cell transplantation, see The European Blood and Marrow Transplantation Textbook for Nurses **[QR code 12]**.

For guidelines for the vaccination of patients with haematological malignancies who did not have transplantations, see **QR code 13**.

## 25 Vaccine hesitancy

Vaccine hesitancy refers to delays in acceptance or refusal of vaccines even when they are freely available. Vaccine hesitancy is complex and context-specific, varying across time, geographic area and disease type. It is influenced by factors such as complacency, convenience and confidence, and can have its roots in religious beliefs, or in mistrust of 'modern' medicine.

Vaccine hesitancy has been around as long as vaccines have, and in 1802, the satirist James Gillray ridiculed the opponents of vaccination (Figure 33).

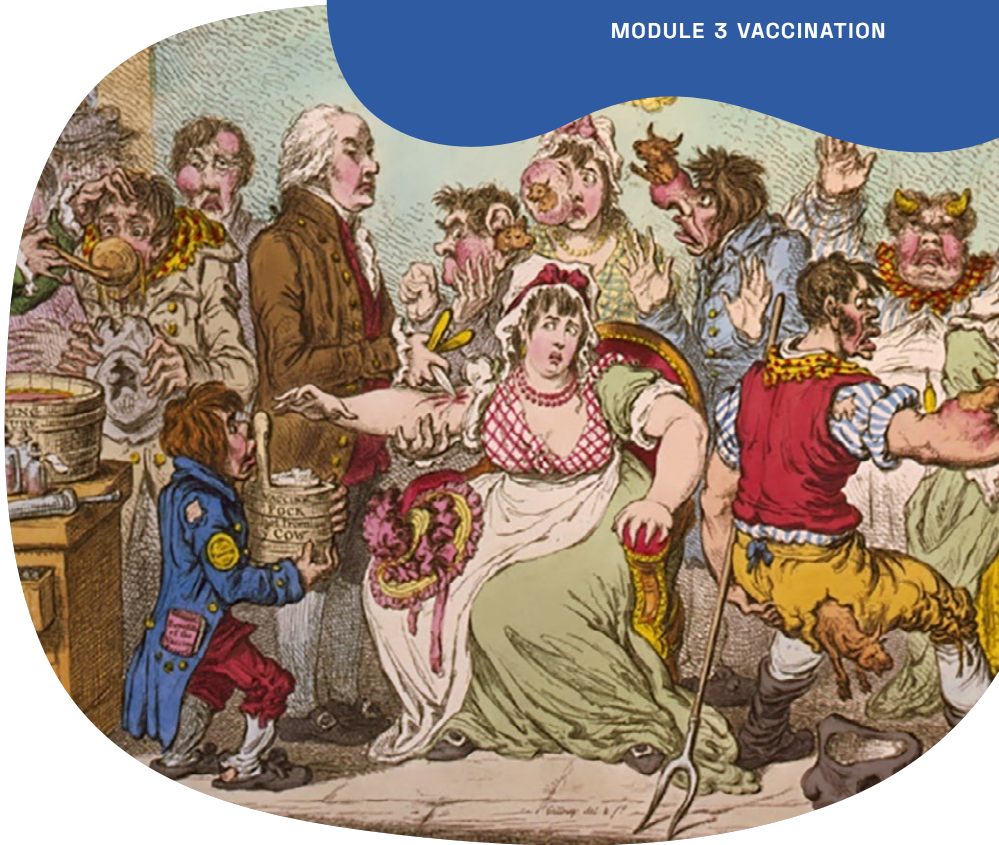


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[QR code 13]



**FIGURE 33: THE COW-POCK—OR—THE WONDERFUL EFFECTS OF THE NEW INOCULATION!—VIDE. THE PUBLICATIONS OF YE ANTI-VACCINE SOCIETY**

Source: James Gillray (public domain)



### The outcomes of vaccine hesitance

Vaccine hesitancy in Europe and the US have resulted in large outbreaks and fatalities in countries that had previously been reported free of certain diseases. For example, measles in Europe primarily occurs in unvaccinated populations in both adults and children. In 2019, the UK lost its measles-free status. Europe is polio-free, but falling vaccine rates could mean its return. There have also been rising numbers of diphtheria in countries whereas the disease was virtually eliminated thanks to high vaccination coverage.

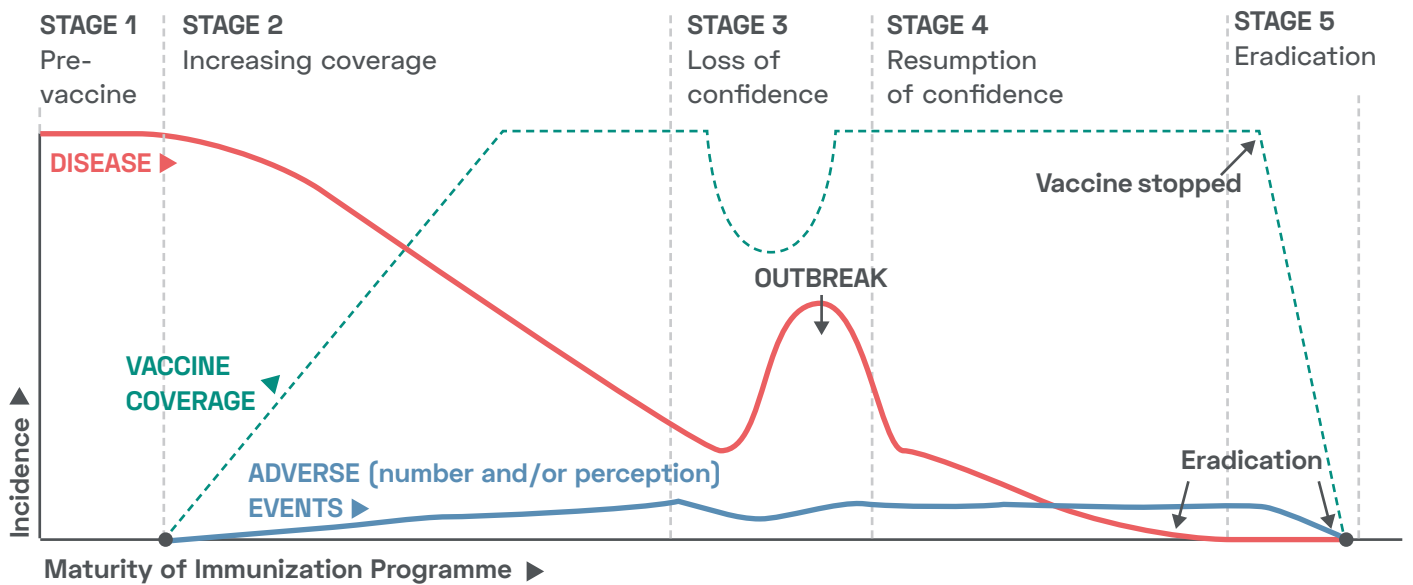
Hesitancy in vaccination is not a refusal but often a natural response to protect. The challenge is to provide accurate and tailored information rather than overwhelming with data and morality. Time and trust are important ingredients towards acceptance and adaptation

In the pre-vaccine era, morbidity and mortality caused by infectious diseases that are now preventable were high. The more successful a vaccination campaign is, the less visible the prevented disease may become to the public. As the threat of the original disease vanishes in the perception of the public, the attention of the population may focus to the adverse events of the vaccine. A distorted perception of the risk of vaccines and negligence of the much greater health threat by the original disease may lead to decreased acceptance of the vaccine (Figure 34).

To ensure continued public acceptance of vaccines, it is essential to:

- Monitor the incidence of AEFIs,
- Scientifically evaluate the likely associations,
- Respond to newly identified risks from vaccines,
- Communicate the benefits and risks to patients and parents through a trusted health care source in advance of the vaccination visit.

FIGURE 34: CHANGES IN VACCINE USE OVER THE TIME OF AN IMMUNISATION PROGRAMME



## 25.1 The role of healthcare professionals

Vaccine hesitance is very complex, and the group of people who are hesitant cover a wide range:

- Questioning
- Not informed
- Not engaged
- Doubtful
- Refusing outright

Telling people in these groups to just trust the healthcare professional is not enough. Giving them scientific data, reports or vaccine brochures may not help, especially those people who have total mistrust of vaccines. Healthcare professionals need to be informed, able to communicate and competent. They also need support, especially those nurses responsible for teams, education activities and training programs.

## 25.2 Myth: Understandings and misunderstandings

Parents, patients, and healthcare professionals all have misconceptions about vaccinations.

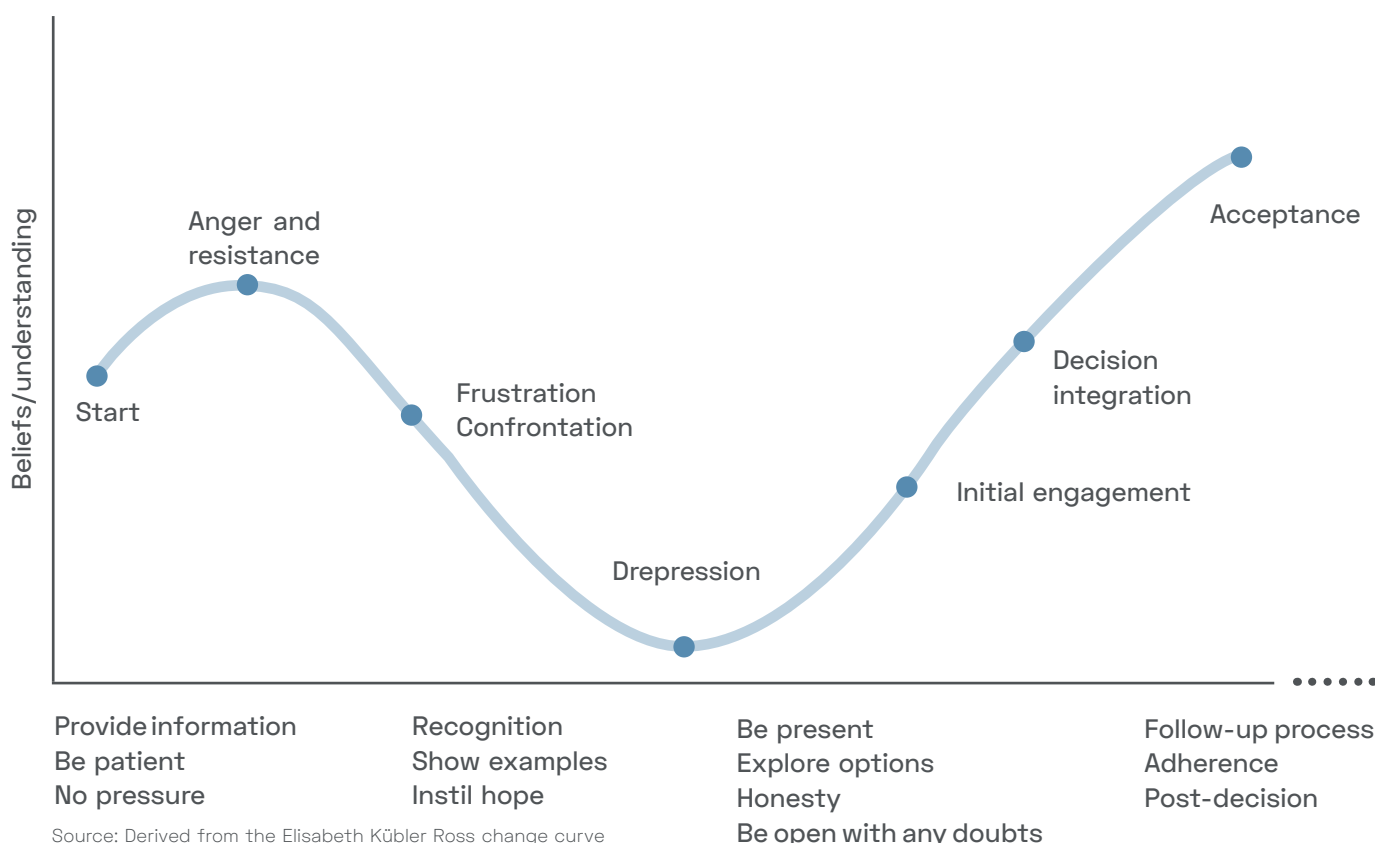
Patients and parents are increasingly questioning the safety and effectiveness of vaccines. This is supported by anti-vaccination groups and fake news spread on social media. Responding to patients and parents requires knowledge, tact, and time. Healthcare professionals can miss opportunities to vaccinate by following unnecessary or outdated rules.

Useful and effective tools have been developed by European and global organizations such as WHO, ECDC, LHSTM and others to help you to debunk myths, provide you with up to date recommendations and support you in your conversations about vaccines.

## 25.3 Response strategies for vaccine hesitancy

Healthcare professionals, including nurses, need to be informed about vaccine-hesitant people and understand the impact vaccine hesitancy. Vaccine myths may have convinced some people for decades, and this may be supported by their communities – it may not be possible to change their viewpoint in a single discussion. One approach is to use the Kübler-Ross curve of change (see Figure 35).

**FIGURE 35: USING THE KÜBLER ROSS IDEAS OF CHANGE FOR TALKING TO VACCINE-HESITANT PEOPLE**



### Case study

A head nurse asked a team nurse to inform some patients at the ward about their vaccination, to be given the following week. An hour later the nurse returned, saying that only half of them will take the vaccination; the rest have refused.

The head nurse asked the nurse to go back and ask the refusers to explain why. This resulted in a debate in the ward amongst the nurses and between the nurses and patients, leading to a campaign on vaccination, and giving one of the nurses the responsibility of being a ‘vaccination steward’. There was a positive result in the first year, moving from ‘shock’ on the Kübler-Ross curve, through ‘experiment’ and ‘decision’ to ‘integration’.

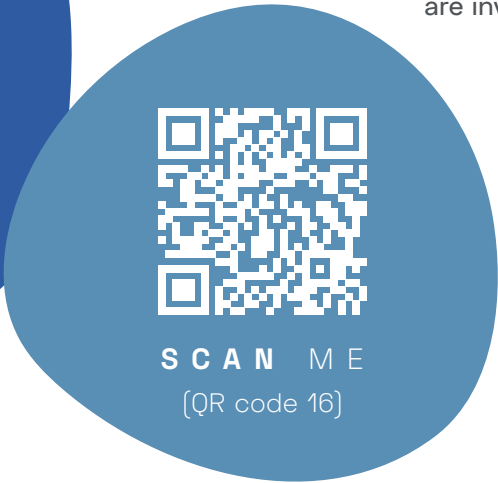
As numbers of people who are vaccine-hesitant or anti-vaccination grows, the WHO has developed a document ‘How to respond to vocal vaccine deniers in public’ that provides very practical principles for health providers how to respond **(QR code 14)**.

The document includes an algorithm to suggest approaches, depending on the reasons given by the vaccine-hesitant person.

- Step 1
  - > Identifying the approach that the vaccine-hesitant person is using to deny the value of vaccination, for example conspiracy or false logic
- Step 2
  - > Identifying the topic behind the technique, for example denial of the threat of disease, or validity of alternatives to vaccination
- Step 3
  - > Respond by unmasking the technique used, and using they key message, for example exposing the fake expert behind the claim that there is no threat of disease, and then confirming the importance of vaccination as a protection



The ECDC has developed guidance called ‘Let’s talk about protection: enhancing childhood vaccination uptake’ **(QR code 15)**. This is practical peer-reviewed advice and evidence-based guidance to increase the uptake of childhood vaccinations for healthcare professionals who are involved with immunisation services.



The Vaccine Confidence Project **(QR code 16)** by the London School of Hygiene & Tropical Medicine (LHSTM), Strategic Advisory Group of Experts (SAGE) on Immunization – WHO working group and ECDC (European Centre for Disease Prevention and Control) has led research and developed well-designed tools to understand, monitor and restore public confidence in immunization programmes.

## 25.4 HPV vaccination: Uptake and hesitancy

Every year in Europe, more than 60,000 new cervical cancer cases are diagnosed and over 25,000 women die from the disease, making it one of the commonest cancers in women [5].

There are currently three HPV vaccines licensed in Europe: the bivalent vaccine Cervarix (GlaxoSmithKline Biologicals) that contains virus-like-particles (VLPs) of HPV types 16 and 18, the quadrivalent HPV vaccine Gardasil (Merck Sharp & Dohme – MSD) that includes VLPs of HPV types 6, 11, 16 and 18 and the nonavalent

vaccine Gardasil 9 (MSD), that contains VLPs of HPV types 6, 11, 16, 18, 31, 33, 45, 52 and 58. Potentially, the bivalent and the quadrivalent vaccines could prevent 71% of all cervical cancer cases worldwide (i.e. those attributable to HPV types 16 and 18), while the nonavalent vaccine could increase the preventive potential to 89% of cervical cancer cases.

The three vaccines are licensed for the prevention of premalignant anogenital lesions (cervical, vulvar, vaginal and 163 anal), cervical cancers and anal cancers and for Gardasil 9 also vulvar and vaginal cancers causally related to high-risk types included in the vaccines. In addition, the quadrivalent and nonavalent vaccines are licensed for the prevention of genital warts. All vaccines are approved from the age of 9 years with a recommended schedule of two doses (0–6 months) up to and including the age of 14 years for the bivalent and nonavalent vaccines and up to and including the age of 13 years for the quadrivalent vaccine. In individuals older than the above indicated ages (15 years of age for the bivalent and nonavalent, 14 years of age for the quadrivalent), the recommended schedule is 3 doses administered at months 0, 1 (or 2) and 6 [6-8].

The duration of protection from HPV-related cervical and genital disease attributable to serotypes 6, 11, 16 and 18 has been demonstrated for at least 14 years with the quadrivalent vaccine given in a 3-dose schedule to preadolescents and adolescents and at least 12 years with the quadrivalent vaccine given in a 3-dose schedule to women 16-26 years old. A duration of 9.4 years of protection from infection and cervical lesions attributable to HPV-16 and HPV-18 has also been demonstrated with the bivalent vaccine in a Phase II study with a 3-dose schedule. Finally, 7.6 years of protection from infection and cervical, vulvar and vaginal lesions with the nonavalent vaccine in a 3-dose schedule was shown [6-8].

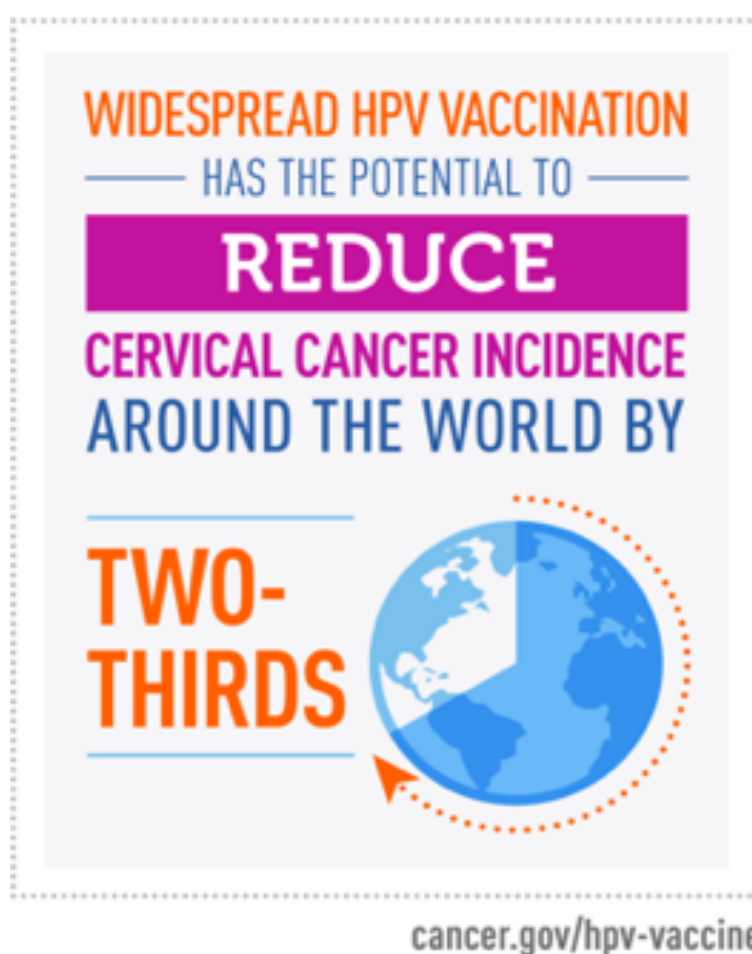
In countries such as the UK, where coverage has been good, infections by the most aggressive strains of HPV have been reduced by 86% and precancerous cervical disease has been reduced by 71% [9]. Other diseases attributed to HPV infection have also fallen dramatically [10].

### FIGURE 36: THE IMPORTANCE OF HPV VACCINATION

Source: National Cancer Institute (NCI) (public domain)

#### Falling trust in HPV vaccination

Trust in HPV vaccination is currently being shaken in many European countries, the impact of which is indicated by low and/or decreasing coverage rates [11]. Currently, HPV vaccine coverage rates (VCR) in Europe are very variable. In a recent study, highest HPV VCRs were associated with school delivery within structured vaccination programmes and the use of reminders [12].





Apart from issues of affordability and access to healthcare common to any vaccination program, the HPV vaccines have struggled with the distribution of inaccurate information about the vaccine's safety via media and social media and with the fact that HPV is considered a sexually-transmitted disease [10,13,14]. Since vaccination is a prophylactic intervention, it makes sense to vaccinate against HPV before the initiation of sexual activity, but in some countries, parents struggle with the concept of vaccinating pre-teen girls against a sexually-transmitted disease [15].

The dissemination of inaccurate information via social media has had dramatic, negative impact on uptake of the HPV vaccine in some countries [13]. Although this can be countered by effective public health campaigns, not all health authorities have responded effectively [16]. Where misinformation is not countered, HPV vaccination rates continue to languish, even though there are no signals that the vaccine is unsafe [17]. This shows the importance of providing comprehensive, accurate information on the safety and effectiveness of HPV vaccination to the public – and on the risks of not getting vaccinated. Parental concerns that vaccination against HPV may (for example) promote promiscuity have also been shown to be unfounded and the same approach can be effective here, namely providing clear and accurate information about vaccine benefits and risks [18].

Strategies developed with the goal of addressing HPV vaccine hesitancy should not only focus on providing more information about the safety and effectiveness of the vaccine, but also aim to rebuild and maintain trust in public health institutions, including HCPs and health authorities, in order to prevent or manage future potential confidence crises.

The European Center for Disease Control (ECDC) has developed a set of guides for communication about immunisation (QR code 17). Many organisations have had similar initiatives, with the purpose of inform, support and guide HCPs as well as the public on the importance of immunisation.

In collaboration with the National Nursing Associations (NNA), 15 of the 36 OECD (Office of Economic Cooperation and Development) countries were invited to participate in a survey to determine the current state of nursing's involvement in immunisation in their countries, fifteen countries responded. The survey consisted of five key areas reflecting:

1. nursing's overall role in, and preparation for immunisation interventions
2. prescribing immunisation
3. administering vaccination
4. activities related to expanding nursing's role in immunisation; and
5. respondent information. In addition, further analysis was carried out to determine the degree of nurse immunisation role engagement by country.

The results of the immunisation survey of 15 OECD countries, provide a profile of nurses' role in immunisation and can be used to shape further action in this area. Such action should focus on reinforcing and expanding nurses' contribution to immunisation through support for more involvement in immunisation education, and in immunisation programme and policy development.



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[QR code 17]

In addition, advocating for nurse prescribing and addressing the major barriers to nurses working to full potential in immunisation, requirement for a prescription to immunise, time for immunisation interventions in the work schedule, and necessary enabling legislation would have a marked effect on nursing's ability to impact immunisation rates [19].

Countries excelling in nurse immunisation role engagement were those in which nurses were:

1. very likely to promote and support immunisation
2. involved and prepared in all aspects of immunisation- education, managing vaccination, vaccine administration and prescription, and advisory roles
3. successful in overcoming key barriers to full engagement in immunisation activities such as requirement for prescription and other individual, system and organisational barriers
4. supported to prescribe immunisations, particularly the RN and APN roles and the National Nursing Association was engaged in expanding the role of nurses in prescribing, and enhancing their role in immunisation.

Furthermore, an expert technical meeting on the role that HCPs can play to increase the uptake of HPV vaccine and screening concluded that: [20]

1. increasing HCP norms of getting vaccinated
2. training providers to make effective recommendations
3. making culturally appropriate materials available, in local languages
4. centralizing and coordinating education and information material, to direct both HCPs and the general public to the best material available.

The message is clear: HPV vaccination is an effective method for reducing the burden of serious HPV-related disease, and healthcare providers need to be proactive in refuting the myths about the vaccine that continue to circulate.

## 25.5 Leading by example

There has been a sharp decline of vaccination of healthcare professionals across Europe. During the 2018 flu season, the number of cases of flu in nurses was high, with the consequence that certain wards in hospitals had to be closed in part because of staff sickness. This came at a time when there was already a shortage of nurses in Europe.

From Anonymous Nurse:  
Convincing Patients to Get  
Vaccinated is Becoming  
More Difficult (QR code 18)



**The spread of  
misinformation has meant  
more patients are refusing  
vaccines**



From Anonymous Nurse:  
Convincing Patients to Get  
Vaccinated is Becoming  
More Difficult **(QR code 18)**



**Yet despite overwhelming evidence of the complications from not being vaccinated, the huge amount of information, and misinformation, available on the internet still results in patients refusing vaccines. There's so much information floating around out there that it can be difficult for non-medical people to understand what is legit and what is downright false**



SCAN ME  
(QR code 18)

People who work in healthcare settings are frequently exposed to germs while being with or around patients. Vaccinating healthcare professionals, including physicians and nurses, helps protect them from potentially dangerous diseases such as flu and whooping cough, as well as protecting the patients in their care. This is particularly important when working in hospital settings, as vaccination of healthcare professionals is the main measure for preventing nosocomial infections, such as influenza.

Hospitals, medical staff and regulators have the responsibility to support nurses to be up-to-date on recommended routine vaccines. Immunization promotes optimal health and protects patients and the community from vaccine preventable diseases. Nurses work in environments where they are exposed to many communicable diseases and infections, so it's especially important to have the following vaccines:

- Seasonal influenza
- Tetanus, diphtheria, and pertussis (TDaP) – especially for nurses working with new-born or compromised infants
- Measles, mumps, and rubella (MMR)
- Hepatitis B
- Varicella zoster

## 26 Q&A

### 26.1 Questions about vaccination in general

#### Question 1

#### IS THERE A LINK BETWEEN VACCINATION AND AUTISM?

**Answer 1** No – there is no link between vaccination and autism. This has been proven by many studies over the past decade, involving hundreds of thousands of people.

#### Question 2

#### I HAVE HEARD THAT THERE ARE HEAVY METALS/ANTIFREEZE/MERCURY/HARMFUL CHEMICALS IN VACCINES

**Answer 2** All of the ingredients in vaccines have been shown to be safe in many clinical trials, and in the millions of people who have been given vaccines over many years.

#### Question 3

#### I'M HEALTHY AND DISEASES LIKE MEASLES AND FLU AREN'T REALLY THAT SERIOUS - WHY SHOULD I GET VACCINATED?

**Answer 3** Even in healthy people, vaccine-preventable diseases can be dangerous for some. In pregnant women, babies and those who have issues with their immune systems, the complications can be life-changing or even fatal. People who are not vaccinated can pass on infection even when they feel well. The more people who are vaccinated, the less infection is circulating in the community and so the vulnerable people are protected. Getting vaccinated protects you. But it also protects your friends, your family, your colleagues and the wider community.

#### Question 4

#### WHAT IS HERD IMMUNITY?

**Answer 4** When enough people in a community are vaccinated, the risk of infection goes down, protecting people who are not vaccinated – this is known as herd or community immunity. When the levels of vaccination go down, the risk of disease increases.

#### Question 5

#### CAN EVERYBODY BE VACCINATED?

**Answer 5** Not everybody can be vaccinated – it depends on age, health and treatments for illness. Talk to your nurse about whether you can be vaccinated.

#### Question 6

#### CAN PEOPLE HAVING CHEMOTHERAPY OR STEM CELL/BONE MARROW TRANSPLANTS BE VACCINATED?

**Answer 6** People having chemotherapy, or being prepared for stem cell/bone marrow transplants can be more vulnerable to infection. Vaccine choice and vaccine timing is important – for example, these individuals can have inactivated vaccines, but not live vaccines. It is also important that friends, family and healthcare professionals are up to date on vaccinations, to avoid transmitting the disease during this critical period.

**Question 7****WHY DO PEOPLE OLDER THAN 60 OR 65 GET DIFFERENT VACCINES?**

**Answer 7** As people age, their immune system becomes less effective. They may be given higher dose vaccines, or vaccines that contain an adjuvant to increase the immune response. Older people may also be given boosters to increase the response to earlier vaccines.

**Question 8****WHY SHOULD I ONLY HAVE A VACCINATION WHEN I FEEL WELL**

**Answer 8** Vaccines are more effective when you are healthy. However, mild illness is not a reason to delay vaccination.

**Question 9****I WORK IN A HOSPITAL BUT I'M IN THE OFFICE – WHY DO I NEED TO BE VACCINATED?**

**Answer 9** Even if you aren't in direct contact with patients, you may be in contact with doctors, nurses and patients, for example in the corridors or in the hospital restaurant, and so you may put them at risk if you are not vaccinated.

**26.2 Questions about flu vaccines****Question 10****I HAD THE FLU VACCINE LAST YEAR AND A STILL GOT THE FLU – SOMEONE SAID IT WAS BECAUSE THEY USED THE WRONG STRAIN. WHY SHOULD I GET A VACCINE THIS YEAR?**

**Answer 10** The team developing the flu vaccine each year track data from 142 national influenza centres in 113 different countries around the world. This allows them to understand which strains of the virus are making people sick, how efficiently those strains are spreading, and how well previous vaccines have worked to combat their targeted viruses. Researchers at the World Health Organization Collaborating Centres for Reference and Research on Influenza analyse the data to identify new flu strains and to determine which strains of the virus are most likely to spread and cause illness in the upcoming flu season. Recommendations are made in February for the composition for the annual seasonal flu vaccine for the northern hemisphere, and in September for the southern hemisphere. This information is shared with all vaccine manufacturers.

Even if the flu strains in the vaccine and those that are circulating aren't an exact match, the vaccine will still protect against some cases of flu, and can reduce the risk of complications such as pneumonia.

Getting a flu vaccine every year helps to maintain levels of immunity.

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## MODULE 4

# Antimicrobial Resistance



**After reading Module 4,** you will understand the basics of AMR, how it develops, and how it spreads. You will know more about how to treat patients with AMR infections. You will also understand how to prevent and contain AMR, and know more about the role of the One Health approach, which co-ordinates action across sectors, including veterinary health, agriculture and environmental health. You will understand the key principles of stewardship and help to create programs. You will also know more about the specialist nurses' engagement in European Union initiatives and international health organisations.

J. RICHARD  
**CLARKE**

”

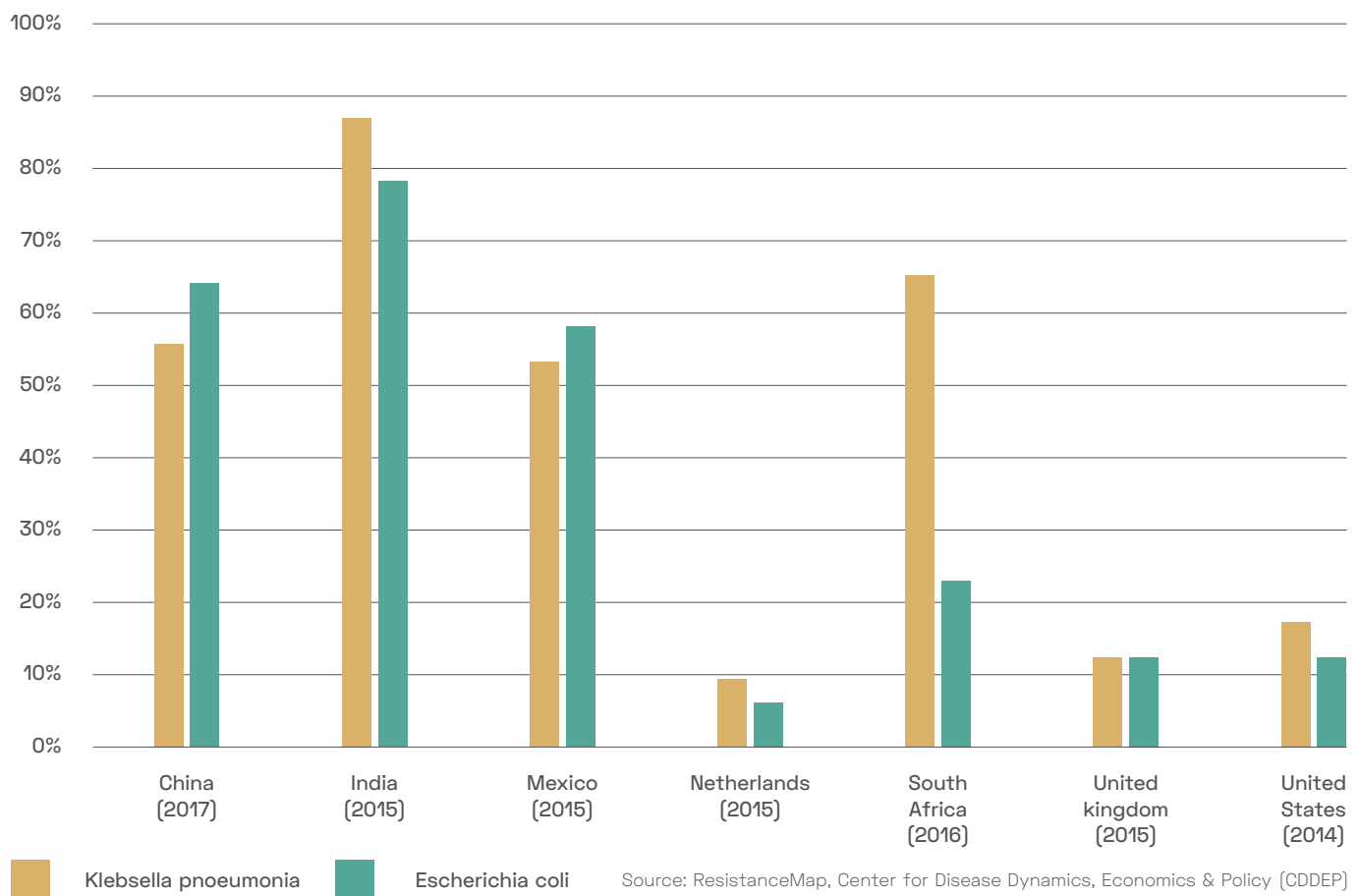
**The best leader  
brings out the best  
in those he has  
stewardship over**

## 28 Antimicrobial resistance, a threat to human health and professional practice

Drug-resistant infections are one of the most urgent global threats to human and animal health. Unless appropriate measures are put in place worldwide, by 2050, 10 million people will die because of infections [1].

Although these infections affect all countries, nurses in each country may face different challenges because of variations in microorganisms, patterns of resistance and available resources – for example, many infections are much more frequent in southern and eastern countries [2] (Figure 34). To deal with these variations, nurses need to learn best practices for antimicrobial use and infection prevention and control.

**FIGURE 37: CROSS-COUNTRY COMPARISON OF E.COLI AND K. PNEUMONIAE RESISTANCE PATTERNS**



Drug resistant infections will affect the delivery of many clinical procedures and treatments, such as cancer chemotherapy or obstetric surgery. Such effect will have a major impact on nursing care and practice across Europe.

Drug resistance is a natural part of the evolution of microorganisms, and cannot be stopped. However, excessive or inappropriate use of antibiotics can speed up its development [3]. To slow the increase of antimicrobial resistance, and to reduce its effects, a combination of clinical, organisational, and educational processes, known as antimicrobial stewardship (AMS), has been developed to improve the use of antibiotics [4].



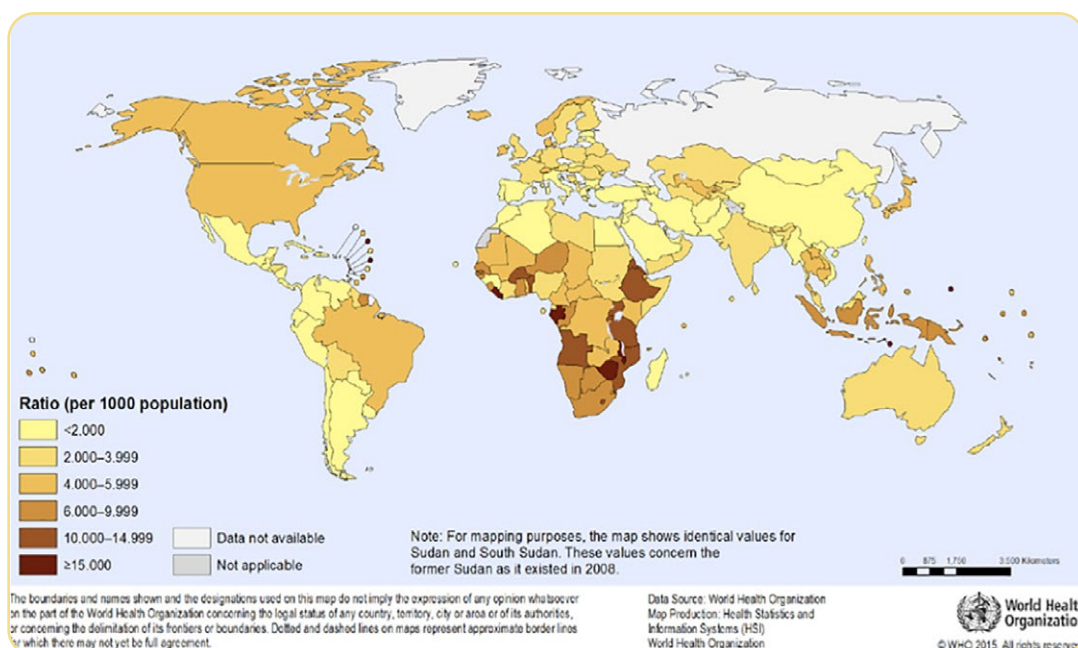
The effectiveness of AMS measures varies, depending on where and how they have been implemented. Many factors influence the decisions to use antibiotics, including personal, team and organisational approaches, culture and policy. However, AMS is overall an effective and safe approach [5,6].

## 28.1 Excellent nursing care includes optimal use of antibiotics

Nurses are the largest workforce in healthcare [7] (Figure 38), and they play a key role in AMS. In many settings worldwide, nurses are the closest to the community, and may be the only, most qualified or most accessible healthcare workers [8].

**FIGURE 38:  
NURSE-  
MIDWIFE/  
PHYSICIAN  
RATIO PER 1000  
POPULATION**

Source: WHO



There are many points in the antibiotic prescribing process where generalist and specialist nurses and their nursing skills and knowledge can be involved, and where nurses can demonstrate how best manage these drugs. See the following sections for some examples of clinical tasks and responsibilities which are central to nursing practice and antimicrobial stewardship.

Antimicrobial stewardship is not an extra or new task that nurses must include in their routines, but a set of skills, knowledge and behaviour that are already part of essential routine nursing care [9].

**Excellent nursing care is excellent antimicrobial stewardship, and equally, excellent antimicrobial stewardship is excellent nursing care [9]**

## 28.2 Challenges remain for nurses to engage in AMS


There are challenges that need to be resolved to help nurses to get involved in AMS, for example some nurses are not familiar with the meaning of antimicrobial stewardship, or think that stewardship refers only to the correct prescription of antibiotics. This puts the responsibility of the appropriate use of antibiotics on just those doctors and nurses that are qualified to prescribe.

However, non-prescribing nurses can still influence the decisions to prescribe antibiotics by:

- Being part of multidisciplinary ward rounds and providing information about their patients
- Reporting the clinical improvement of patients following the administration of intravenous antibiotics
- Ensuring that appropriate biological samples are obtained promptly, and their results are transmitted swiftly so they inform prescribing decisions
- Administering antibiotic doses correctly and without interruption

These are all part of essential nursing tasks and behaviours, and these behaviours are required worldwide [10].

**TABLE 24: AMS TASKS UNDERTAKEN AS PART OF THE JOB**



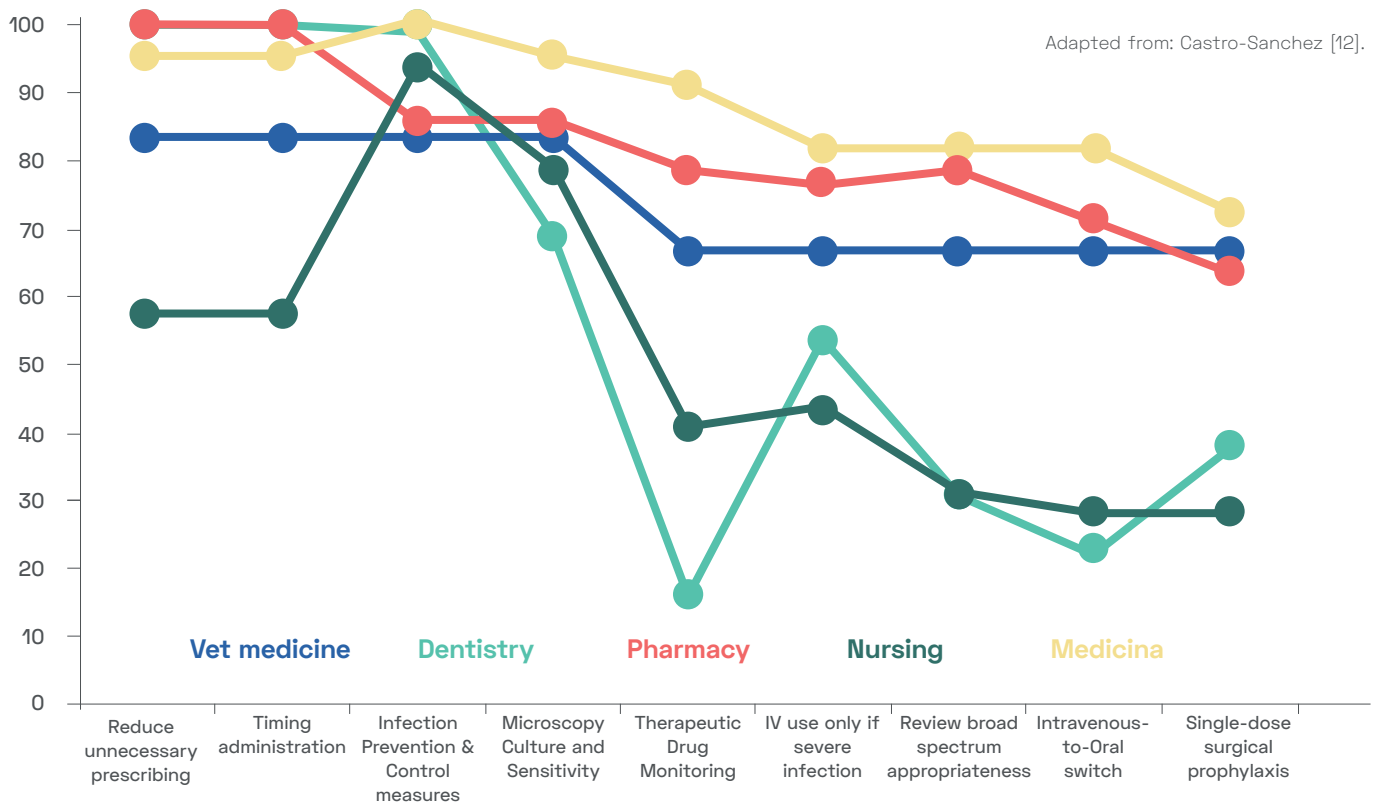
Teach about infection prevention and control
Teach about appropriate use of antimicrobials
Lead or take part in audits and data collection on antimicrobial usage
Communicate laboratory reports daily to the treating prescriber
Remind the treating prescriber to review daily the need for any devices e.g. urinary catheters, central line
Ensure the suitable implementation of protocols for antimicrobial treatments
Ensure that the correct dose of antimicrobials is administered at the right time
Membership of the committee making decisions about antimicrobial prescribing
Remind the treating prescriber to review the antimicrobial daily once the specimen result is known
Ensure adequate and prompt timing of antimicrobial administration in critically ill patients ('hang time')
Remind the treating prescriber to review the need for antimicrobials on day 3 and 7
Ensure that adequate doses of antimicrobials are given according to patient characteristics
Develop antimicrobial prescribing policies and guidelines
Prescribe antimicrobials

Source: Bulabula [10]

## 28.3 Gaps in education about antibiotics hinder the participation of nurses in AMS

The optimal use of antibiotics, and the participation of nurses in the process, is not necessarily part of the undergraduate nursing education curricula [11]. For example, in the UK only 63% of nursing university courses included AMS among the content, with an average of 10 (interquartile range 4.5–13.5) hours taught to students. More worryingly, only 13% of nursing courses included all the principles of AMS recommended by the national public health agency within the educational content. The least time is given to the optimal use of antibiotics in the intravenous-to-oral antibiotic switch, and the need to administer only one dose of antibiotic as surgical prophylaxis [12].

**FIGURE 39: ANTIMICROBIAL STEWARDSHIP EDUCATION, UNDERGRADUATE UK COURSES, 2013**



Gaps in knowledge behaviour because of lack of training mean that nurses may hesitate to take part in antibiotic improvement interventions. This is not only a problem in the UK; there are similar problems in the US and Europe [13,14].

**What is the education about antibiotics in the undergraduate curriculum in your country? Find out. Consider how to get involved via your professional association or union, or your national regulatory nursing body**

As an example, proposals to include nurses in stewardship programmes have given them bedside roles, such as reminding prescribers about the ideal duration of antibiotic courses, or challenging inappropriate or suboptimal antibiotic prescribing [15]. However, the nurses didn't always get support or training to help them deal with any friction resulting from these requests, which can lead to disinterest and disengagement [11]. These tasks can also reinforce the nurse's role as an assistant, rather than as an HCP in his or her own right.

### How to engage in conversations about appropriate use of antibiotics?

Some teams have proposed to use structured conversations about antibiotics to raise issues related to prescriptions and decisions about antibiotics, with a view to improve organisational performance in this area [16]

«Ms X's culture results are back from the laboratory. The culture is positive for \_\_\_\_\_. She is currently receiving the following antibiotic(s)\_\_\_\_\_. Do you want to continue this/these antibiotic(s)?»

«The sensitivities on Ms X's culture(s) have been received from the laboratory. The report indicates the isolate is sensitive/resistant to\_\_\_\_\_. She is currently receiving the following antibiotic(s)\_\_\_\_\_. Do you want to continue this/these antibiotic(s)?»

«Ms X is afebrile and tolerating clear liquids, do you want to change her intravenous antibiotic to an oral alternative?»

Making AMS more relevant for nurses needs to reinforce their role in quality of care, patient safety, or excellence of nursing care (Table 25). Making it about ‘doing the right thing for patients is the most important thing for nurses’ will be easier to build into nursing routines, and empower nurses to get involved in prescribing decisions [17].

**TABLE 25: TAILORING ANTIMICROBIAL STEWARDSHIP MESSAGES TO DIFFERENT HEALTHCARE WORKERS**

Healthcare professional category	Key messages and suggested intervention tag lines		
	Hand hygiene	Antimicrobial stewardship	MRO isolation
Doctors—overall	«Hand hygiene appropriately—you know it’s right»	«Think about what’s needed—use antibiotics carefully»  «Re-assess the situation and prescribe appropriately»	«MRO isolation?—it’s too important—so follow the rules»  «Isolation rules are important—so follow them and avoid the consequences»
Senior medical officers—fulltime (SMOs)	«The benefits of good hand hygiene in preventing hospital-acquired infections are indisputable»	«Antimicrobial prescribing should be rational with a clear indication, duration and expected outcome»	«Placing patients into isolation is inconvenient, but the risk of transmitting MROs to other patients is a much bigger issue»
Senior medical officers—part-time (VMOs)	«Unless you do good hand hygiene, your reputation will suffer»	«You are smart, so prescribe appropriately»	«You will be monitored with mandatory reporting—so don’t risk your reputation»  «The bugs are smart too, so follow the isolation rules»
		«Prescribe appropriately—or there could be problems»	

<b>Hospital medical officers (HMOs)</b>	<<Realise your potential—perform good hand hygiene>>	<<Check and get antibiotic approval, you know your career is worth it>>	<<It's easy to follow the isolation protocols and lead the way—don't jeopardise your future>>
	<<Don't wreck your future career by striking out on hand hygiene>>	<<Appropriate antibiotic prescribing shows your potential>>	
<b>Nurses-allied health</b>	<<Every time you hand hygiene, it shows you care>>	<<Antibiotic prescribing is a doctor's responsibility, caring for the patient is yours>>	<<Don't take the bugs in this room home with you—follow the rules>>
	<<Every 50 times you hand hygiene you save a life>>	<<Caring for your patients means it is OK to ask if the antibiotic is appropriate>>	<<Care for all your patients and follow the isolation rules>>
		<<Care for your patients—check if their antibiotics are appropriate>>	
<b>Support services</b>	<<A good job needs good hand hygiene>>	Not applicable	<<Keep your job—follow the isolation rules>>
	<<Good hand hygiene is essential to doing a good job>>		<<Isolation rules?—just do it>>
	<<You know when to hand hygiene—so do it>>		

Source: Grayson [17]

Improving AMS teaching could fall into the domains shown in Table 26.

**TABLE 26: SUGGESTIONS FOR AMS TEACHING DOMAINS FOR NURSES**

Source: Castro-Sanchez [11]

<b>Domain</b>	<b>Topic</b>
<b>Domain One</b>	Infection prevention and control
<b>Domain Two</b>	Antimicrobials and antimicrobial resistance
<b>Domain Three</b>	The diagnosis of infection and the use of antimicrobials
<b>Domain Four</b>	Antimicrobial prescribing practice
<b>Domain Five</b>	Person centred care
<b>Domain Six</b>	Interprofessional collaborative practice

## 28.4 Antimicrobial stewardship is not an extra job for nurses

Nurses have heavy workloads, and they may feel that adding another task to their daily activities is hard because of staff shortages, clinical and administrative workloads, or lack of resources. The principles of optimal antibiotic management included in national and international guidelines are already part of their day-to-day work. The steps included in the UK national action plan ‘Start Smart then Focus’ [18] are all part of nursing roles and responsibilities (see Table 27).

**TABLE 27: START SMART THEN FOCUS KEY STEPS**



Start smart	Then focus
<p>Do not start antimicrobial therapy unless there is clear evidence of infection</p> <p>Take a thorough drug allergy history</p> <p>Initiate prompt effective antibiotic treatment within one hour of diagnosis (or as soon as possible) in patients with severe sepsis or life-threatening infections. Avoid inappropriate use of broad-spectrum antibiotics</p> <p>Comply with local antimicrobial prescribing guidance</p> <p>Document clinical indication (and disease severity if appropriate), drug name, dose and route on drug chart and in clinical notes</p> <p>Include review/stop date or duration</p> <p>Obtain cultures prior to commencing therapy where possible (but do not delay therapy)</p> <p>Prescribe single dose antibiotics for surgical prophylaxis where antibiotics have been shown to be effective</p> <p>Document the exact indication on the drug chart (rather than stating long term prophylaxis) for clinical prophylaxis</p>	<p>Reviewing the clinical diagnosis and the continuing need for antibiotics at 48-72 hours (or earlier) and documenting a clear plan of action - the ‘antimicrobial prescribing decision’</p> <p>The five ‘antimicrobial prescribing decision’ options are:</p> <ol style="list-style-type: none"> <li>1. Stop antibiotics if there is no evidence of infection</li> <li>2. Switch antibiotics from intravenous to oral</li> <li>3. Change antibiotics – ideally to a narrower spectrum – or broader if required</li> <li>4. Continue and document next review date or stop date</li> <li>5. Outpatient Parenteral Antibiotic Therapy (OPAT)</li> </ol> <p>It is essential that the review and subsequent decision is clearly documented in the clinical notes and on the drug chart where possible e.g. stop antibiotic</p>

Source: Public Health England [18]

## 28.5 The prevention of infections is an area where nurses can excel

Nurses have many opportunities to take part in the process of antibiotic use. Their most important role may be in the prevention of infection, maintenance of patients' health, and promotion of patients' self-care. These steps will reduce antibiotic prescription and, in the long term, reduce the development of antimicrobial resistance.

# 29 Preventing infections

## 29.1 Vaccination

Nurses in hospitals and primary care, school nurses, midwives and health visitors play an important role in promoting vaccination. Nurses can reduce infections in patients and in the general population by promoting the uptake of routine vaccines in national immunisation schedules [19,20]. By lowering the numbers of medical visits, diagnostic tests, treatments and hospital stays, vaccination can reduce healthcare costs [21,22].

**Promoting influenza vaccines can help to lower the numbers of bacterial infections, decreasing antibiotic use and potentially lowering the development of antibiotic resistance [23]**

Nurses and midwives can encourage and support pregnant women to make decisions about whooping cough or influenza vaccination, two health problems particularly relevant for this population group [24]. Module 3 on vaccination provides resources for nurses involved in vaccination programs.

## 29.2 Patient, families and citizen education

An essential part of nursing is educating patients, caregivers, colleagues and the general public in the correct and best use of antibiotics. This includes:

- Practical skills to increase effective and safe self-management of minor health problems
- Information on the role of antibiotics in bacterial infections, including benefits and potential side effects in the short- and long-term
- The importance of taking antibiotics as prescribed and disposing of any remaining antibiotics safely.
- Understanding the cultural, social and behavioural backgrounds of patients, where it might affect their use of antibiotics
- Using the right levels of language, supported by patient representative groups.
- Sometimes people use antibiotics inappropriately because of their situation:
- Patients know that they should complete the course of antibiotics, but they can't afford to buy all that they need
- Patients can't afford the consultation fees, so they don't get the right information or help
- Patients buy antibiotics over the internet, because it's easier than getting an appointment with a nurse or doctor.

Understanding this helps nurses to provide support as well as education.





The advice and information should be tailored to local self-care measures, and could be useful for patients to show to relatives and neighbours. Nurses need to be aware of guidelines and agreed best practice, and use their clinical judgement along with shared decision-making to find the best solution for their patients.

Nurses and other prescribers can give patients a delayed prescription, advising patients to wait for a period of time before taking the prescription.

### Case studies

In a UK study of no prescriptions or delayed prescribing for patients visiting the doctor for respiratory tract infections, fewer than 40% of the patients had antibiotics [25]

## 29.4 Nursing in long-term care facilities and nursing homes

People in long-term care and nursing homes need skilled nursing care because of their vulnerability, and because of the potential difficulties accessing medical or specialist advice. One of the important care needs for these patients is ensuring that they get enough fluids. This can reduce infection, and could also cut the number of urine analyses or dip tests for 'concentrated urine' [26,27]. These samples and tests can bring up false positives for bacterial infection, which could lead to unnecessary antibiotic prescribing [28].

Another way to reduce infection levels is to manage urinary catheters carefully. This includes optimal care, daily evaluation of their continued need and use, and prompt decisions to remove them when no longer needed [29,30]. The use of incontinence pads is linked with increased risk of UTIs [31]. Cutting down the use of incontinence pads and helping people to remain mobile and use toilets independently may help with infection prevention, and also preserves people's dignity and self-sufficiency.

Oral care is important for people unable to look after themselves, and improving oral care may reduce the risk of infection [32]. Avoiding the build-up of tartar reduces the risk of bacterial infections inflammation in the mouth and gums, which can lead to infection [33]. It is equally important for nurses to remember that dentures should receive similar attention. Keeping hydrated increases comfort in people's mouths and enhances the antibacterial action of saliva [34].

All of the activities suggested in this section are useful to nurses and patients in every setting, and allow nurses to use their clinical judgement, experience and expertise to make decisions about optimal care for all patients. These actions play an important part in both antimicrobial stewardship and essential nursing care. Nurse educators and nurses in leadership and management positions should help to build and sustain healthcare approaches that support nurses in clinical practice, and help them to resolve the challenges presented by infections.

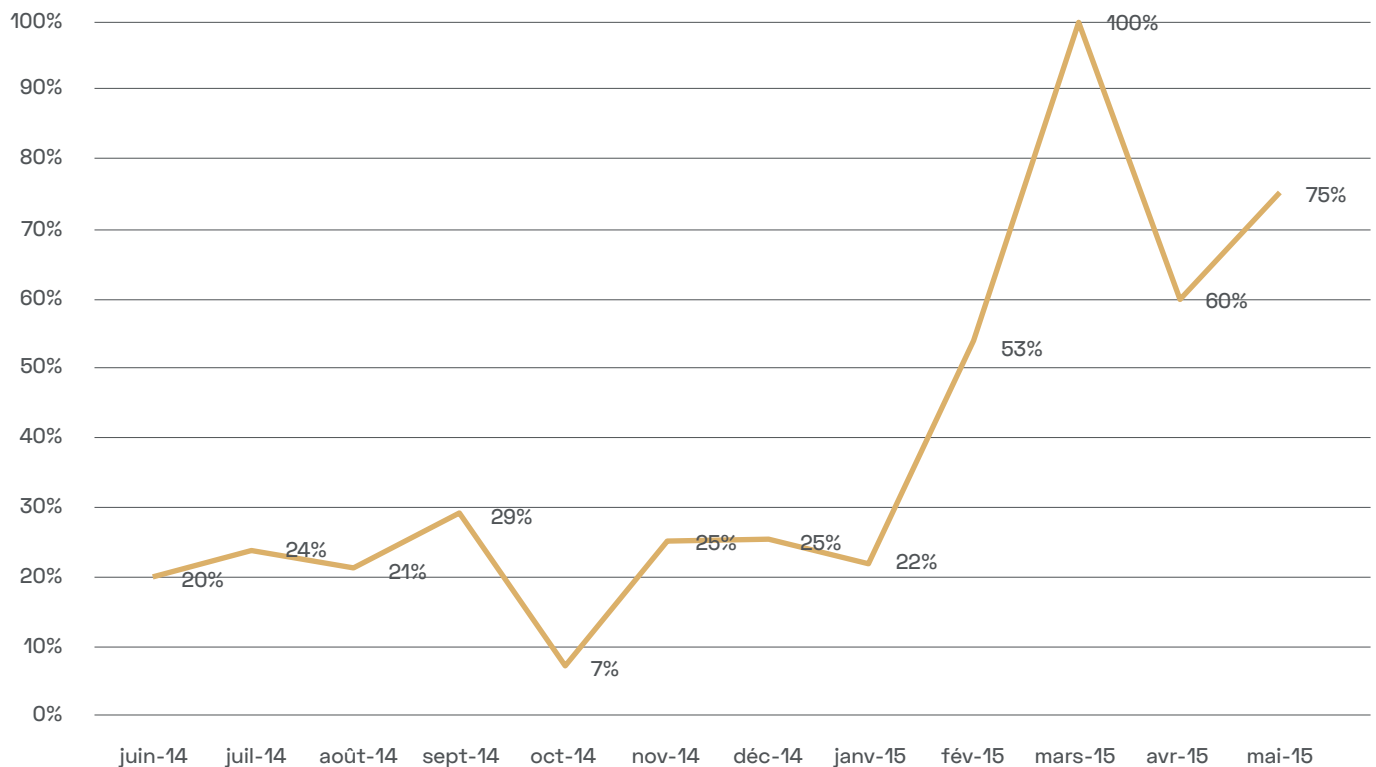
Different populations have different factors that affect health and illness, and that drive infections and antibiotic use. Understanding these can help nurses in community and public health positions care for the populations and reduce the reliance on antibiotics. All nurses can work as advocates for patients and the wider population to make sure that the factors affecting health and disease, such as poverty and deprivation are addressed by policymakers in health and non-health policies.

## 30 Promoting optimal antibiotic use

The approach to optimal antibiotic use, as included in national and international recommendations, reflects the best nursing practice and is appropriate for nurses across all settings and countries.

Training in and understanding of antimicrobial stewardship can improve the number of days that patients remain on treatment (Figure 41).

**FIGURE 41: IMPROVEMENT IN ANTIBIOTIC TREATMENT DURATION FOLLOWING A NURSE-FOCUSED INTERVENTION**



Source: du Toit [35]

**Nurses are ideally placed to contribute to the reduction of unnecessary antibiotic use or the improvement of antibiotic decisions by taking appropriate biological samples for microscopy and culture before beginning antibiotic treatment.**

TABLE 28: OPTIMAL SAMPLE COLLECTION



Do	Don't
Obtain the specimen before the patient starts antimicrobial therapy if possible	Don't take a specimen from exudate or eschar
Review the indication for obtaining the wound culture	Don't use a cotton-tipped swab
Gather supplies to clean the wound, obtain the specimen, and redress the wound	Don't let the sterile swab touch your fingers or other objects
Provide privacy	
Confirm the patient's identity and explain the procedure	
Position the patient	
Perform hand hygiene and put on clean gloves	
Remove the dressing, dispose of gloves and dressing, and perform hand hygiene	
Assess the wound and surrounding tissue	
Arrange the sterile field	
Put on clean gloves and thoroughly rinse the wound with sterile saline solution	
Remove the gloves, perform hand hygiene, and put on clean gloves	
Collect specimen by swabbing the wound in a gentle, rotating manner	
Use a sterile calcium alginate or rayon swab between your fingers	
Swab from margin to margin in a 10-point zigzag fashion	
Use enough pressure to express fluid from within the wound tissue	
Place the swab in the culture medium, label it as per local policy	
Send to the lab immediately	
Redress the wound	
Take off gloves and perform hand hygiene	
Assess patient, ensure that wound pain is managed	
Document the procedure, any findings, and the patient's response	



Samples should be collected according to agreed best practice and guidelines. Wound swabs are not always needed, as they can just reflect the bacteria that normally live on the body or that are contaminating the wound, rather than showing that there is an infection [36]. When wound swabs are needed, these should be taken from the appropriate sites (see Table 28).

## 30.1 Review and communicate microscopy or culture results promptly

Nurses should be aware of the timescales for laboratory results, review these when they arrive, and then pass the results on to prescribers so that the patient treatment can be started or adjusted as quickly as possible. This also allows infection prevention and control measures to be put in place, for example for *C. difficile* stool samples, or carbapenem-resistant organisms. Nurses can help to improve communication by being familiar with standard operating procedures and engaging in their development.

## 30.2 Timely administration of antibiotics

Another core activity for nurses across all settings is the timely administration of antibiotics, including loading doses, according to the prescription. Understanding how the levels of drug vary in the body (pharmacokinetics and pharmacodynamics) can help as a reminder of the importance of timely dosing, and of getting the loading dose right.

## 30.3 Missed antibiotic doses

Patients can miss antibiotic doses for a variety of reasons. For example, a study in a shock trauma intensive care unit showed that over half had missed doses or off-schedule doses, and this was linked with a longer stay in hospital [38]. As well as affecting patient health, missed doses also weaken any public health messages focused on keeping up with antibiotic dosing after discharge or when accessing primary and community care. Patients may feel that if there is no apparent issue when missing antibiotic doses whilst in hospital, there may not be any concern about similar events when at home.

Nurses can avoid the risk of missing antibiotic doses by planning care tasks and activities around the timing of doses. They should also ensure that patients receive the full dose of antibiotic by flushing the infusion lines when the bag containing the antibiotics is empty. Failing to do this can result in patients missing out on around a fifth of the dose [39].

## 30.4 Monitor patient response to treatment

Because nurses remain close by throughout patient treatment, this gives them a unique opportunity to monitor the effectiveness of antibiotic therapy. To help decisions about treatment, nurses should measure and record observations and vital signs accurately and at the best time, including temperature and blood pressure. Nurses can also make sure that the route of administration, for example oral, is the most appropriate for the patient, and discuss this with the clinical team and prescribers. If the patient's condition deteriorates and different therapeutic regimens are needed, nurses should alert the multidisciplinary team and be aware of potential alternative treatments

## 30.5 Monitor duration of antimicrobial therapy

Along with monitoring the patient's response to therapy, nurses should also feel confident to discuss therapy duration with colleagues in the multidisciplinary team, as the treatment approaches or exceeds recommended length. This is part of an emerging drive to minimise as much as safely possible the exposure of patients to antimicrobials, underpinned by a growing body of evidence over the optimal duration [40,41]

Often, nurses have been asked to ‘challenge’ inappropriate prescribing or remind colleagues of best practice, and this is not always easy to do, especially if colleagues are senior to the nurse [42] or there are social or team norms on prescribing. However, nurses must recognise their potential to participate and influence antibiotic decisions, particularly when antimicrobial course duration is based on good quality evidence.

## 30.6 Educate students, trainees and other healthcare workers

Nurses play a crucial role as mentors and educators for other nurses and healthcare worker colleagues. The gaps in undergraduate and postgraduate education about appropriate use of antimicrobials may be mitigated by demonstration of essential nursing in practice. Nurses can use bedside, research and managerial opportunities to highlight the collective role that the profession has in this area.

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## MODULE 5

# Infection Prevention and Control



**After reading module 5,** you will understand how to prioritise activities on infection control and prevention within healthcare settings. You will know about the chain of infection, and the principles of hygiene. You will understand how hand hygiene and personal protective equipment safeguards both patients and healthcare professionals, and know about the role of aseptic no-touch techniques. You play a critical role in infection control, both through practical roles, and as educators for healthcare professionals, patients and carers.

JIDDU  
KRISHNAMURTI

”

**One is never afraid  
of the unknown,  
but is afraid of the  
known coming to  
an end**

## 32 Introduction

Ignaz Semmelweis (1818-1865) began the modern understanding of infection prevention and control. Born in Buda (now Budapest) in Hungary, he gained his medical degree at the University of Vienna in 1844 and started working as an assistant to a professor in maternity in 1846. In the First Department, between 13% and 18% of women who had their babies delivered by physicians and medical students died as a result of childbed fever (today known as puerperal fever), brought in on the hands of the physicians and students who came from the dissection room. In the Second Department, where babies were delivered by midwives and midwife trainees, the mortality rate was around 2%.

Semmelweis placed large bowls of bleach at the entrance to the maternity clinic, so that everyone who attended a birth would do so with clean hands. During the next seven months the rate of death from puerperal fever fell to decrease to 3%, and then to 1.2% in 1848 the figures for both departments fell to 1.2 percent, when the instruments were washed as well [1].

## 33 Infection

### 33.1 The chain of infection

By breaking the chain of infection (Figure 42), nurses can help to stop transmission of infection.

**FIGURE 42:  
THE CHAIN  
OF INFECTION**



## 33.2 How to break the chain of infection

Breaking the chain of infection needs answers to a lot of questions:

- **The organism**
  - > What is the organism?
  - > Bacteria, virus, parasite, or fungi?
  - > Is it aerobic or anaerobic?
  - > What are its virulence factors?
  - > What is its target host tissue?
  
- **The reservoir**
  - > Where is the organism in between infections and outbreaks?
  - > Is the reservoir in the hospital, the environment (e.g. the soil), the food or in a living organism, such as a human, rodent, bird or even a snail?
  
- **The route out of the reservoir**
  - > How does the organism leave the reservoir? In faeces, respiratory droplets, blood or mucus; in contaminated water; or in the blood meal of an insect?
  
- **The transmission route**
  - > How is the organism transmitted from the environment or host to the next host?
  - > Does it need a living vector like a mosquito or flea?
  - > Can it be passed from human to human?
  - > When passed from human to human, it is transmitted by respiratory droplets, blood contact, semen or other secretions?
  - > Is it transmitted on the hands of health care workers or the hospital ventilation system?
  
- **The route into the body**
  - > How does the organism enter the body?
  - > Does it come through inhalation, a break in the skin or mucus membrane, an insect bite, or through contaminated food?
  
- **Population**
  - > Is the population vulnerable for a specific reason?

Infection spread can be contact (Table 29), droplet (Table 30) or airborne (Table 31).

TABLE 29: CONTACT TRANSMISSION CHAIN OF INFECTION

Chain of infection	
Organism or infection	Methicillin-resistant Staphylococcus aureus (MRSA) Carbapenem-resistant Enterobacteriaceae (CRE) Extended spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae Clostridioides difficile
Reservoir	Skin/gastrointestinal tract
Route out of the reservoir	Wound Nose Urine Faeces
Transmission	Contact, for example nurse or other HCP does not perform hand hygiene after patient contact
Route into the body	Contact, for example nurse HCP empties the urinary bag and contaminates the urinary catheter system, allowing an infection to get into the bladder
Population	Patient
Transmission prevention approach	Gloves, gown or apron, and hand hygiene

In order for someone to get infected through droplet transmission, he/she needs to be <1 meter away from the patient.

TABLE 30: DROPLET TRANSMISSION CHAIN OF INFECTION

Chain of infection	
Organism or infection	Influenza Common cold Pertussis Mumps Meningococcal meningitis
Reservoir	Respiratory tract
Route out of the reservoir	Nose and mouth
Transmission	Surfaces, contaminated hands
Route into the body	Nose and mouth
Population	Patient/staff
Transmission prevention approach	Surgical mask, apron, gloves and hand hygiene

In airborne transmission, the organism remains suspended in the air. To prevent transmission, patients need to be isolated in a negative pressure room whereby the air within the room is changed 12 times per hour and the air is filtered so that infection does not spread outside of the isolation room.

**TABLE 31: AIRBORNE TRANSMISSION CHAIN OF INFECTION**

<b>Chain of infection</b>	
<b>Organism or infection</b>	Tuberculosis Measles Varicella (chickenpox)
<b>Reservoir</b>	Respiratory tract
<b>Route out of the reservoir</b>	Nose and mouth
<b>Transmission</b>	Air
<b>Route into the body</b>	Nose and mouth
<b>Population</b>	Patient
<b>Transmission prevention approach</b>	FFP2/FFP3 rated mask, gown, gloves and hand hygiene

## 34 Prevention and control

Having good hand hygiene compliance rates and antibiotic stewardship will help control the spread of infections [2].

### 34.1 Healthcare-associated infections

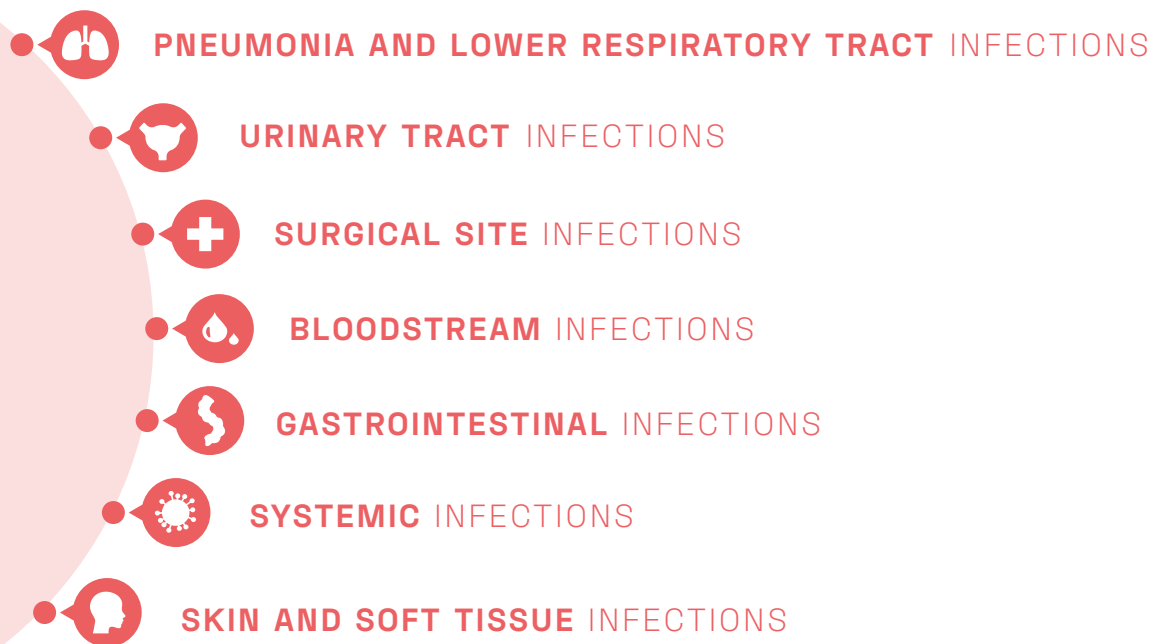
Healthcare-associated infections (HAIs) are infections acquired in any healthcare setting such as a hospital, an outpatients department or a nursing home. These infections develop after 48 hours or more following admission, or up to 30 days after care in a healthcare facility [3]. According to the WHO, the incidence of HAIs in developed countries can range from 3.5% to 12% [4]. The ECDC reported that an average of 7.1% of patients in the European Union acquire an HAI during their stay in hospital [4].

Healthcare-associated infections affect illness and death rates, in both developed and developing countries. HAIs are also very costly to treat [3]. According to the WHO, in the EU around €7 billion is spent on HAIs, with 16 million extra days of hospital stay [4].

For the most common HAIs reported by ECDC in 2016/2017, see Figure 43.



**FIGURE 43: POINT PREVALENCE SURVEILLANCE OF HOSPITAL-ASSOCIATED INFECTIONS AND ANTIMICROBIAL USE IN EUROPEAN ACUTE CARE HOSPITALS, 2016–2017**



Unless we are committed to implement infection prevention as a top priority in our healthcare institutions, patients will continue to acquire infections within the healthcare system, leading to longer hospital stays and more deaths

## 34.2 Patient safety and HAIs

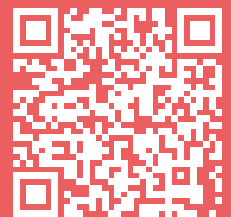
Patient safety depends on a combination of infection prevention, such as hand hygiene (the most important measure), and infection control, along with better antimicrobial stewardship. Approaches such as care bundles and checklists mean better patient care and improved use of resources [6].

## 34.3 Sepsis and systemic inflammatory response syndrome (SIRS)

### 34.3.1 Sepsis

In sepsis the immune system overreacts to an infection, damaging organs and tissues. Sepsis is a very serious condition with high rates of illness and death. In the US, admissions to hospital due to sepsis are greater than those for myocardial infarctions and strokes combined. The death rate is 25-30% [7].

Systemic inflammatory response syndrome (SIRS) and sepsis share common features, however SIRS is a broader term describing a syndrome caused by variety of factors, while sepsis is due to an infection.



SCAN ME

[QR code 19]

Early treatment with antibiotics reduces the risk of organ failure and death. The nurse has a very important role in identifying the early signs of sepsis in patients as she/he has the most interactions with patients. A sepsis screen has proven to be a useful tool for nurses when caring for patients in hospital [8].



### Case study

In a study carried out in an emergency department and in a community hospital, giving ward nurses a flow chart for sepsis identification, treatment and physician response time improved observation, increased the probability of survival and reduced with a treatment flow chart improved their clinical observations, increased the odds of survival, reduced the risk of organ failure and shortened length of stay [9].

The tool used the following criteria

SIRS TRIAGE – IF TWO OR MORE, THEN →	HAEMODYNAMIC/ORGAN FUNCTION VARIABLES		
		Medical consultation within 20 minutes	Immediate medical consultation
Blood pressure		Syst >90 mmHg	Syst <90 mmHg Syst BP fall >40 mmHg
	Mental status/Glasgow coma scale (GCS)	GCS 14-15	Acute disorientation or GCS ≤13
Temperature <36 °c or >38 °c	Saturation	>90% with O2	<90% with O2
Pulse >90 bpm	Capillary filling time	<3 sec	>3 sec
Respiratory rate >20 breaths per minute or pco <sub>2</sub> <4.3 kPa	S lactate	<3 mmol/l	>3 mmol/l
Leucocytes <4x10 <sup>9</sup> /l or >12x10 <sup>9</sup> /l	Thrombocytes	>100x10 <sup>9</sup> /l	<100x10 <sup>9</sup> /l
	Urine output	>0.5 ml/kg/h	<0.5 ml/kg/h

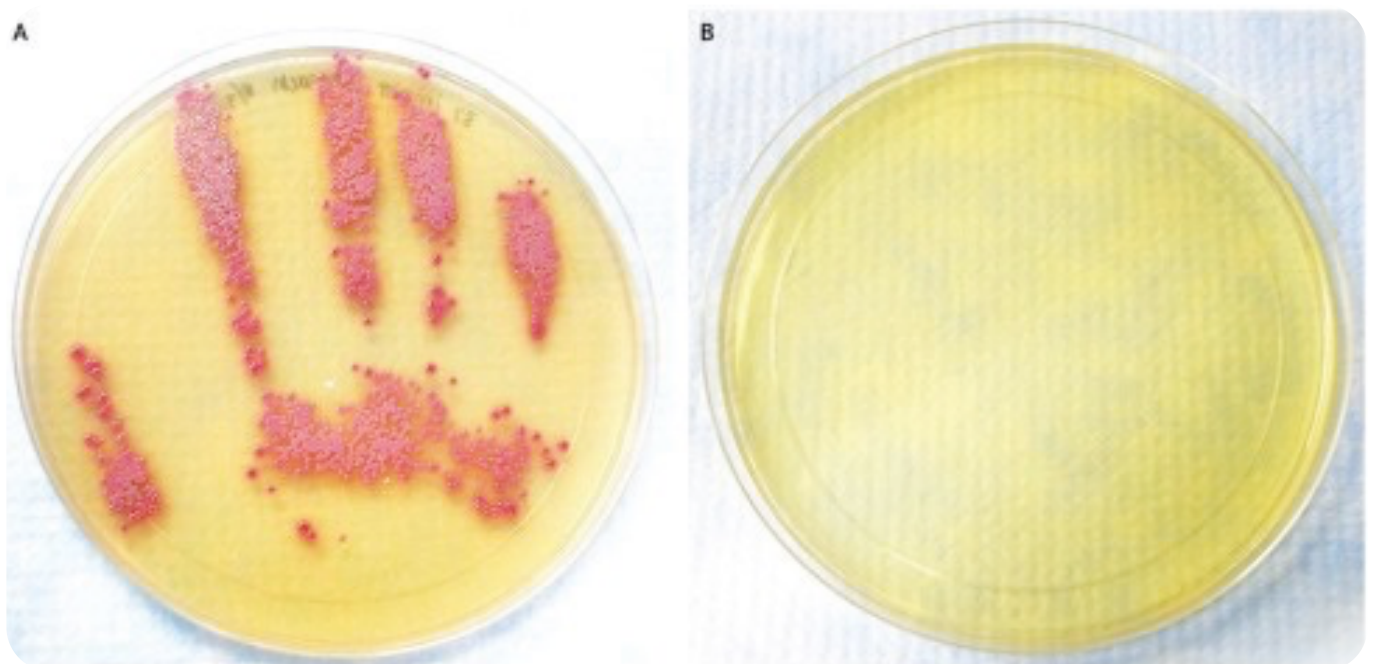
Different hospitals and countries may use different screening tools and criteria.

## 35 Principles of hygiene

### 35.1 Hand hygiene and handwashing

The Centers for Disease Control (CDC) and the World Health Organisation (WHO) have published guidelines that define hand hygiene and its role in stopping the transmission of infections, especially MDR organisms including CRE (carbapenem-resistant Enterobacteriaceae), and the other carbapenem-resistant Gram-negative organisms (CRAB, CRPA); MRSA (methicillin-resistant Staphylococcus aureus) and ESBL-producing Enterobacteriaceae.

**FIGURE 44: MRSA GROWTH BEFORE AND AFTER HAND HYGIENE**



Source: Donskey & Eckstein [10] (permission from the author)

In Figure 44 the left-side image shows an imprint of an ungloved hand following an abdominal examination of an MRSA-positive patient. The right-side image is from the same worker, after using an alcohol-based hand rub. This shows why it is important for nurses to make sure that hands are disinfected properly before and after examining patients.

Figure 45 and Figure 46, from the WHO, show the steps of effective hand hygiene using soap and water or an alcohol hand rub

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GLOBAL HANDWASHING DAY

OCTOBER 15

October 15 is Global Handwashing Day, a global advocacy day dedicated to increasing awareness and understanding about the importance of handwashing with soap as an effective and affordable way to prevent diseases and save lives.

# How to Handwash?

WASH HANDS WHEN VISIBLY SOILED! OTHERWISE, USE HANDRUB



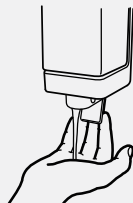
Duration of the entire procedure: 40-60 seconds

0



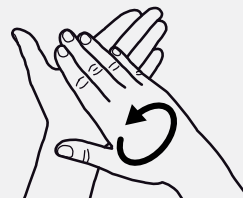
Wet hands with water;

1



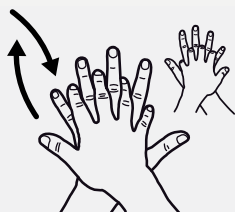
Apply enough soap to cover all hand surfaces;

2



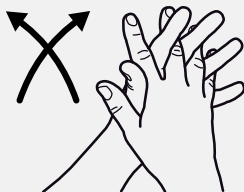
Rub hands palm to palm;

3



Right palm over left dorsum with interlaced fingers and vice versa;

4



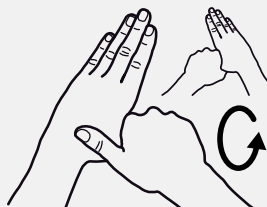
Palm to palm with fingers interlaced;

5



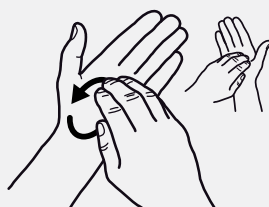
Backs of fingers to opposing palms with fingers interlocked;

6



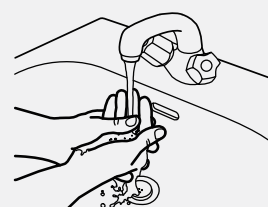
Rotational rubbing of left thumb clasped in right palm and vice versa;

7



Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;

8



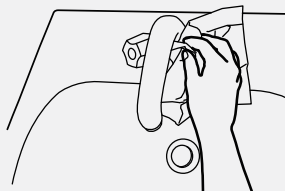
Rinse hands with water;

9



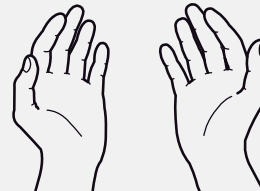
Dry hands thoroughly with a single use towel;

10



Use towel to turn off faucet;

11



Your hands are now safe.



World Health Organization

Patient Safety

A World Alliance for Safer Health Care

SAVE LIVES

Clean Your Hands

All reasonable precautions have been taken by the World Health Organization to verify the information contained in this document. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization be liable for damages arising from its use. WHO acknowledges the Hôpitaux Universitaires de Genève (HUG), in particular the members of the Infection Control Programme, for their active participation in developing this material.

FIGURE 46: HOW TO USE ALCOHOL HAND RUB

# How to Handrub?

**RUB HANDS FOR HAND HYGIENE! WASH HANDS WHEN VISIBLY SOILED**

 **Duration of the entire procedure: 20-30 seconds**

**1a**

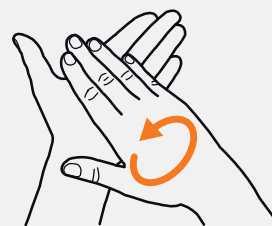


Apply a palmful of the product in a cupped hand, covering all surfaces;

**1b**

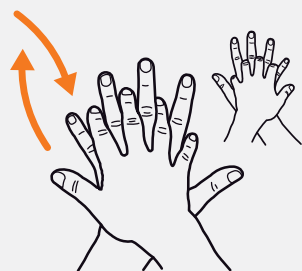


**2**



Rub hands palm to palm;

**3**



Right palm over left dorsum with interlaced fingers and vice versa;

**4**



Palm to palm with fingers interlaced;

**5**



Backs of fingers to opposing palms with fingers interlocked;

**6**



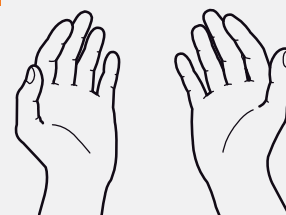
Rotational rubbing of left thumb clasped in right palm and vice versa;

**7**



Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;

**8**



Once dry, your hands are safe.



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Source: WHO

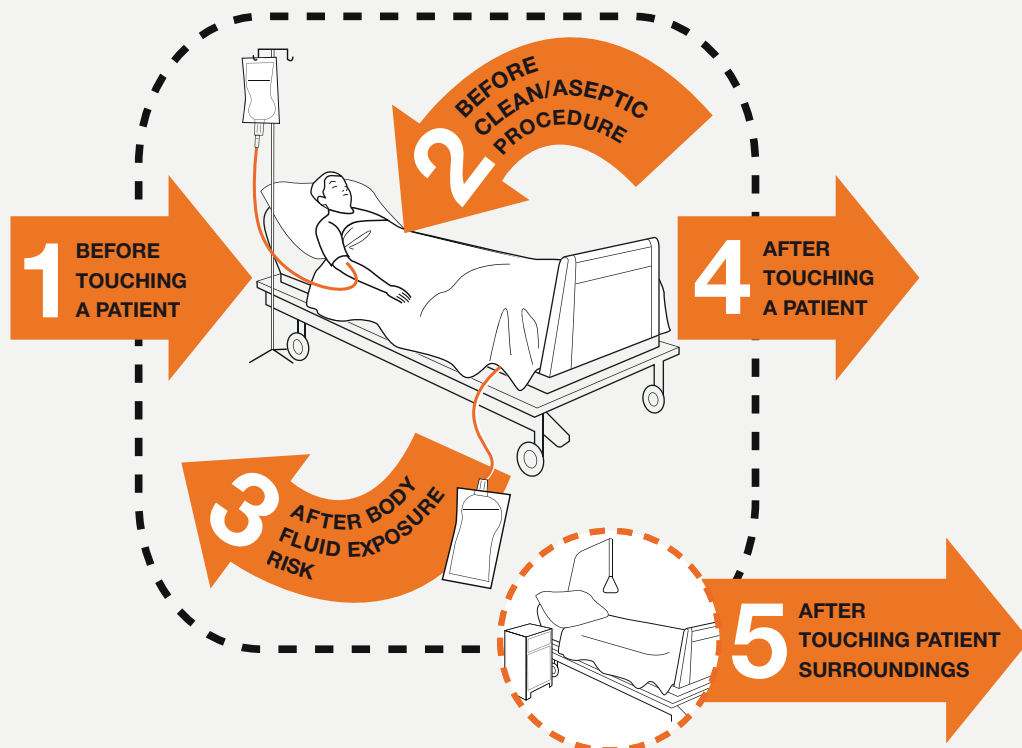
The WHO has also developed 'moments of hand hygiene', which are important steps to stop the transmission of infection between nurses and patients, on a ward (Figure 47), and in a residential home (Figure 48).



FIGURE 47: MOMENTS FOR HAND HYGIENE ON A WARD

# When?

## YOUR 5 MOMENTS FOR HAND HYGIENE



<p><b>1</b> BEFORE TOUCHING A PATIENT</p>	<p><b>WHEN?</b> Clean your hands before touching a patient when approaching him/her.</p> <p><b>WHY?</b> To protect the patient against harmful germs carried on your hands.</p>
<p><b>2</b> BEFORE CLEAN/ASEPTIC PROCEDURE</p>	<p><b>WHEN?</b> Clean your hands immediately before performing a clean/aseptic procedure.</p> <p><b>WHY?</b> To protect the patient against harmful germs, including the patient's own, from entering his/her body.</p>
<p><b>3</b> AFTER BODY FLUID EXPOSURE RISK</p>	<p><b>WHEN?</b> Clean your hands immediately after an exposure risk to body fluids (and after glove removal).</p> <p><b>WHY?</b> To protect yourself and the health-care environment from harmful patient germs.</p>
<p><b>4</b> AFTER TOUCHING A PATIENT</p>	<p><b>WHEN?</b> Clean your hands after touching a patient and her/his immediate surroundings, when leaving the patient's side.</p> <p><b>WHY?</b> To protect yourself and the health-care environment from harmful patient germs.</p>
<p><b>5</b> AFTER TOUCHING PATIENT SURROUNDINGS</p>	<p><b>WHEN?</b> Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving – even if the patient has not been touched.</p> <p><b>WHY?</b> To protect yourself and the health-care environment from harmful patient germs.</p>

## Reducing infection transmission by handwashing

Frequent and thorough handwashing is an excellent way to reduce the transmission of bacteria, viruses and other pathogens between people, both in a hospital or clinic setting and in everyday life. Different products can work better in different situations. Key recommendations are to follow international, national, regional and or even local guidelines.

### 1. Plain non-antimicrobial soap

Lathering with soap and detergent-based handwashes and rinsing removes things sticking to the hands, including dirt, grease, organic substances and bacteria, viruses and other pathogens. The detergent properties also break down the lipids in the membranes around many bacteria and viruses. Wash all surfaces of the hands, including between the fingers, rubbing for around 20 seconds.

### 2. Alcohol

Alcohol and alcohol gels are effective against bacteria, viruses and other pathogens, but the alcohol content should be 60% or above. In lab studies, alcohols work against Gram-positive and Gram-negative bacteria (including multidrug-resistant pathogens such as MRSA and VRE), *M. tuberculosis*, and a variety of fungi.

### 3. Chlorhexidine

Chlorhexidine works by disrupting bacterial cell membranes, releasing the cell contents. Chlorhexidine works more slowly than alcohol.

### 4. Chloroxylenol

Chloroxylenol inactivates enzymes in bacteria and affects their cell walls. In lab studies, chloroxylenol works well against Gram-positive bacteria, and moderately well against Gram-negative bacteria, mycobacteria and some viruses.

### 5. Hexachlorophene

Hexachlorophene inactivate essential enzyme systems in microorganisms. Hexachlorophene is bacteriostatic, with good activity against *S. aureus* and relatively weak activity against Gram-negative bacteria, fungi, and mycobacteria.

### 6. Iodine and iodophors (PVP-I)

Iodine molecules enter the cell wall of microorganisms, affecting protein synthesis and cell membranes. PVP-I is effective against bacteria, viruses, fungi, spores, protozoa, and amoebic cysts. PVP-I has shown efficacy against coronaviruses like MERS-CoV and SARS-CoV and other viruses such as Ebola virus there has been no reported resistance or cross-resistance in over 150 years of use.

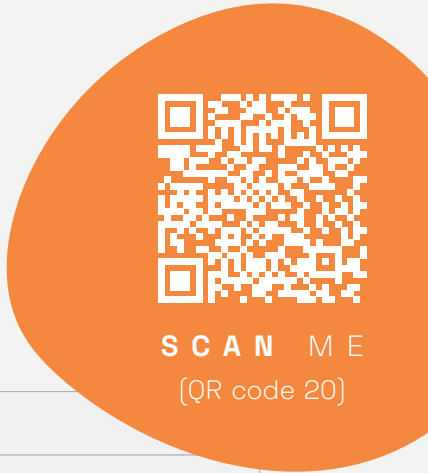
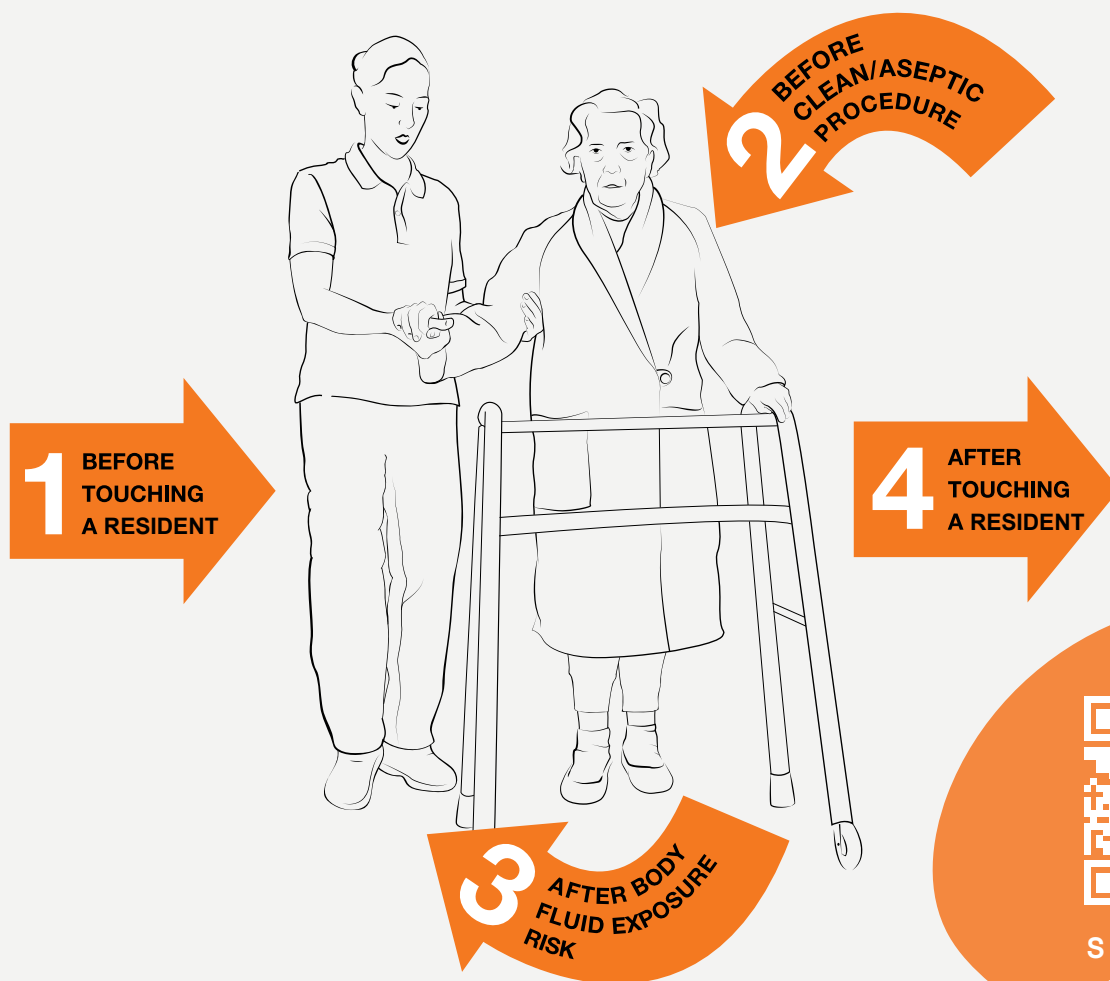
Source WHO



FIGURE 48: MOMENTS FOR HAND HYGIENE IN A RESIDENTIAL HOME

# Your Moments for Hand Hygiene

## Health care in a residential home



<b>1</b>	<b>BEFORE TOUCHING A RESIDENT</b>	<b>WHEN?</b> Clean your hands before touching a resident. <b>WHY?</b> To protect the patient against harmful germs carried on your hands.
<b>2</b>	<b>BEFORE CLEAN/ASEPTIC PROCEDURE</b>	<b>WHEN?</b> Clean your hands immediately before performing a clean/aseptic procedure. <b>WHY?</b> To protect the patient against harmful germs, including the resident's own, from entering his/her body.
<b>3</b>	<b>AFTER BODY FLUID EXPOSURE RISK</b>	<b>WHEN?</b> Clean your hands immediately after a procedure involving exposure risk to body fluids (and after glove removal). <b>WHY?</b> To protect yourself and the environment from harmful patient germs.
<b>4</b>	<b>AFTER TOUCHING A RESIDENT</b>	<b>WHEN?</b> Clean your hands after touching the resident at the end of the encounter or when the encounter is interrupted. <b>WHY?</b> To protect yourself and the environment from harmful patient germs.



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WHO acknowledges the Ministry of Health of Spain and the Hôpitaux Universitaires de Genève (Infection Control programme) for their active participation in developing this material.

Source: WHO

March 2012

You can test your knowledge on hand hygiene and contact precautions by scanning QR code 20. After completing both modules, you will receive certificates.

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SCAN ME  
(QR code 21)

### BOX: Speak out – Doctor, have you washed your hands?

In a study at a Sydney hospital, doctors and nurses failed to wash their hands properly when no one was watching. Hand-washing rate fell from 94% with human auditors watching to 30% when this switched to automated surveillance (QR code 21). This puts patient’s lives at risk [11].

The compliance with hand washing is an issue for any HCP, but particularly for doctors (QR code 22). While they have fewer total patient contacts than nurses, they see more individual patients and perform most invasive procedures, so have more potential for opportunities for transmission of pathogens. Doctors also play a role in influencing the attitudes and behaviour of other members of staff [12].



SCAN ME  
(QR code 22)

## 35.2 Personal protective equipment

Personal protective equipment (PPE) is designed to protect nurses and other HCPs from infectious diseases. PPEs include gloves, masks, aprons, gowns and visors. The choice of PPE depends on how the infection is transmitted. PPE should be used whenever there is a risk of exposure to blood or other potentially infectious material such as sputum, vomit or faeces]. The following is a guidance, please follow your hospital protocols. (see Figure 49).

### FIGURES 49: PUTTING ON AND REMOVING PPE IN EIGHT STEPS

Make sure you have all the necessary Personal Protective Equipment:

- Disposable isolation gown that is water resistant
- FFP2/FFP3 mask
- Face visor with anti-fog properties
- Non-sterile nitrile gloves

#### Putting on PPE:

Staff should wear the following PPE, put on in the following order:

**Tying at the neck than at the back**



STEP 2  
FFP3 RESPIRATOR  
AND FIT CHECK



1. Check the FFP 2/3 mask

2. Hold the mask  
in your hand



3. Wear the FFP2/3 mask by applying the mask  
tightly around the face and pulling the straps  
above your head

4. Secure the  
mask around  
your face



5. Check for leakages.  
If FFP2/3 has a valve,  
ensure that it forms a  
tight seal.



STEP 3  
EYE  
PROTECTION



Wear a visor

STEP 4  
DISPOSABLE  
GLOVES

Wear 1 pair of  
gloves ensuring  
the gloves  
overlap the  
edge of the  
gown



Back to top  
↑

Removal of PPE:

STEP 1



Remove the glove of the non-dominant hand from the base of the palm, without touching the inside of the glove, and flip it over the fingers



STEP 2



Using the non-dominant hand (which is partially gloved) to remove the glove from the dominant hand from the base of the palm without touching the inside of the glove

STEP 3

Dispose of the gloves in the appropriate bin

STEP 4

Perform hand hygiene using alcohol-based hand rub





STEP 5

Remove gown by using a peeling motion, fold gown in on itself and place in clinical waste bin



STEP 6

Remove visor only by the headband or sides and dispose in clinical waste bin



STEP 7

Remove respirator from behind using the rubber bands away from your face and dispose in clinical waste



STEP 8

Perform hand hygiene using alcohol-based hand rub



This sequence of putting and removal of PPE's is recommended by the ECDC and WHO

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## Use of respiratory face protection when caring for a suspected or confirmed case of the new COVID-19

The following guideline is based on the recommendation of the WHO and CDC published in view of the new COVID-19 virus. Every nurse should be trained well so that when using PPE, she/he will not be exposed to the virus especially during the removal of such PPE. In this section we will explain about the types of masks that are available and recommended for use when caring for patients with a high consequence infectious diseases. Since it is a new virus we do not know exactly the mode of transmission. From what is known till when this has been published that the COVID-19 is transmitted from person to person via respiratory droplets. Transmission will occur if the nurse is within approximately 6 feet (2 meters) of a patient with 2019-n-CoV for a prolonged period of time. Therefore, proper wearing and removal of PPE will protect the nurse from becoming infected while caring for such patients.

### Types of face masks available on the market

Both the WHO and CDC have recommended the use of N95 or FFP2 masks which offer protection against airborne infections including the current COVID-19. It is important that the mask says either N95 or FFP2 mask has a 95% efficiency filter. The N99(FFP3) that mask has a 99% efficiency filter. However both masks are safe to use when caring for such patients.

It is highly important that every time the nurse puts the respiratory mask she/he needs to perform a fit check (refer to poster showing the steps on how to put on and remove the PPE). It is also important that a fit test is performed on all nurses to ensure that the face mask fits well. The fit test should be carried out by a trained technician.

## 35.2.1 Glove use – To glove or not to glove?

Gloves do not replace the need for hand hygiene when caring for patients. Gloves are not 100% safe as there can be tiny holes that are not visible to the naked eye but can allow microorganisms through to colonise nurses' hands. This can happen in almost a third of cases [13].

Gloves should be worn in the following circumstances:

- When dealing with body fluids such as blood, urine, sputum and discharging wounds
- In contact with mucous membranes or broken skin
- Taking blood samples or working with catheters
- When dealing with patients who are colonised/infected with virulent organisms, MDROs such as CRE, CRAB, MRSA and VRE, or in epidemic or emergency situations
- As part of transmission-based precautions.







Gloves should be changed:

- Between patients to prevent cross-transmission of microorganisms especially MDROs
- Between different body sites, for example when a patient has two different wounds, to prevent cross-contamination.




Put on and remove gloves using the techniques shown in Figure 50.

FIGURE 50: PUTTING ON AND REMOVING NON-STERILE GLOVES

### HOW TO DON GLOVES

<p><b>1</b></p>  <p>Take out a glove from its original box.</p>	<p><b>1b</b></p>  <p>Touch only a restricted surface of the glove corresponding to the wrist (at the top edge of the cuff).</p>	<p><b>3</b></p>  <p>Don the first glove.</p>
<p><b>4</b></p>  <p>Take the second glove with the bare hand and touch only a restricted surface of the glove corresponding to the wrist.</p>	<p><b>5</b></p>  <p>To avoid touching the skin of the forearm with the gloved hand, turn the external surface of the glove to be donned on the folded fingers of the gloved hand, thus permitting to glove the second hand.</p>	<p><b>6</b></p>  <p>Once gloved, hands should not touch anything else that is not defined by indications and conditions for glove use.</p>

### HOW TO REMOVE GLOVES

<p><b>1</b></p>  <p>Pinch one glove at the wrist level to remove it, without touching the skin of the forearm, and peel away from the hand, thus allowing the glove to turn inside out.</p>	<p><b>2</b></p>  <p>Hold the removed glove in the gloved hand and slide the fingers of the ungloved hand inside between the glove and the wrist. Remove the second glove by rolling it down the hand and fold into the first glove.</p>	<p><b>3</b></p>  <p>Discard the removed gloves</p>
<p><b>4</b> Then, perform hand hygiene by rubbing with an alcohol-based handrub or by washing with soap and water.</p>		



SCAN ME  
(QR code 23)

Source: British Columbia Institute of Technology (BCIT)  
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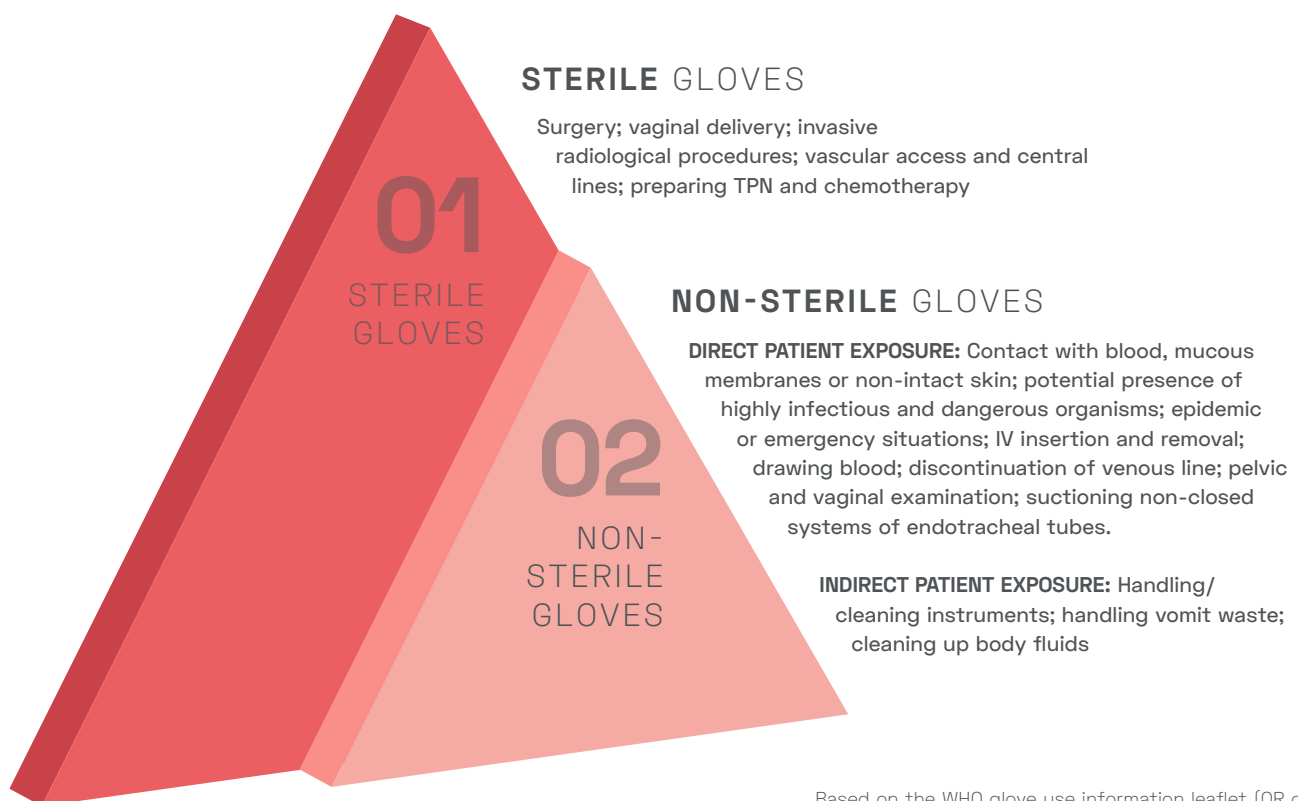
If there is no risk of exposure to body fluids (unless transmission-based precautions are in place), no gloves need to be worn, for example when:

- Changing bedsheets
- Assisting patients to get out of bed
- Helping patients to walk
- Transporting patients
- Touching intact skin

This also reduces the risk of nurses developing allergies to glove materials, such as latex [14]. Healthcare providers may reserve latex gloves for the surgical setting, except for latex-free paths or latex-free operators, and use alternative gloves in other settings. The glove pyramid (Figure 51: The glove pyramid – to aid decision-making) and the WHO glove use information leaflet (QR code 24) provide support in the decision-making process.



FIGURE 51: THE GLOVE PYRAMID – TO AID DECISION-MAKING



## 35.3 Standard precautions

Standard precautions are designed to reduce the risk of transmission of infection to the nurse or other HCP and from patient to patient. These should be used with every patient, irrespective of whether their infectivity status is known or not. A risk assessment will help to decide what kind of PPE is needed.

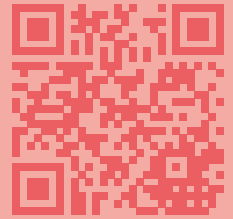
Standard precautions include:

- Hand hygiene
- Personal protective equipment (mask, gown, apron, visor/goggles, gloves)
- Proper disposal of sharps
- Environmental cleaning
- Aseptic technique
- Sterile instruments – reprocessing of reusable equipment and instruments
- Cough etiquette
- Waste management
- Appropriate handling of linen

There is no need for isolation in a single room. When standard precautions are not enough to stop the transmission of infections, the next step is transmission-based precautions. For more information look at the CDC (QR code 25) and WHO websites (QR code 26).



SCAN ME  
[QR code 25]



SCAN ME  
[QR code 26]

## 35.4 Transmission-based precautions

Transmission based precautions are used as well as standard precautions when there is a risk of patients passing the infection on to others. These patients need to be isolated in a single room or cared for with patients with the same infection. If the door cannot be closed because of safeguarding issues, this will need to be discussed with the infection prevention and control team.

Transmission based precautions differ according to whether it is contact, droplet and airborne transmission (see Figure 52: Transmission-based precautions).

**FIGURE 52: TRANSMISSION-BASED PRECAUTIONS**



Notes: \* Depends on the task being carried out. E.g. If bath bathing a patient, a gown will be more appropriate because of the close contact with the patient. \*\* It is very important to check the fit before approaching the patient



SCAN ME  
[QR code 27]

For more information on transmission-based precautions see the CDC website (QR code 27).

### 35.4.1 The impact of patient isolation

Patients who are isolated in a single room may become anxious, withdrawn and/or depressed, and feel stigmatised. Patients who are in isolation tend to receive less attention by doctors than patients in normal rooms. They are also twice as likely to have adverse events and eight times more likely to experience falls and pressure ulcers. [15]. This anxiety is worsened by a lack of information (see Figure 53). Nurses can help anxious and isolated patients and their families through good communication, and by providing information and reassurance.

**FIGURE 53: LACK OF INFORMATION CAN INCREASE ANXIETY**



#### Case study: lack of information

Following an accident, a male patient was admitted to intensive care. After a few days he was isolated because he was diagnosed as having a multi-drug resistant (MDR) infection. The information given to his wife was so limited she had to go on the internet to search for further information. The internet searches increased her anxiety, stress and fear.

## 35.4.2 Improving patient-nurse interaction

Nurses need to put on appropriate PPE before entering an isolation room. The time taken to dress can reduce the time that they can spend with patients. The inconvenience of PPEs may also reduce compliance with requirements.

### Case study: Isolation floor taping

In a study carried out at Trinity Regional Medical Centre, the hospital used red tape to make a safe zone at the entrance of the isolation room. Nurses standing in this area did not need to put on PPEs to interact with the patient. This increased staff-patient interaction, generating a high level of satisfaction, and reducing PPE costs.

## 35.5 Aseptic non-touch technique

Aseptic non-touch technique (ANTT) was created to improve the understanding of infection control and reduce or prevent the transfer of microorganisms from nurses, equipment and the environment, so safeguarding patients [17,18]. The aim is to improve patient safety and reduce HAIs.

ANTT was originated by Stephen Rowley in the late 1990s [17] and has since been defined by NICE as,

STEPHEN  
ROWLEY

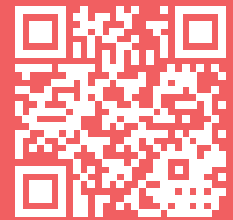


**A specific type of aseptic technique, with a unique theory and practice framework [19]**

The purpose of ANTT was to highlight the various problems when it comes to practicing aseptic technique, the lack of standardisation of teaching, practice and the confusion of terms «Sterile», «Aseptic» and «Clean» [18].

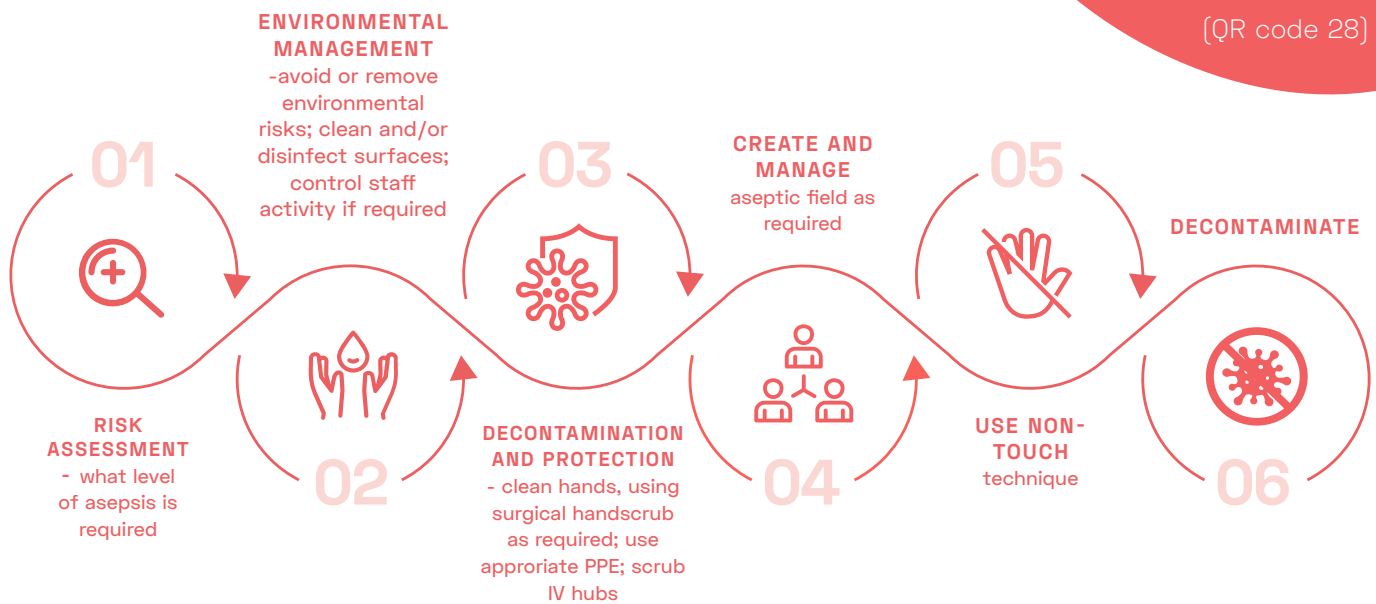
The ANTT Clinical Practice Framework is comprehensive and carefully defines practice, providing a set of clinical rules for supporting effective and safe aseptic technique. The term 'clean' is not used as a practice aim because the definition of 'clean' is a visual one – and micro-organisms are invisible! The term sterile is not used because once sterilized equipment is opened to air, it is not technically possible to maintain its sterility [18]. ANTT is therefore based upon the terms 'asepsis' and 'aseptic' as they are achievable and if established and maintained in practice, will protect the patient.

ANTT helps provide a better understanding of the Infection Control invasive procedures which are undertaken on patients. ANTT can prevent micro-organisms transfer from HCPs, the equipment and the immediate environment safeguarding the procedure Key-Parts and Key-Sites – using a concept called Key-Part and Key-Site Protection (see Figure 54).



SCAN ME  
[QR code 28]

FIGURE 54: STEPS TO ENHANCE PATIENT SAFETY



For further information about ANTT and its implementation, go to the ANTT website (QR code 28).

## 36 Roles and responsibilities of the infection control nurse

The role of an infection control nurse (ICN) is very important in both hospital and community care settings. It includes preventing infection, implementing infection control policies and teaching nurses and other HCPs.

### Role of an infection control nurse



Lead the infection prevention and control team and provide high quality infection prevention and control services

Advise and educate patients, carers, nurses and other HCPs

Develop evidence-based policies and guidelines for the prevention and control of HAIs and community-acquired infections (CAIs), and put these in place

Communicate laboratory results, especially relating to multi-drug resistant organisms, to both hospitals and the community

Ensure that patients with MDROs are cared for in isolation or with patients with the same type of infection, so that it does not spread to other patients

Carry out audits of isolation practices and hand hygiene.

Observe nurses and other healthcare professionals to ensure that the necessary precautions are being followed when a patient is isolated

Although the role of the ICN can be quite challenging, it can be very gratifying for its part in both staff and patient safety.

ICNs also have responsibilities leadership, education, quality improvement and clinical practice (see Table 32).

**TABLE 32: 1.1 RESPONSIBILITIES OF THE INFECTION CONTROL NURSE**

Role	Competences
<b>Leadership &amp; management</b>	<ul style="list-style-type: none"> <li>Lead and manage the work of the infection prevention and control team to achieve objectives</li> <li>Lead high quality infection prevention and control services</li> <li>Design, plan and monitor the development of services</li> <li>Demonstrate leadership and management skills</li> </ul>
<b>Education</b>	<ul style="list-style-type: none"> <li>Develop own knowledge, skills and practice</li> <li>Advise and educate patients, carers and all the staff working in health and social care settings</li> <li>Identify and respond to the need for learning opportunities using an evidence-based approach</li> <li>Work with others to embed infection prevention and control within workforce and organisational development strategies</li> </ul>
<b>Quality improvement</b>	<ul style="list-style-type: none"> <li>Utilise improvement methodologies to enhance and sustain infection prevention and control practices</li> <li>Demonstrate the use of risk assessment in infection prevention and control practice</li> <li>IPC is an integral part in preventing antimicrobial resistance</li> <li>Research in clinical practice</li> </ul>
<b>Clinical practice</b>	<ul style="list-style-type: none"> <li>Collect, understand, interpret and report surveillance data</li> <li>Monitor, review and advise on service developments to support the infrastructure of the organisation in relation to decontamination and the built environment</li> <li>Improve quality and safety by developing and implementing evidence-based policies and guidelines for the prevention and control of infection</li> <li>Maintain patient safety by recognising, reporting and managing incidents and outbreaks</li> </ul>

Adapted from the Infection Prevention Society [20]

## 37 Infection control challenges in long-term care facilities (LTF)

Although residents in a residential care setting do not undergo complex or invasive, they are still at risk of transmissible infections, and the consequences can be serious. Elderly people's immune systems may also be impaired, affecting their ability to fight infections [21]. Elderly people are also more at risk of pneumonia, urinary tract infections (UTIs) and soft tissue infections than younger people, and these carry a high risk of illness and death.

The nurse or carer's role in infection control and prevention is to reduce the risk of infections being passed on to residents from HCPs or other residents. Vaccination in elderly people may not always be effective, so vaccination of nurses and other HCPs may help in controlling the spread of infections.

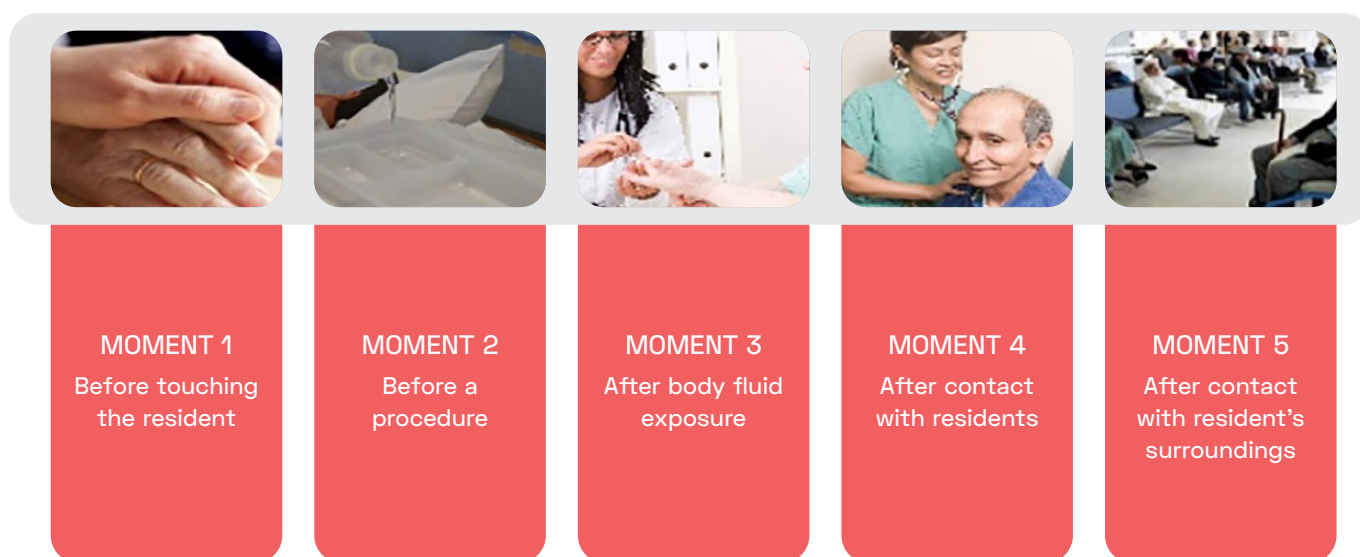
### 37.1 Managing residents with MDROs

Managing MDROs is a major challenge in residential care settings such as nursing homes. The spread of MDROs can be increased because of the longer length of stay compared with an acute care setting, and because of the homelike environment that potentially means less stringent infection prevention and lack of support from an infection prevention and control team. Frequent transfers to and from acute care to nursing homes can also increase the transmission of MDROs [22]. Elderly people are more likely to get infections. This, combined with issues of self-care and difficulties with diagnosis, can lead to greater antibiotic prescribing which then increases the risk of antibiotic resistance [23].

Long term care facilities may not have nurses on site, and they may not have isolation facilities. This means that infection control measures must be adapted according to the facility [24].

### 37.2 Hand hygiene

The WHO's 'moments of hand hygiene' (see 37.1: Hand hygiene) are also important for care of elderly persons in residential care (see Figure 55).



Adapted from the WHO's five moments of hand hygiene



### Case study: Hand hygiene and infection rates

Implementing hand hygiene for residents, nurses and other healthcare professionals in a long-term care facility aimed to reduce cross-transmission, given that the residents shared the dining room, bathrooms and rehabilitation facilities. The greatest decrease in infections was that of LRTI (lower respiratory tract infections) from 0.97 LRTIs pre-intervention, to 0.53 post-intervention per 1,000 resident-days [25]

## 37.3 Managing outbreaks within the residential homes

Because of shared facilities, residential care homes run the risk of disease outbreaks.

**TABLE 33: MOST COMMON TYPES OF INFECTION OUTBREAKS IN CARE HOMES**

Type of infection	Most common causative infectious agents	Mode of transmission
<b>Respiratory infection</b>	Influenza virus (A or B)	Droplets and physical contact
	Mycobacterium tuberculosis	Airborne infection
<b>Skin and soft tissue infection</b>	Streptococcus pyogenes	Droplets and physical contact
	Staphylococcus aureus (MSSA or MRSA)	Physical contact and airborne dissemination
	Sarcoptes scabiei (the mite causing scabies)	Physical contact
<b>UTI (with or without a urinary catheter)*</b>	Escherichia coli MDROs	Physical contact (transmission will have taken place sometime before the organism causes UTI)
<b>Gastrointestinal infections</b>	Norovirus Salmonella and other foodborne infectious organisms	Physical contact with contaminated items followed by ingestion** or direct ingestion of contaminated food
	Clostridioides difficile	Physical contact with contaminated items followed by ingestion**

\*UTIs are more often caused by a resident's own gut flora than by an external infectious organism

\*\* Also known as the faecal-oral route

Adapted from Curran [26]

## 37.4 Prevention of outbreaks in nursing homes

Outbreaks in nursing homes can be prevented by making sure that nurses, carers and other HCPs follow standard precautions (see 37.3: Standard precautions).

Vaccination against influenza is important to prevent outbreaks. Influenza can cause serious illness and death in elderly people. There are a lot of myths and misconceptions about Influenza vaccination and these should be addressed both in HCPs and the residents within the nursing homes to increase vaccination uptake.

If a resident is diagnosed as having an infection that might cause an outbreak, he/she must be segregated from the other residents until he/she is no longer infectious.

Once an outbreak is declared it is important to carry out a risk assessment to understand the extent of the outbreak and its cause. The questions in Figure 56 are useful.

**FIGURE 56: MANAGING AN INFECTIOUS DISEASE OUTBREAK**

**About the people who are sick**

- What are the people sick with?
- How many are/have been sick?
- When did they get sick?
- Which GPs have been called?

**About the care home**

- How many people live in the home?
- On how many floors is the accomodation?
- On how many floors are the sick residents?
- Do staff work on affected as well as unaffected floors?
- Are there any plans in place for the next few days?



**SCAN ME**  
(QR code 29)

Once an outbreak is confirmed the target is to bring that particular outbreak to an end. The following may be included as measures to control the outbreak:

- Close the care facility to admissions and stop transfers
- Limit or stop visits from friends and family
- Clean the facility thoroughly, especially high touch surfaces, using appropriate disinfectants

For more information on standard infection control and prevention in residential homes see the CDC website (QR code 29).

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# Annexe

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# 39 ESNO position statement on antimicrobial resistance [1]

## SPECIALIST NURSES WITH KEY ROLES IN TACKLING AMR

Antimicrobial resistance (AMR) represents a serious public health threat, with an estimated 10 million people predicted to die globally from multidrug-resistance infections every year by 2050 if urgent action is not taken [2]. As caregivers for an increasing number of patients with multidrug-resistant infections, health care professionals play a crucial role in addressing AMR [3] with nurses both in Europe and worldwide who are on the frontline of the AMR crisis. Nurses observe first-hand how multidrug-resistant infections lead to longer hospital stays, higher health care costs and increased mortality.

Nurses play several central roles in tackling AMR: infection control and prevention, advocating for rational antibiotic use and educating patients and their families on the responsible use of antibiotics. Firstly, nurses are involved in the preparation, administration and prescription of antimicrobials along with monitoring their effects.

Nurses, especially Infection Prevention and Control Nurses, are heavily involved in preventing the acquisition and spread of infections in hospitals and other healthcare settings. Hand hygiene compliance and the use of specific contact precautions are paramount in controlling transmission. Nurses are also essential in promoting awareness of AMR amongst other health care workers, patients and the general public. Due to their close relationship with patients, nurses are ideally placed to support adherence to treatment and the appropriate use of antibiotics in everyday practice. Misconceptions around drug resistance still exist, for example, some people believe that they can stop taking a prescribed course of antibiotics as soon as they feel better, and nurses play a key role in altering public perceptions and behaviour.

Despite their manifold roles in combatting AMR, nurses have been under-recognised and underutilised in antimicrobial stewardship [4]. EU and National AMR Action Plans have not previously emphasised the role of nurses. Initiatives promoting prudent antimicrobial prescribing and management have generally lacked nurses' involvement. However, with relevant training, nurses have the potential to play an even more important role in combatting AMR, through influencing clinical decision making related to monitoring prescription decisions. With their consistent presence as patient advocate, nurses play an invaluable role in monitoring and communicating daily patient progress to ensure that antibiotics are being given in an appropriate manner. Through empowerment, nurses can play a larger role in advocating prudent use of antimicrobials within the multidisciplinary team. This is particularly true since nurses are becoming increasingly involved with prescribing in Europe. Hence, ESNO endorses the engagement of nurses in policy designs. In addition, ESNO supports further involvement of nurses in AMR surveillance. Through collaborating with data collection, nurses could help to provide the evidence base for action and advocacy on AMR.

To ensure that nurses and other healthcare workers are engaged in tackling AMR, training and educational resources on AMR need to be made available. ESNO therefore promotes the creation of tailored resources on AMR, specifically designed for nurses. Throughout Europe, undergraduate training should place a greater emphasis on AMR and how nurses can contribute to combatting it. Furthermore, ESNO supports the integration of AMR courses into the continued professional education of nurses, particularly accredited courses.

Accordingly, ESNO is currently working on the production of an Information and Communication Guide on AMR to ensure that nurses across Europe can access accurate, consistent information on drug resistance to be published April 2020. It is our belief that if all nurses throughout Europe were to receive specific education on AMR, a huge difference could be made.

## 39.1 ESNO position statement on vaccination [5]

### NURSES AS STABLE FACTOR IN VACCINATION UPTAKE

Public misunderstanding of vaccines is a concern to all those working in health care across each of the disciplines and ranks. Over the past few years, we have seen a serious decrease of vaccination uptake, increasing the risk of new outbreaks of vaccine-preventable diseases. For example, the number of measles infections tripled to over 14,000 cases across Europe in 2017 compared to 2016 [6].

For the cases with known vaccination status, 87% of cases were unvaccinated whilst only 3% were vaccinated with two or more doses. A public trust campaign on vaccinations has been insufficient in communicating the benefits of vaccines and increasing the uptake of vaccinations in Europe. In parallel, we have seen an increase in the distribution of misinformation and misconceptions on vaccination which has added to the decrease in immunisation uptake.

The European Specialist Nurses Organisations (ESNO) has witnessed a significant increase in the outbreaks of vaccine-preventable infectious diseases. These outbreaks have resulted in the deaths of people young and old, including healthy young people. Nurses have directly observed the consequences of reduced vaccination uptake. Not only has this led to great loss of human life, it has also had a paralysing effect on the healthcare systems. We have seen a particularly strong impact on diseases such as influenza, rubella and measles, for example.

This has prompted ESNO to take a position on this issue by promoting vaccination with an emphasis on factual information and education. Far too many misconceptions and misleading information is circulating, even among healthcare professionals, including nurses. The consequences can be huge: we have seen complete hospital wards shut down and operations postponed due to preventable influenza outbreaks, as well as productivity losses due to lost working days which has a knock-on impact on wider society.

Nurses, as frontline health professionals, provide information to hesitant populations, helping to explain common misconceptions regarding immunisation [7]. ESNO calls on national health regulators to support nurses to initiate educational activities at the ward level. In addition, ESNO advises national health regulators to invest more funds in promoting seasonal influenza vaccination. In parallel, national health regulators should provide a structured long term scheme to address this issue for as long as is necessary to increase trust and vaccination uptake.

To ensure that nurses and other healthcare workers are engaged in addressing vaccination, training and educational resources on infections and vaccination need to be made available. ESNO therefore promotes the creation of tailored resources on vaccination, specifically designed for nurses.

Throughout Europe, undergraduate training should place a greater emphasis on vaccination and how nurses can contribute to address it. Furthermore, ESNO supports the integration of vaccination courses into the continued professional education of nurses, particularly accredited courses.

Accordingly, ESNO is currently working on the production of an Information and Communication Guide on Vaccination and AMR to ensure that nurses across Europe can access accurate, consistent information on infections and vaccines. It is our belief that if all nurses throughout Europe were to receive extensive training infection control and vaccination, a huge difference could be made.

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