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COM 501

EPIDEMIOLOGY AND PRINCIPLES OF CONTROL OF COMMUNICABLE DISEASES AND EPIDEMIC DISEASES OF GLOBAL IMPORTANCE

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Course code: COM 501

Course title: Epidemiology and Principles of Control of Communicable Diseases and Epidemic Diseases of Global Importance

Course credit load: 2 Units

Series 1: Principles and Concepts of Communicable Disease Prevention and Control

- **Part 1.1: Basic Concepts in Communicable Disease Epidemiology**
  - Sub Part 1.1.1: Definition and characteristics of communicable diseases
  - Sub Part 1.1.2: The chain of infection: agent, host, and environment
  - Sub Part 1.1.3: Modes of transmission of communicable diseases
- **Part 1.2: Natural History and Course of Communicable Disease**
  - Sub Part 1.2.1: Stages in the natural history of disease
  - Sub Part 1.2.2: The incubation period
  - Sub Part 1.2.3: The period of communicability
- **Part 1.3: Levels of Prevention and Control Measures**
  - Sub Part 1.3.1: Primary prevention
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- **Part 1.4: Quarantine, Isolation, and Herd Immunity**
  - Sub Part 1.4.1: Quarantine
  - Sub Part 1.4.2: Isolation
  - Sub Part 1.4.3: Herd immunity and its role in disease control

Introduction

Communicable diseases remain a major cause of illness and death in Nigeria and across the world, from familiar endemic conditions such as **malaria** and **tuberculosis** to sudden **epidemic** threats such as **Ebola** and **COVID-19**. Picture a rural health post where a cluster of patients arrives within days of one another, each reporting similar symptoms, prompting the health worker to ask a set of practical questions: how is this disease spreading, how long before an exposed person becomes ill, and what measures can break the chain of transmission. Answering such questions rests on a shared foundation of **epidemiological principles**, and it is this foundation that forms the subject of this opening Series.

The aim of this Series is to equip you with the core **concepts and principles** that underpin the prevention and control of communicable diseases, providing the conceptual toolkit on which every later Series in this course will build.

This Series begins with **basic concepts in communicable disease epidemiology**, before turning to the **natural history and course of communicable disease**. Next, we examine the **levels of prevention and control measures**, before concluding with **quarantine, isolation, and herd immunity**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 1.1:** define a communicable disease and describe its key characteristics
- **SLO 1.2:** describe the chain of infection and the modes of transmission of communicable diseases
- **SLO 1.3:** describe the stages in the natural history of disease
- **SLO 1.4:** define the incubation period and the period of communicability and explain their epidemiological importance
- **SLO 1.5:** describe primary prevention and give examples of primary preventive measures
- **SLO 1.6:** describe secondary and tertiary prevention and distinguish between them
- **SLO 1.7:** define quarantine and isolation and distinguish between them, and
- **SLO 1.8:** explain herd immunity and describe its role in the control of communicable diseases.

1.1 Basic Concepts in Communicable Disease Epidemiology

1.1.1 definition and characteristics of communicable diseases

A disease that spreads from an infected source to a susceptible host

A **communicable disease** is an illness caused by a specific **infectious agent**, or its toxic products, that arises through **transmission** of that agent, or its products, from an infected person, animal, or reservoir to a **susceptible host**, either directly or indirectly through an intermediate plant or animal host, a **vector**, or the inanimate environment. Communicable diseases are distinguished from **non-communicable diseases**, such as diabetes or hypertension, precisely by this capacity to spread from one host to another, a property with major implications for how such diseases are prevented and controlled at population level.

Every communicable disease depends on the interaction of three elements, the **agent**, the **host**, and the **environment**, often described together as the **epidemiological triad**, and it is the dynamic balance between these three elements, examined in detail in the next sub-Part, that determines whether disease transmission occurs, persists, or is interrupted within a given population.

Fill in the blank: A communicable disease is caused by a specific agent that is transmitted from an infected source to a susceptible _____.

1.1.2 the chain of infection: agent, host, and environment

The **agent** is the specific micro-organism, such as a **bacterium**, **virus**, **parasite**, or **fungus**, capable of producing infection or disease, and the likelihood that an agent will cause disease depends on properties including its **infectivity**, its ability to establish infection in a host, its **pathogenicity**, its ability to produce clinical disease once infection is established, and its **virulence**, the severity of the disease it produces among those who become clinically ill.

The **host** is the person or animal that provides a living environment for the agent, and host factors such as **age**, **nutritional status**, **immunity**, and underlying illness influence **susceptibility** to infection, while the **environment** encompasses all external factors, physical, biological, and social, that affect the agent's existence and its transmission from a reservoir to a new host, including **climate**, **sanitation**, **housing**, and population **crowding**, all of which are considered further in later Series of this course.

Fill in the blank: The interaction of agent, host, and environment is often described together as the epidemiological _____.

1.1.3 modes of transmission of communicable diseases

Transmission describes the mechanism by which an infectious agent is spread from a **source** or **reservoir** to a susceptible host, and is broadly classified as **direct transmission**, involving essentially immediate transfer of the agent from an infected host to a susceptible one, for example by touch or droplet spread, or **indirect transmission**, in which the agent survives for a period on an intermediate object, in the air, or within a living vector before reaching a new host.

The specific **routes** through which diseases are transmitted, including **ingestion**, **inhalation**, **vector-borne**, **contact**, and **zoonotic** transmission, are examined in detail in the following two Series of this course, but recognising, even at this introductory stage, that identifying the dominant route of transmission for a given disease is the single most important step in selecting appropriate control measures provides an essential orientation for everything that follows.

Fill in the blank: Transmission that involves essentially immediate transfer of an agent from an infected host to a susceptible one is termed _____ transmission.

Figure 1.1: A laboratory scientist examining a microbial culture plate to identify a disease-causing agent.

Pilot questions 1.1

1. Define a communicable disease and distinguish it from a non-communicable disease. (Linked to SLO 1.1)
2. List the three elements of the epidemiological triad. (Linked to SLO 1.1)
3. Distinguish infectivity, pathogenicity, and virulence as properties of an infectious agent. (Linked to SLO 1.2)

4. Give two examples of host factors that influence susceptibility to infection. (Linked to SLO 1.2)
5. Distinguish direct transmission from indirect transmission, with an example of each. (Linked to SLO 1.2)

1.2 Natural History and Course of Communicable Disease

1.2.1 stages in the natural history of disease

A predictable sequence from exposure to outcome

The **natural history of disease** describes the predictable sequence through which a disease progresses in an individual, in the complete absence of any intervention, beginning with the **stage of exposure**, in which the host first encounters the infectious agent, followed by the **stage of subclinical disease**, during which the agent multiplies within the host but no symptoms are yet apparent, and the **stage of clinical disease**, during which recognisable **signs** and **symptoms** appear.

The natural history concludes with the **stage of outcome**, which may take the form of **recovery**, with or without lasting **disability**, **chronic carriage** of the agent, or **death**, and understanding this full sequence is essential because effective **prevention** and **control** measures, discussed later in this Part, are deliberately targeted at specific stages of this natural history in order to interrupt the disease process before it can progress further.

Fill in the blank: The natural history of disease describes the predictable sequence of disease progression in the complete absence of any _____.

1.2.2 the incubation period

The **incubation period** is the interval of time between **exposure** to an infectious agent and the first appearance of **clinical signs and symptoms** of the disease it causes, and this interval varies considerably between diseases, ranging from a matter of hours for some forms of **food poisoning** to several weeks for diseases such as **hepatitis B**, with the typical incubation period for a given disease being a well established and clinically useful figure.

Knowledge of the incubation period is of substantial practical importance in disease control, since it determines the appropriate duration of **quarantine**, discussed further later in this Series, for individuals who have been exposed to a case, and it also assists **surveillance** teams, discussed in a later Series of this course, in working backwards from a case's date of symptom onset to identify the likely time and source of exposure during an outbreak investigation.

Fill in the blank: The incubation period is the interval between exposure and the first appearance of clinical signs and _____.

1.2.3 the period of communicability

The **period of communicability** is the specific interval of time during which an infected person or animal is capable of transmitting the infectious agent to a susceptible host, either directly or indirectly, and this period does not necessarily coincide with the period of clinical illness, since some diseases are communicable before symptoms appear, during the incubation period itself, while others remain communicable for some time after clinical recovery.

Diseases in which transmission occurs readily before the onset of recognisable symptoms, sometimes termed **pre-symptomatic transmission**, present particular challenges for control, since affected individuals cannot be identified and isolated, discussed later in this Series, on the basis of symptoms alone, making measures such as **contact tracing** especially important for such diseases.

Fill in the blank: The period of communicability is the interval during which an infected person is capable of transmitting the agent to a susceptible _____.

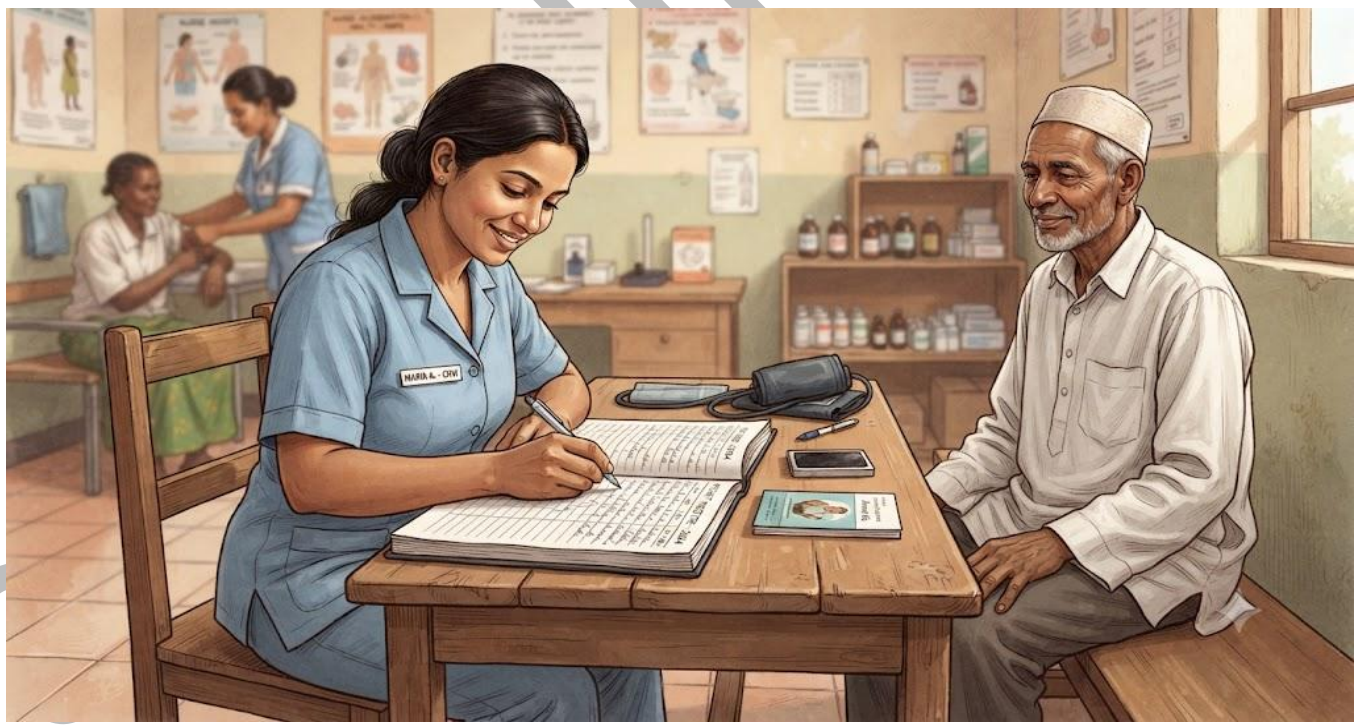

Figure 1.2: A community health worker recording a patient's date of symptom onset in a clinic register.

Pilot questions 1.2

1. List the four stages in the natural history of disease. (Linked to SLO 1.3)
2. Describe the possible outcomes of the natural history of a communicable disease. (Linked to SLO 1.3)
3. Define the incubation period and explain its practical importance in disease control. (Linked to SLO 1.4)
4. Distinguish the period of communicability from the period of clinical illness. (Linked to SLO 1.4)
5. Explain why pre-symptomatic transmission poses a particular challenge for disease control. (Linked to SLO 1.4)

1.3 Levels of Prevention and Control Measures

1.3.1 primary prevention

Preventing disease before it occurs

Primary prevention comprises measures applied before disease occurs, aimed at removing or reducing **exposure** to a causative agent or at increasing host **resistance**, and its principal tools include **health education**, **immunisation**, **environmental sanitation**, and provision of **safe water**, each of which acts, in a different way, to break the chain of infection described earlier in this Series before transmission can occur.

Because primary prevention acts before any infection has taken place, it is generally considered the most **cost effective** and desirable level of intervention, and the great majority of measures examined throughout the remainder of this course, from **immunisation** programmes to **vector** control, discussed in the next Series, fall within this category, reflecting the strong emphasis placed on primary prevention within modern public health practice in Nigeria and elsewhere.

Fill in the blank: Primary prevention comprises measures applied before disease occurs, aimed at reducing exposure or increasing host _____.

1.3.2 secondary prevention

Secondary prevention comprises measures aimed at **early detection** and prompt **treatment** of disease that has already occurred but has not yet become clinically apparent or has only recently become so, with its principal tools including **screening programmes**, **surveillance**, discussed in a later Series, and prompt **case finding**, all intended to interrupt the natural history of disease, described earlier in this Series, at the earliest possible point.

The value of secondary prevention lies in **limiting disability**, reducing the **severity** of illness, and, in the case of communicable diseases specifically, **shortening the period of communicability**, thereby reducing the opportunity for onward transmission to other susceptible members of the population.

Fill in the blank: Secondary prevention comprises measures aimed at early detection and prompt _____ of disease.

1.3.3 tertiary prevention

Tertiary prevention comprises measures applied once disease has produced lasting impairment, aimed at reducing **disability**, preventing **complications**, and supporting **rehabilitation**, so that an affected individual can achieve the fullest possible level of function despite established disease, with examples including physiotherapy following paralytic illness and structured programmes of chronic disease management.

Taken together, **primary**, **secondary**, and **tertiary prevention** form a coherent, sequential framework spanning the entire natural history of disease described earlier in this Series, from measures preventing initial exposure through to those minimising the long-term consequences of established disease, and this framework underlies virtually every control programme examined in the remainder of this course.

Fill in the blank: Tertiary prevention is applied once disease has produced lasting impairment and aims to reduce disability and support _____.

Table 1.3: Comparing primary, secondary, and tertiary prevention.

Feature	Primary prevention	Secondary and tertiary prevention
Timing	Before disease occurs	After disease has occurred
Main aim	Prevent exposure or increase resistance	Detect early, treat promptly, or limit disability
Example tool	Immunisation	Screening (secondary); rehabilitation (tertiary)

Pilot questions 1.3

1. Define primary prevention and give two examples of primary preventive measures. (Linked to SLO 1.5)
2. Explain why primary prevention is generally considered the most cost effective level of intervention. (Linked to SLO 1.5)
3. Define secondary prevention and describe its principal tools. (Linked to SLO 1.6)

4. Explain how secondary prevention can reduce the period of communicability of a disease. (Linked to SLO 1.6)
5. Define tertiary prevention and give an example of a tertiary preventive measure. (Linked to SLO 1.6)

1.4 Quarantine, Isolation, and Herd Immunity

1.4.1 quarantine

Restricting movement of the exposed but not yet ill

Quarantine is the restriction of movement or activity of persons or animals who have been **exposed** to a communicable disease, but are not yet showing signs of illness, for a period at least as long as the longest usual **incubation period** of the disease concerned, discussed earlier in this Series, applied in order to prevent transmission during the period in which exposed individuals might become infectious before symptoms appear.

Quarantine has historically been applied to travellers and communities during major **epidemics**, and remains an important tool for diseases of global importance such as **Ebola**, discussed in a later Series of this course, though its use requires careful balancing of public health benefit against the considerable social and economic burden it places on those affected, meaning it is generally reserved for diseases of significant severity or epidemic potential.

Fill in the blank: Quarantine is applied to persons who have been exposed to a communicable disease but are not yet showing signs of _____.

1.4.2 isolation

Isolation is the separation, for the period of **communicability**, discussed earlier in this Series, of **infected** persons or animals from others, in order to prevent or limit the direct or indirect transmission of the infectious agent to susceptible contacts, and, unlike quarantine, isolation is applied specifically to individuals who are already known or suspected to be **infected**, whether or not they are yet showing symptoms.

The practical measures used during isolation vary according to the specific **route of transmission** of the disease concerned, discussed in detail in the next two Series of this course, ranging from simple separation into a single room through to more stringent barrier precautions for diseases transmitted by the airborne route, with the duration of isolation guided, wherever possible, by the known period of communicability of the disease.

Fill in the blank: Isolation is applied specifically to individuals who are already known or suspected to be _____.

1.4.3 herd immunity and its role in disease control

Herd immunity, also termed **community immunity**, is the indirect protection from a communicable disease that results when a sufficiently large proportion of a population has become **immune**, whether through prior infection or through **immunisation**, such that sustained transmission of the agent through the population is no longer possible, thereby indirectly protecting even those individuals within the population who remain susceptible.

The precise proportion of a population that must be immune to achieve herd immunity, termed the **herd immunity threshold**, varies from disease to disease according to how readily the agent is transmitted, and maintaining population immunity above this threshold, principally through sustained high **immunisation coverage**, represents one of the most powerful tools available for the long-term control, and potential **elimination**, of many communicable diseases, a theme developed further in a later Series of this course.

Fill in the blank: Herd immunity results when a sufficiently large proportion of a population becomes immune, preventing sustained _____ of the agent.

Figure 1.4: A health worker administering a vaccination to a child at a rural immunisation outreach clinic.

Pilot questions 1.4

1. Define quarantine and explain why its duration is linked to the incubation period. (Linked to SLO 1.7)
2. Distinguish quarantine from isolation. (Linked to SLO 1.7)
3. Explain why the practical measures used during isolation vary between diseases. (Linked to SLO 1.7)
4. Define herd immunity and explain how it protects susceptible individuals. (Linked to SLO 1.8)
5. Explain the role of immunisation coverage in achieving and maintaining herd immunity. (Linked to SLO 1.8)

Series Summary

This opening Series introduced the **basic concepts and principles** that underpin the epidemiology and control of communicable diseases, beginning with the definition and characteristics of a communicable disease and the **epidemiological triad** of agent, host, and environment, before examining the broad classification of direct and indirect **modes of transmission**, and then turning to the **natural history of disease**, tracing its predictable sequence from exposure through subclinical and clinical disease to eventual outcome, with particular attention to the **incubation period** and the **period of communicability**, two intervals of major practical importance for disease surveillance and control that recur throughout the remainder of this course.

We then examined the **levels of prevention**, primary, secondary, and tertiary, before concluding with **quarantine, isolation, and herd immunity**. Having worked through this Series, you should now possess the conceptual foundation needed to understand the more specific epidemiology and control measures addressed for particular transmission routes and diseases in the Series that follow.

Glossary of Terms

- **Communicable disease:** an illness caused by a specific infectious agent that is transmitted from an infected source to a susceptible host.
- **Epidemiological triad:** the interaction of agent, host, and environment that determines disease transmission.
- **Infectivity:** the ability of an agent to establish infection in a host.
- **Pathogenicity:** the ability of an agent to produce clinical disease once infection is established.
- **Virulence:** the severity of disease produced by an agent among those who become clinically ill.

- **Natural history of disease:** the predictable sequence of disease progression in the absence of intervention.
- **Incubation period:** the interval between exposure to an agent and the first appearance of clinical signs and symptoms.
- **Period of communicability:** the interval during which an infected person is capable of transmitting the agent to a susceptible host.
- **Primary prevention:** measures applied before disease occurs, aimed at reducing exposure or increasing host resistance.
- **Secondary prevention:** measures aimed at early detection and prompt treatment of disease.
- **Quarantine:** restriction of movement of exposed but not yet ill persons for the incubation period of a disease.
- **Herd immunity:** indirect protection from a disease resulting from a sufficiently high proportion of an immune population.

Concept Check Questions [Series 1]

Objective questions

1. A communicable disease is caused by a specific agent transmitted from an infected source to a susceptible _____.
2. The interaction of agent, host, and environment is often described as the epidemiological _____.
3. The interval between exposure and the first appearance of clinical signs and symptoms is the _____ period.
4. Primary prevention aims to reduce exposure or increase host _____.
5. Herd immunity prevents sustained _____ of an agent through a population.

Short-answer questions

6. Distinguish direct transmission from indirect transmission, with an example of each.
7. List the four stages in the natural history of disease.
8. Distinguish the period of communicability from the period of clinical illness.
9. Define secondary prevention and describe its principal tools.
10. Distinguish quarantine from isolation.

Long-answer questions

11. Discuss the definition and characteristics of a communicable disease and the epidemiological triad. (Linked to SLO 1.1, SLO 1.2)

12. Discuss the natural history of disease, including the incubation period and period of communicability. (Linked to SLO 1.3, SLO 1.4)
13. Discuss the levels of prevention: primary, secondary, and tertiary. (Linked to SLO 1.5, SLO 1.6)
14. Discuss quarantine and isolation and distinguish between them. (Linked to SLO 1.7)
15. Discuss herd immunity and its role in the control of communicable diseases. (Linked to SLO 1.8)

Answers to Concept Check Questions [Series 1]

Objective questions

1. Host.
2. Triad.
3. Incubation.
4. Resistance.
5. Transmission.

Short-answer questions

6. Direct transmission is essentially immediate transfer, such as by touch; indirect transmission involves an intermediate object, air, or vector.
7. Exposure, subclinical disease, clinical disease, and outcome.
8. Communicability may begin before symptoms appear and can continue after clinical recovery, unlike the period of clinical illness.
9. Secondary prevention aims at early detection and prompt treatment, using screening programmes, surveillance, and case finding.
10. Quarantine restricts movement of exposed but not yet ill persons; isolation separates persons already known or suspected to be infected.

Long-answer questions

11. **Basic response:** A communicable disease is caused by a specific agent transmitted from an infected source to a susceptible host, and every case depends on the interaction of agent, host, and environment, the epidemiological triad.

Value-added response: Agent properties such as infectivity, pathogenicity, and virulence, together with host susceptibility and environmental factors such as sanitation and crowding, together determine whether transmission occurs, persists, or is interrupted within a population.

12. **Basic response:** The natural history of disease progresses from exposure through subclinical and clinical disease to outcome, with the incubation period and period of communicability being two intervals of major practical importance.

Value-added response: Knowledge of the incubation period guides quarantine duration and outbreak investigation, while the period of communicability, which need not coincide with clinical illness, guides isolation duration and highlights the particular challenge posed by pre-symptomatic transmission.

13. **Basic response:** Primary prevention acts before disease occurs to reduce exposure or increase resistance; secondary prevention detects and treats disease early; tertiary prevention reduces disability once disease has caused lasting impairment.

Value-added response: These three levels form a coherent sequential framework spanning the entire natural history of disease, with primary prevention generally regarded as the most cost effective, underlying the strong emphasis on immunisation and environmental measures throughout this course.

14. **Basic response:** Quarantine restricts movement of exposed but not yet ill persons for the incubation period; isolation separates persons already known or suspected to be infected for the period of communicability.

Value-added response: Both measures interrupt transmission but are applied to different groups and at different points in the natural history of disease, with the practical measures used during isolation varying according to the specific route of transmission of the disease concerned.

15. **Basic response:** Herd immunity is the indirect protection from disease that results when a sufficiently high proportion of a population is immune, whether through prior infection or immunisation, preventing sustained transmission.

Value-added response: The herd immunity threshold varies by disease according to transmissibility, and maintaining population immunity above this threshold through sustained high immunisation coverage is a powerful tool for long-term disease control and potential elimination.

Answers to Pilot Questions [Series 1]

Part 1.1

1. A communicable disease is caused by a specific transmissible agent, unlike a non-communicable disease such as diabetes.
2. Agent, host, and environment.

3. Infectivity is the ability to establish infection; pathogenicity is the ability to produce clinical disease; virulence is the severity of disease produced.
4. Age, nutritional status, immunity, or underlying illness.
5. Direct transmission is essentially immediate, such as by touch; indirect transmission involves an intermediate object, the air, or a vector.

Part 1.2

1. Exposure, subclinical disease, clinical disease, and outcome.
2. Recovery, with or without disability, chronic carriage, or death.
3. The incubation period is the interval between exposure and first symptoms; it guides quarantine duration and outbreak investigation.
4. Communicability may begin before symptoms and continue after recovery, unlike clinical illness itself.
5. Affected individuals cannot be identified by symptoms alone, making contact tracing especially important.

Part 1.3

1. Primary prevention includes health education and immunisation.
2. It acts before infection occurs, avoiding the costs of treatment and disability altogether.
3. Secondary prevention aims at early detection and prompt treatment, using screening, surveillance, and case finding.
4. By detecting and treating disease early, secondary prevention shortens the time an infected person remains communicable.
5. Tertiary prevention includes rehabilitation such as physiotherapy following paralytic illness.

Part 1.4

1. Quarantine restricts exposed persons for at least the longest usual incubation period, since this covers the time they might become infectious.
2. Quarantine applies to the exposed but not yet ill; isolation applies to those already infected.
3. Because the route of transmission differs between diseases, requiring different practical barrier measures.
4. Herd immunity indirectly protects susceptible individuals because sustained transmission through the population is no longer possible.
5. High immunisation coverage raises the proportion of the population that is immune above the herd immunity threshold.

References and Attributions [Series 1]

- Park, K. (2021). Park's Textbook of Preventive and Social Medicine (26th ed.). Banarsidas Bhanot.
- World Health Organization (2020). Communicable disease control in emergencies: a field manual. WHO Press.
- Federal Ministry of Health, Nigeria (2019). National Technical Guidelines for Integrated Disease Surveillance and Response (3rd ed.).
- Heymann, D. L. (Ed.) (2015). Control of Communicable Diseases Manual (20th ed.). American Public Health Association.

Figures, Plates, Tables, and Boxes

- Figure 1.1: A laboratory scientist examining a microbial culture plate to identify a disease-causing agent. AI-generated using the prompt: "A single clean, realistic clinical illustration of a laboratory scientist in a white coat examining a culture plate at a laboratory bench, calm and focused expression, soft laboratory lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."
- Figure 1.2: A community health worker recording a patient's date of symptom onset in a clinic register. AI-generated using the prompt: "A single clean, realistic clinical illustration of a community health worker seated at a simple clinic desk, writing in a patient register while a patient sits opposite, calm rural clinic setting, soft natural lighting, no text overlays, no multiple panels, respectful and accurate depiction, no graphic detail."
- Table 1.3: Comparing primary, secondary, and tertiary prevention. AI-generated using the prompt: "Create a clean reference table titled Levels of Prevention, listing feature, primary prevention, and secondary and tertiary prevention. Simple clinical reference table style with outside border."
- Figure 1.4: A health worker administering a vaccination to a child at a rural immunisation outreach clinic. AI-generated using the prompt: "A single clean, realistic clinical illustration of a health worker administering a vaccination to a calm young child at a simple outdoor rural clinic table, caregiver present, warm natural lighting, no text overlays, no multiple panels, respectful and accurate depiction, no graphic medical detail."

Series 2: Epidemiology and Control of Diseases Transmitted by Ingestion, Inhalation, and Contact Routes

- **Part 2.1: Faeco-Oral (Ingestion) Transmission: Principles and Examples**
    - Sub Part 2.1.1: Mechanism of faeco-oral transmission
    - Sub Part 2.1.2: Diarrhoeal diseases transmitted by ingestion
    - Sub Part 2.1.3: Prevention and control of faeco-orally transmitted diseases
- **Part 2.2: Cholera: Epidemiology and Control**
    - Sub Part 2.2.1: Causative agent and epidemiology of cholera
    - Sub Part 2.2.2: Clinical features and transmission of cholera
    - Sub Part 2.2.3: Prevention and control of cholera
- **Part 2.3: Airborne (Inhalation) Transmission: Principles and Tuberculosis**
    - Sub Part 2.3.1: Mechanism of airborne transmission
    - Sub Part 2.3.2: Epidemiology of tuberculosis
    - Sub Part 2.3.3: Prevention and control of tuberculosis
- **Part 2.4: Contact Transmission: Principles and Control**
    - Sub Part 2.4.1: Mechanism of direct and indirect contact transmission
    - Sub Part 2.4.2: Examples of diseases transmitted by contact
    - Sub Part 2.4.3: Prevention and control of contact-transmitted diseases

Introduction

In the last Series, we explored the **basic concepts and principles** underlying the epidemiology and control of communicable diseases, including the epidemiological triad, the natural history of disease, and the levels of prevention. We now turn to the first two of the specific **routes of transmission** identified in this course, the **faeco-oral (ingestion)** route and the **airborne (inhalation)** route, together with the **contact** route. Picture a community recording a sudden rise in cases of profuse watery diarrhoea shortly after a change in the local water supply, alongside a separate cluster of persistent cough cases identified through routine clinic attendance.

Recognising the specific route by which each disease spreads is the essential first step in selecting effective control measures, and it is this task that occupies this Series.

The aim of this Series is to equip you with the knowledge required to understand the mechanisms of faeco-oral, airborne, and contact transmission, and to describe the epidemiology and control of **cholera** and **tuberculosis** as key examples of diseases transmitted by these routes.

This Series begins with **faeco-oral (ingestion) transmission**, before turning to **cholera**, a key example of this route. Next, we examine **airborne (inhalation) transmission** and **tuberculosis**, before concluding with **contact transmission** and its control.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 2.1:** describe the mechanism of faeco-oral transmission and list examples of diseases transmitted by this route
- **SLO 2.2:** describe the prevention and control of faeco-orally transmitted diseases
- **SLO 2.3:** describe the causative agent, epidemiology, and clinical features of cholera
- **SLO 2.4:** describe the prevention and control of cholera
- **SLO 2.5:** describe the mechanism of airborne transmission and the epidemiology of tuberculosis
- **SLO 2.6:** describe the prevention and control of tuberculosis
- **SLO 2.7:** describe the mechanism of direct and indirect contact transmission and give examples of diseases transmitted by this route, and
- **SLO 2.8:** describe the prevention and control of contact-transmitted diseases.

2.1 Faeco-Oral (Ingestion) Transmission: Principles and Examples

2.1.1 mechanism of faeco-oral transmission

Pathogens excreted in faeces reaching a new mouth

Faeco-oral transmission, sometimes described using the shorthand **five Fs**, **faeces**, **fingers**, **flies**, **fields**, and **fluids**, occurs when an infectious agent excreted in the **faeces** of an infected person or animal is subsequently **ingested** by a susceptible host, most commonly through contaminated **water** or **food**, unwashed **hands**, or **flies** that mechanically carry the agent from faecal matter to food or eating surfaces.

This route depends heavily on the adequacy of **sanitation**, **hygiene**, and access to **safe drinking water** within a community, meaning that faeco-orally transmitted diseases are, in general, considerably more common where these environmental conditions are poor, and, correspondingly, that improving these same conditions remains the single most powerful long-term strategy for reducing the burden of disease transmitted by this route.

Fill in the blank: Faeco-oral transmission occurs when an infectious agent excreted in faeces is subsequently _____ by a susceptible host.

2.1.2 diarrhoeal diseases transmitted by ingestion

A wide range of **diarrhoeal diseases** are transmitted by the faeco-oral route, including **typhoid fever**, caused by **Salmonella typhi**, **cholera**, examined in detail in the next Part of this Series, various forms of **bacterial** and **viral gastroenteritis**, and several intestinal **helminth** infections acquired through ingestion of contaminated food or water.

These diseases share a broadly similar epidemiological pattern, with **outbreaks** frequently linked to a common contaminated water source or food item, particularly during periods of **flooding**, population **displacement**, or breakdown of normal sanitation infrastructure, meaning that outbreak investigation for such diseases typically focuses on identifying the shared water or food source responsible.

Fill in the blank: Typhoid fever, a faeco-orally transmitted disease, is caused by Salmonella _____.

2.1.3 prevention and control of faeco-orally transmitted diseases

Prevention of faeco-orally transmitted diseases rests principally on **primary prevention** measures, discussed in the previous Series, including provision of **safe drinking water**, adequate **excreta disposal**, such as improved **latrines**, promotion of **handwashing** with soap, and safe **food handling** practices, each acting to interrupt one of the specific pathways summarised in the five Fs described earlier in this Part.

Where **outbreaks** do occur, prompt **case management**, particularly **oral rehydration therapy** for diseases causing significant diarrhoea, together with rapid identification and elimination of the **common source**, remain the priorities, and **health education** promoting safe water and food handling practices provides an important complementary measure to these structural interventions.

Fill in the blank: Prevention of faeco-orally transmitted diseases rests principally on provision of safe drinking water and adequate excreta _____.

Figure 2.1: A community member drawing water from a protected borehole with a hand pump.

Pilot questions 2.1

6. Describe the five Fs of faeco-oral transmission. (Linked to SLO 2.1)
7. List three diseases transmitted by the faeco-oral route. (Linked to SLO 2.1)
8. Explain why faeco-orally transmitted diseases are more common where sanitation is poor. (Linked to SLO 2.1)
9. Describe two measures used to prevent faeco-orally transmitted diseases. (Linked to SLO 2.2)
10. Describe the priority actions during an outbreak of a faeco-orally transmitted disease. (Linked to SLO 2.2)

2.2 Cholera: Epidemiology and Control

2.2.1 causative agent and epidemiology of cholera

A rapidly dehydrating diarrhoeal disease of major epidemic importance

Cholera is an acute diarrhoeal disease caused by the bacterium **Vibrio cholerae**, transmitted by the **faeco-oral route**, discussed earlier in this Series, typically through **contaminated water** or, less commonly, contaminated food, and remains a disease of major **epidemic** and public health importance in Nigeria and many other parts of the world, particularly where access to safe water and adequate sanitation is limited.

Cholera outbreaks characteristically occur in explosive **clusters**, often associated with a specific contaminated water source, and disproportionately affect populations living in conditions of **overcrowding**, poor sanitation, or **displacement**, such as camps for refugees or persons displaced by conflict or natural disaster, reflecting the strong dependence of this disease on the environmental conditions discussed in the previous Part.

Fill in the blank: Cholera is caused by the bacterium Vibrio _____.

2.2.2 clinical features and transmission of cholera

Cholera characteristically produces sudden onset of **profuse watery diarrhoea**, often described as **rice water stools**, together with **vomiting**, leading, in severe cases, to rapid and life threatening **dehydration** within hours of symptom onset, a pattern that distinguishes cholera clinically from most other causes of diarrhoeal illness.

Following ingestion of contaminated water or food, **Vibrio cholerae** colonises the small intestine and produces **cholera toxin**, which causes the intestinal lining to secrete large volumes of fluid and electrolytes, and an infected person may shed the organism in stool for several days, contributing further to the ongoing faeco-oral transmission described in the previous Part if adequate sanitation is not maintained.

Fill in the blank: Cholera characteristically produces profuse watery diarrhoea, often described as _____ stools.

2.2.3 prevention and control of cholera

Prevention of cholera rests on the same general measures described for faeco-orally transmitted diseases in general, safe **water supply**, adequate **sanitation**, and **hygiene** promotion, together with **oral cholera vaccines**, which provide additional protection in high risk settings and are increasingly deployed as part of outbreak response and preparedness in vulnerable communities.

Management of cholera cases centres on prompt **rehydration**, using **oral rehydration solution** for milder cases and **intravenous fluids** for severe dehydration, since deaths from cholera result principally from dehydration rather than the infection itself, meaning that timely, effective rehydration can reduce case fatality dramatically even without **antibiotic** treatment, which is reserved for more severe cases.

Fill in the blank: Deaths from cholera result principally from _____ rather than the infection itself.

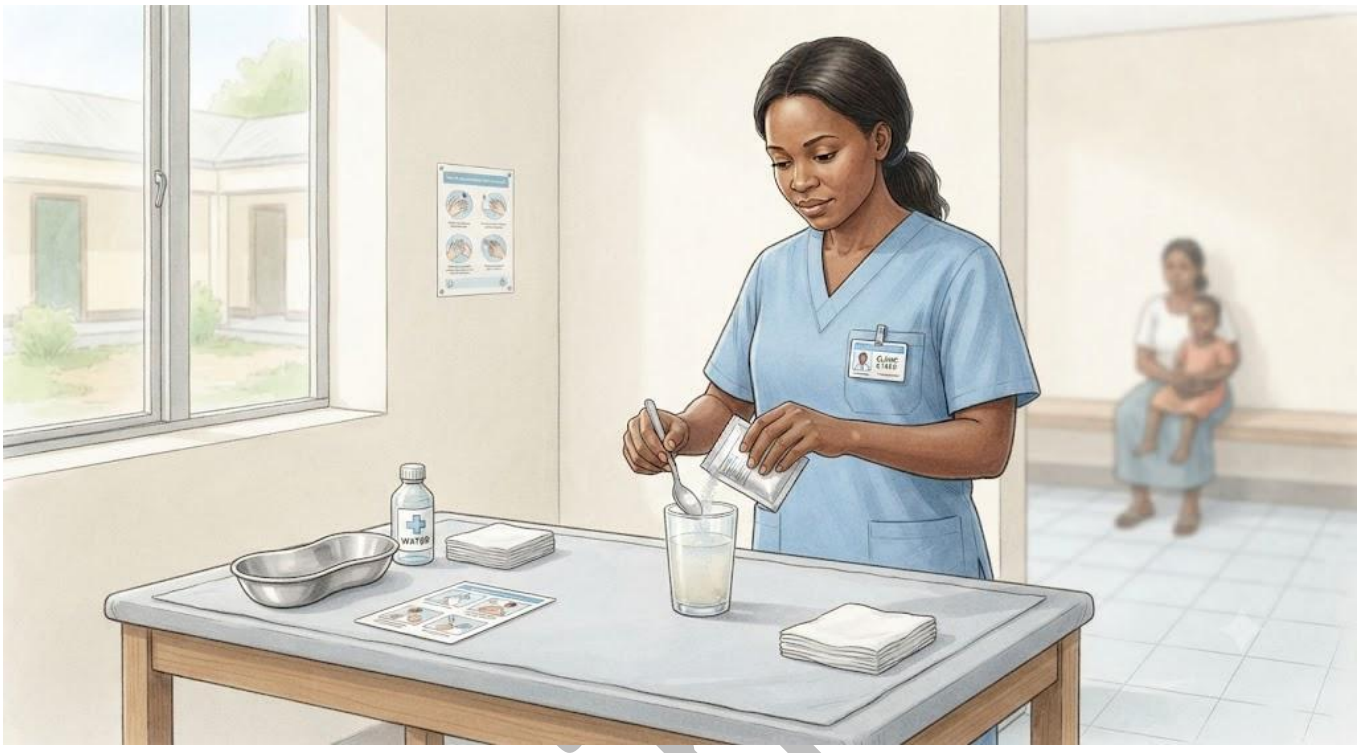

Figure 2.2: A health worker preparing oral rehydration solution for a patient with acute diarrhoea.

Pilot questions 2.2

6. Identify the causative organism of cholera and its usual route of transmission. (Linked to SLO 2.3)
7. Explain why cholera outbreaks disproportionately affect displaced populations. (Linked to SLO 2.3)
8. Describe the characteristic clinical features of cholera. (Linked to SLO 2.3)
9. Explain why prompt rehydration is the priority in cholera management. (Linked to SLO 2.4)
10. Describe the role of oral cholera vaccines in prevention. (Linked to SLO 2.4)

2.3 Airborne (Inhalation) Transmission: Principles and Tuberculosis

2.3.1 mechanism of airborne transmission

Pathogens carried on respiratory droplets or nuclei

Airborne transmission occurs when an infectious agent is spread through the air via **respiratory droplets**, expelled during **coughing**, **sneezing**, or talking, or via smaller **droplet nuclei**, which can remain suspended in the air for longer periods and travel further than larger droplets, and is subsequently **inhaled** by a susceptible host, most typically in **crowded**, poorly **ventilated** indoor settings.

The relative importance of larger droplets, which settle quickly and generally require closer contact, compared with smaller droplet nuclei, which behave more like a true aerosol, varies between specific diseases, and this distinction has important practical implications for the specific control measures, such as **ventilation** and **respiratory protection**, appropriate to a given airborne disease.

Fill in the blank: Airborne transmission occurs when an infectious agent spread through the air is subsequently _____ by a susceptible host.

2.3.2 epidemiology of tuberculosis

Tuberculosis, caused by **Mycobacterium tuberculosis**, remains one of the leading causes of death from a single infectious agent globally, and a disease of major public health importance in Nigeria, with transmission occurring almost exclusively via **airborne droplet nuclei** produced by a person with **active pulmonary disease**, meaning prolonged, close contact with an infectious case is generally required for transmission to occur.

Following initial infection, most individuals develop **latent tuberculosis infection**, in which the organism remains **dormant** and the person is neither symptomatic nor infectious, while only a proportion progress to **active disease**, a risk substantially increased by conditions that weaken **immunity**, particularly **HIV** co-infection, malnutrition, and other predisposing conditions relevant to the Nigerian context.

Fill in the blank: Following initial infection, most individuals develop latent tuberculosis infection, in which the organism remains _____.

2.3.3 prevention and control of tuberculosis

Prevention of tuberculosis includes **BCG vaccination**, given in infancy, which provides some protection against severe childhood forms of the disease, together with **infection control**

measures in health facilities and households, including adequate **ventilation** and, where appropriate, **respiratory protection** for those in close contact with an infectious case.

Control of established disease depends on prompt **case detection**, typically through **sputum microscopy** or more sensitive **molecular tests**, followed by **directly observed treatment, short course**, or **DOTS**, a structured, supervised multi-drug treatment regimen that both cures the individual patient and, by rendering them non-infectious, interrupts further **transmission** within the community.

Fill in the blank: Control of established tuberculosis depends on directly observed treatment, short course, commonly abbreviated as _____.

Figure 2.3: A health worker examining a sputum sample under a microscope in a laboratory.

Pilot questions 2.3

6. Distinguish respiratory droplets from droplet nuclei in airborne transmission. (Linked to SLO 2.5)
7. Identify the causative organism of tuberculosis and its usual route of transmission. (Linked to SLO 2.5)

8. Distinguish latent tuberculosis infection from active tuberculosis disease. (Linked to SLO 2.5)
9. Explain the role of BCG vaccination in tuberculosis prevention. (Linked to SLO 2.6)
10. Describe DOTS and explain how it contributes to interrupting tuberculosis transmission. (Linked to SLO 2.6)

2.4 Contact Transmission: Principles and Control

2.4.1 mechanism of direct and indirect contact transmission

Transmission through touch or a shared contaminated surface

Contact transmission is divided into **direct contact transmission**, involving essentially immediate physical transfer of an infectious agent between an infected person and a susceptible host, for example through touching, kissing, or sexual contact, and **indirect contact transmission**, involving transfer via a contaminated intermediate object, or **fomite**, such as shared clothing, bedding, or medical instruments.

Because contact transmission generally requires reasonably close or direct physical interaction, diseases spread by this route often cluster within **households**, **schools**, or other settings involving sustained close contact, and understanding whether a given disease spreads predominantly by direct or indirect contact informs the specific hygiene and barrier measures most appropriate to its control.

Fill in the blank: Indirect contact transmission involves transfer of an infectious agent via a contaminated intermediate object, or _____.

2.4.2 examples of diseases transmitted by contact

Diseases transmitted predominantly by **direct contact** include many common **skin infections**, such as **scabies** and **ringworm**, and certain **sexually transmitted infections**, while diseases transmitted significantly by **indirect contact** include some **conjunctival infections** spread via shared towels and certain **gastrointestinal infections** spread via contaminated surfaces in addition to the faeco-oral route discussed earlier in this Series.

Some diseases spread by contact are also transmissible by **blood** or other body fluids, a category of particular importance in the Nigerian context given the significant burden of **HIV**, and such **blood-borne** contact transmission, whether through unsafe injection practices, unscreened blood transfusion, or unprotected sexual contact, is addressed further in a later Series of this course.

Fill in the blank: Diseases transmitted predominantly by direct contact include common skin infections such as scabies and _____.

2.4.3 prevention and control of contact-transmitted diseases

Prevention of contact-transmitted diseases relies principally on **personal hygiene**, including regular **handwashing** and avoidance of sharing personal items such as towels or clothing, together with prompt **treatment** of affected individuals to reduce the period during which they remain a source of infection to close contacts.

In healthcare settings specifically, **standard precautions**, including appropriate **hand hygiene**, use of **gloves** where indicated, and safe handling and disposal of **sharps** and other contaminated materials, form the cornerstone of preventing contact transmission of infection between patients and healthcare workers, principles that apply equally to the blood-borne diseases discussed further in a later Series of this course.

Fill in the blank: In healthcare settings, standard precautions include appropriate hand hygiene and safe handling and disposal of _____.

Table 2.4: Comparing faeco-oral, airborne, and contact transmission.

Feature	Faeco-oral / Airborne	Contact
Typical vehicle	Contaminated water, food, or air	Touch or a contaminated object (fomite)
Key control measure	Safe water, sanitation, ventilation	Personal hygiene, standard precautions
Example disease	Cholera (ingestion); tuberculosis (airborne)	Scabies; certain sexually transmitted infections

Pilot questions 2.4

6. Distinguish direct contact transmission from indirect contact transmission. (Linked to SLO 2.7)
7. Give two examples of diseases transmitted predominantly by direct contact. (Linked to SLO 2.7)
8. Explain why blood-borne contact transmission is of particular importance in the Nigerian context. (Linked to SLO 2.7)
9. Describe two personal hygiene measures that prevent contact-transmitted diseases. (Linked to SLO 2.8)
10. Describe standard precautions and their role in healthcare settings. (Linked to SLO 2.8)

Series Summary

This Series examined three of the specific **routes of transmission** introduced in the previous Series, beginning with **faeco-oral (ingestion) transmission**, its dependence on water, sanitation, and hygiene, and the range of diarrhoeal diseases it produces, before turning to **cholera** as a key example, exploring its causative organism, its characteristic explosive outbreaks in settings of poor sanitation or displacement, its clinical presentation of profuse watery diarrhoea and rapid dehydration, and the central importance of prompt rehydration in reducing mortality, together with the preventive role of safe water, sanitation, and oral cholera vaccines.

We then examined **airborne (inhalation) transmission** and **tuberculosis**, before concluding with **contact transmission** and its control. Having worked through this Series, you should now be equipped to describe the epidemiology and control of diseases transmitted by ingestion, inhalation, and contact, in preparation for the vector-borne and zoonotic diseases addressed in the next Series of this course.

Glossary of Terms

- **Faeco-oral transmission:** transmission occurring when an agent excreted in faeces is subsequently ingested by a susceptible host.
- **Five Fs:** faeces, fingers, flies, fields, and fluids: the pathways of faeco-oral transmission.
- **Cholera:** an acute diarrhoeal disease caused by Vibrio cholerae, transmitted by the faeco-oral route.
- **Rice water stools:** the profuse watery diarrhoea characteristic of cholera.
- **Oral rehydration solution:** a fluid and electrolyte solution used to treat dehydration from diarrhoeal disease.
- **Airborne transmission:** transmission of an agent through the air via respiratory droplets or droplet nuclei.
- **Droplet nuclei:** small airborne particles that can remain suspended in the air and travel further than larger droplets.
- **Latent tuberculosis infection:** a dormant state of tuberculosis infection with no symptoms and no infectiousness.
- **DOTS:** directly observed treatment, short course, a supervised multi-drug regimen for tuberculosis.
- **Contact transmission:** transmission via direct physical contact or an indirect contaminated object, or fomite.

- **Fomite:** a contaminated intermediate object capable of transferring an infectious agent.
- **Standard precautions:** hygiene and safety practices used in healthcare settings to prevent contact transmission of infection.

Concept Check Questions [Series 2]

Objective questions

6. Faeco-oral transmission occurs when an agent excreted in faeces is subsequently _____ by a susceptible host.
7. Cholera is caused by the bacterium Vibrio _____.
8. Cholera characteristically produces profuse watery diarrhoea, often described as _____ stools.
9. Following initial infection, most individuals develop latent tuberculosis infection, in which the organism remains _____.
10. Indirect contact transmission involves transfer of an agent via a contaminated intermediate object, or _____.

Short-answer questions

11. Describe the five Fs of faeco-oral transmission.
12. Explain why prompt rehydration is the priority in cholera management.
13. Distinguish respiratory droplets from droplet nuclei in airborne transmission.
14. Describe DOTS and its purpose in tuberculosis control.
15. Distinguish direct contact transmission from indirect contact transmission.

Long-answer questions

16. Discuss the mechanism of faeco-oral transmission and the diseases it produces. (Linked to SLO 2.1, SLO 2.2)
17. Discuss the epidemiology, clinical features, and control of cholera. (Linked to SLO 2.3, SLO 2.4)
18. Discuss the mechanism of airborne transmission and the epidemiology of tuberculosis. (Linked to SLO 2.5, SLO 2.6)
19. Discuss the prevention and control of tuberculosis. (Linked to SLO 2.6)
20. Discuss contact transmission and its prevention and control. (Linked to SLO 2.7, SLO 2.8)

Answers to Concept Check Questions [Series 2]

Objective questions

16. Ingested.
17. cholerae.
18. Rice water.
19. Dormant.

20. Fomite.

Short-answer questions

21. Faeces, fingers, flies, fields, and fluids.
22. Deaths from cholera result principally from dehydration rather than the infection itself.
23. Respiratory droplets settle quickly and require closer contact; droplet nuclei remain suspended and travel further.
24. DOTS is directly observed treatment, short course, a supervised multi-drug regimen that cures patients and interrupts transmission.
25. Direct contact involves immediate physical transfer; indirect contact involves transfer via a contaminated object, or fomite.

Long-answer questions

26. **Basic response:** Faeco-oral transmission occurs when an agent excreted in faeces is ingested by a susceptible host, typically via contaminated water, food, hands, or flies, producing diseases such as typhoid fever and cholera.

Value-added response: The five Fs framework, faeces, fingers, flies, fields, and fluids, summarises the main pathways of this route, and outbreaks are frequently linked to a common contaminated water or food source, particularly during flooding or displacement.

27. **Basic response:** Cholera, caused by Vibrio cholerae, produces profuse watery rice water stools and rapid dehydration, with control resting on safe water, sanitation, oral cholera vaccines, and, above all, prompt rehydration.

Value-added response: Cholera outbreaks characteristically occur in explosive clusters associated with a specific contaminated water source, disproportionately affecting overcrowded or displaced populations, while case fatality can be reduced dramatically through timely oral or intravenous rehydration alone.

28. **Basic response:** Airborne transmission occurs via inhaled respiratory droplets or droplet nuclei, and tuberculosis, caused by Mycobacterium tuberculosis, is transmitted almost exclusively by this route from persons with active pulmonary disease.

Value-added response: Most infected individuals develop latent tuberculosis infection, remaining asymptomatic and non-infectious, while progression to active disease is substantially increased by conditions weakening immunity, particularly HIV co-infection.

29. **Basic response:** Prevention of tuberculosis includes BCG vaccination and infection control measures such as ventilation, while control of established disease depends on prompt case detection through sputum microscopy or molecular testing.

Value-added response: Directly observed treatment, short course, or DOTS, both cures the individual patient and, by rendering them non-infectious, interrupts further transmission within the community, making treatment itself a key control measure.

30. **Basic response:** Contact transmission occurs through direct physical contact or indirectly via a contaminated fomite, producing diseases such as scabies and certain sexually transmitted and blood-borne infections.

Value-added response: Prevention rests on personal hygiene and prompt treatment of affected individuals, while healthcare settings additionally rely on standard precautions, including hand hygiene and safe handling of sharps, to prevent transmission between patients and healthcare workers.

Answers to Pilot Questions [Series 2]

Part 2.1

6. Faeces, fingers, flies, fields, and fluids.
7. Typhoid fever, cholera, and viral or bacterial gastroenteritis.
8. Poor sanitation increases faecal contamination of water, food, hands, and surfaces.
9. Provision of safe drinking water and promotion of handwashing with soap.
10. Prompt case management, including rehydration, and rapid identification and elimination of the common source.

Part 2.2

6. Vibrio cholerae, transmitted by the faeco-oral route, usually via contaminated water.
7. They often have overcrowding, poor sanitation, and disrupted water supply.
8. Sudden onset of profuse watery rice water stools and vomiting, with rapid dehydration.
9. Because deaths from cholera result principally from dehydration rather than the infection itself.
10. Oral cholera vaccines provide additional protection in high risk settings and are used in outbreak response.

Part 2.3

6. Respiratory droplets are larger and settle quickly; droplet nuclei are smaller and remain suspended longer.
7. Mycobacterium tuberculosis, transmitted via airborne droplet nuclei from a person with active pulmonary disease.

8. Latent infection is dormant and non-infectious; active disease is symptomatic and infectious.
9. BCG vaccination provides some protection against severe childhood forms of tuberculosis.
10. DOTS ensures completed, supervised treatment, curing patients and rendering them non-infectious, interrupting transmission.

Part 2.4

6. Direct contact is immediate physical transfer; indirect contact involves a contaminated intermediate object, or fomite.
7. Scabies and ringworm.
8. Because of the significant burden of HIV, a blood-borne infection transmissible by contact routes.
9. Regular handwashing and avoiding sharing personal items such as towels.
10. Standard precautions include hand hygiene, use of gloves, and safe handling and disposal of sharps in healthcare settings.

References and Attributions [Series 2]

- Park, K. (2021). Park's Textbook of Preventive and Social Medicine (26th ed.). Banarsidas Bhanot.
- World Health Organization (2022). Cholera fact sheet and technical guidance. WHO Press.
- World Health Organization (2023). Global tuberculosis report. WHO Press.
- Federal Ministry of Health, Nigeria (2019). National Technical Guidelines for Integrated Disease Surveillance and Response (3rd ed.).

Figures, Plates, Tables, and Boxes

- Figure 2.1: A community member drawing water from a protected borehole with a hand pump. AI-generated using the prompt: "A single clean, realistic illustration of a person drawing water from a protected community borehole with a hand pump, calm outdoor rural setting, natural daylight, no text overlays, no multiple panels, accurate and respectful depiction, no graphic detail."
- Figure 2.2: A health worker preparing oral rehydration solution for a patient with acute diarrhoea. AI-generated using the prompt: "A single clean, realistic clinical illustration of a health worker preparing oral rehydration solution in a clear cup at a simple clinic treatment table, calm clinical setting, soft natural lighting, no text overlays, no multiple panels, respectful and accurate depiction, no graphic medical detail."
- Figure 2.3: A health worker examining a sputum sample under a microscope in a laboratory. AI-generated using the prompt: "A single clean, realistic clinical illustration of a laboratory health worker examining a sample under a microscope at a laboratory bench, focused and calm expression, soft laboratory lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."
- Table 2.4: Comparing faeco-oral, airborne, and contact transmission. AI-generated using the prompt: "Create a clean reference table titled Comparing Transmission Routes, listing feature, faeco-oral and airborne, and contact. Simple clinical reference table style with outside border."

Series 3: Epidemiology and Control of Vector-Borne and Zoonotic Diseases

- **Part 3.1: Vector-Borne Transmission and Malaria**
    - Sub Part 3.1.1: Mechanism of vector-borne transmission
    - Sub Part 3.1.2: Epidemiology and life cycle of malaria
    - Sub Part 3.1.3: Prevention and control of malaria
- **Part 3.2: Onchocerciasis (River Blindness)**
    - Sub Part 3.2.1: Causative agent and vector of onchocerciasis
    - Sub Part 3.2.2: Clinical features of onchocerciasis
    - Sub Part 3.2.3: Prevention and control of onchocerciasis
- **Part 3.3: Schistosomiasis**
    - Sub Part 3.3.1: Causative agent and life cycle of schistosomiasis
    - Sub Part 3.3.2: Clinical features of schistosomiasis
    - Sub Part 3.3.3: Prevention and control of schistosomiasis
- **Part 3.4: Zoonotic Diseases**
    - Sub Part 3.4.1: Mechanism of zoonotic transmission
    - Sub Part 3.4.2: Examples of zoonotic diseases
    - Sub Part 3.4.3: Prevention and control of zoonotic diseases

Introduction

In the last Series, we explored diseases transmitted by **ingestion, inhalation, and contact**, including cholera and tuberculosis. We now turn to diseases transmitted by **vectors**, living organisms that carry an infectious agent from one host to another, and to **zoonotic diseases**, those transmitted from animals to humans. Picture a farming community close to a fast flowing river, where recurring fevers are common among children and where a number of older residents have progressively lost their sight. Understanding the specific vectors responsible for such patterns of disease, and the animal reservoirs behind zoonotic infections, is essential to designing effective control programmes, and it is this task that occupies this Series.

The aim of this Series is to equip you with the knowledge required to understand vector-borne transmission and the epidemiology and control of **malaria**, **onchocerciasis**, and **schistosomiasis**, together with the mechanism, examples, and control of zoonotic diseases.

This Series begins with **vector-borne transmission and malaria**, before turning to **onchocerciasis**. Next, we examine **schistosomiasis**, before concluding with **zoonotic diseases** and their control.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 3.1:** describe the mechanism of vector-borne transmission and the epidemiology and life cycle of malaria
- **SLO 3.2:** describe the prevention and control of malaria
- **SLO 3.3:** describe the causative agent, vector, and clinical features of onchocerciasis
- **SLO 3.4:** describe the prevention and control of onchocerciasis
- **SLO 3.5:** describe the causative agent, life cycle, and clinical features of schistosomiasis
- **SLO 3.6:** describe the prevention and control of schistosomiasis
- **SLO 3.7:** describe the mechanism of zoonotic transmission and give examples of zoonotic diseases, and
- **SLO 3.8:** describe the prevention and control of zoonotic diseases.

3.1 Vector-Borne Transmission and Malaria

3.1.1 mechanism of vector-borne transmission

A living carrier transfers the agent between hosts

Vector-borne transmission occurs when a living organism, or **vector**, most commonly an **arthropod** such as a **mosquito**, **tsetse fly**, or **blackfly**, transfers an infectious agent from an infected host or reservoir to a susceptible one, and is classified as **biological transmission**, in which the agent undergoes part of its life cycle or multiplies within the vector before becoming infective, or **mechanical transmission**, in which the vector simply carries the agent on its body surface without any biological development.

The **geographical distribution** and **seasonal pattern** of vector-borne diseases are closely tied to the **ecology** of the specific vector responsible, including factors such as **rainfall**, **temperature**,

and availability of **breeding sites**, meaning that vector-borne disease control, discussed throughout this Series, typically requires measures directed specifically at the vector itself rather than at the human host alone.

Fill in the blank: Vector-borne transmission in which an agent undergoes part of its life cycle within the vector is termed _____ transmission.

3.1.2 epidemiology and life cycle of malaria

Malaria, caused by **Plasmodium** parasites, of which **Plasmodium falciparum** is the most significant species in Nigeria, is transmitted by the bite of an infected female **Anopheles mosquito**, and remains one of the leading causes of illness and death in the country, with young children and pregnant women bearing a disproportionate share of the disease burden.

Following an infective mosquito bite, **Plasmodium** parasites first multiply within the **liver**, before entering the **bloodstream** and invading **red blood cells**, where cyclical multiplication produces the characteristic periodic **fever** of malaria, and a mosquito that subsequently bites an infected person can itself become infected, completing the cycle of transmission within a given area.

Fill in the blank: Malaria is transmitted by the bite of an infected female _____ mosquito.

3.1.3 prevention and control of malaria

Prevention of malaria relies principally on **vector control**, including use of **insecticide treated bednets**, **indoor residual spraying**, and reduction of mosquito **breeding sites** through environmental management, together with **chemoprevention** for particularly vulnerable groups, such as **intermittent preventive treatment** in pregnancy.

Control of established malaria depends on prompt **diagnosis**, using **microscopy** or **rapid diagnostic tests**, followed by treatment with effective **artemisinin-based combination therapy**, since prompt, effective treatment both prevents progression to **severe malaria** and reduces the pool of infected persons available to infect further mosquitoes, thereby also contributing to onward transmission control.

Fill in the blank: Control of established malaria depends on prompt diagnosis followed by treatment with effective artemisinin-based combination _____.

Figure 3.1: A health worker hanging an insecticide-treated bednet over a sleeping area.

Pilot questions 3.1

11. Distinguish biological transmission from mechanical transmission in vector-borne disease. (Linked to SLO 3.1)
12. Explain why vector-borne disease control targets the vector rather than the human host alone. (Linked to SLO 3.1)
13. Identify the vector and causative organism of malaria. (Linked to SLO 3.1)
14. Describe two measures used to prevent malaria through vector control. (Linked to SLO 3.2)
15. Explain why prompt diagnosis and treatment of malaria also contributes to transmission control. (Linked to SLO 3.2)

3.2 Onchocerciasis (River Blindness)

3.2.1 causative agent and vector of onchocerciasis

A filarial worm transmitted near fast flowing rivers

Onchocerciasis, commonly known as **river blindness**, is caused by the filarial worm **Onchocerca volvulus**, transmitted by the bite of an infected **blackfly** of the genus **Simulium**, which breeds specifically in fast flowing, well oxygenated **rivers** and streams, explaining the strong association

between this disease and communities living close to such rivers, particularly in parts of Nigeria and other West African countries.

Following an infective blackfly bite, larvae develop into adult worms that reside in fibrous **nodules** under the skin, where female worms release large numbers of **microfilariae** that migrate through the skin and, critically, the **eye**, with repeated cycles of infection over years, in the absence of control, leading to the progressive **visual impairment** and blindness for which the disease is named.

Fill in the blank: Onchocerciasis is transmitted by the bite of an infected blackfly of the genus _____.

3.2.2 clinical features of onchocerciasis

Clinical manifestations of onchocerciasis include intensely itchy **skin nodules** and chronic **dermatitis**, reflecting the immune response to microfilariae within the skin, and progressive **ocular** involvement, including visual impairment and, in longstanding untreated infection, complete and irreversible **blindness**, the most feared complication of this disease.

Because clinical disease develops only after **years** of repeated infective bites, and because ocular damage in particular is largely **irreversible** once established, the emphasis in onchocerciasis control, discussed in the next sub-Part, falls heavily on sustained community-wide **prevention** rather than on treatment of established disease alone.

Fill in the blank: Onchocerciasis produces intensely itchy skin nodules and chronic _____.

3.2.3 prevention and control of onchocerciasis

Control of onchocerciasis rests principally on mass **community-directed treatment** with **ivermectin**, distributed annually, or in some settings more frequently, across affected communities, since ivermectin kills **microfilariae** and, taken over sustained periods, substantially reduces transmission and the risk of eye disease across a treated population.

Complementary measures include **vector control**, targeting blackfly breeding sites in rivers where feasible, and this disease forms a central part of the **WHO special programme for tropical diseases**, discussed in the final Series of this course, given its historical significance as a target of some of the earliest large scale mass drug administration programmes in Africa.

Fill in the blank: Control of onchocerciasis rests principally on mass community-directed treatment with _____.

Figure 3.2: A community health volunteer distributing ivermectin tablets to villagers.

Pilot questions 3.2

11. Identify the causative organism and vector of onchocerciasis. (Linked to SLO 3.3)
12. Explain why onchocerciasis is associated with communities near fast flowing rivers. (Linked to SLO 3.3)
13. Describe the skin and eye manifestations of onchocerciasis. (Linked to SLO 3.3)
14. Explain why prevention is emphasised over treatment of established onchocerciasis. (Linked to SLO 3.4)
15. Describe the role of ivermectin in the control of onchocerciasis. (Linked to SLO 3.4)

3.3 Schistosomiasis

3.3.1 causative agent and life cycle of schistosomiasis

A water-borne fluke requiring a freshwater snail host

Schistosomiasis, also termed **bilharzia**, is caused by blood flukes of the genus **Schistosoma**, principally **Schistosoma haematobium**, affecting the urinary tract, and **Schistosoma mansoni**, affecting the intestines, both of which require a specific freshwater **snail** as an intermediate host,

explaining why transmission is closely tied to contact with infested freshwater bodies such as rivers, lakes, and irrigation canals.

Infected persons pass parasite eggs in **urine** or **stool** into water, where they hatch and infect the snail host, within which the parasite develops before being released back into the water as **cercariae**, free swimming forms capable of directly penetrating the **skin** of a person in contact with the infested water, completing the life cycle without any biting vector being required.

Fill in the blank: Schistosomiasis requires a specific freshwater _____ as an intermediate host.

3.3.2 clinical features of schistosomiasis

Early infection may produce transient itchy skin **irritation** at the site of cercarial penetration, sometimes termed swimmer's itch, while established infection with **Schistosoma haematobium** classically produces **blood in the urine**, or **haematuria**, and, over time, chronic **bladder** and urinary tract damage, while **Schistosoma mansoni** infection produces chronic intestinal symptoms and, in longstanding cases, **liver** and spleen enlargement.

Because significant **chronic organ damage** develops gradually over years of repeated exposure, schistosomiasis is frequently under-recognised in its early stages, particularly in children in endemic communities where haematuria may be mistakenly regarded as a normal occurrence, underscoring the importance of the school-based control programmes discussed in the following sub-Part.

Fill in the blank: Established Schistosoma haematobium infection classically produces blood in the urine, or _____.

3.3.3 prevention and control of schistosomiasis

Control of schistosomiasis rests principally on periodic **mass drug administration** with **praziquantel**, typically delivered through **school-based deworming** programmes given the particularly high burden of infection among school-age children in endemic communities, together with health education discouraging contact with known infested water bodies.

Longer term control additionally depends on **snail control** measures and, most fundamentally, provision of **safe water** for washing, bathing, and domestic use, together with adequate **sanitation** to prevent continued contamination of water bodies with urine or stool, echoing the environmental measures discussed for faeco-orally transmitted diseases earlier in this course.

Fill in the blank: Control of schistosomiasis rests principally on periodic mass drug administration with _____.

Table 3.3: Comparing malaria, onchocerciasis, and schistosomiasis.

Feature	Malaria / Onchocerciasis	Schistosomiasis
Transmission agent	Mosquito or blackfly bite	Skin penetration by cercariae in water
Intermediate host	Mosquito (Anopheles) or blackfly (Simulium)	Freshwater snail
Key control drug	Artemisinin-based therapy or ivermectin	Praziquantel

Pilot questions 3.3

11. Identify the causative organisms of schistosomiasis and their intermediate host. (Linked to SLO 3.5)
12. Describe how cercariae infect a new human host. (Linked to SLO 3.5)
13. Distinguish the clinical features of Schistosoma haematobium from Schistosoma mansoni infection. (Linked to SLO 3.5)
14. Explain why schistosomiasis is frequently under-recognised in endemic communities. (Linked to SLO 3.6)
15. Describe the role of school-based deworming in schistosomiasis control. (Linked to SLO 3.6)

3.4 Zoonotic Diseases

3.4.1 mechanism of zoonotic transmission

Disease passing naturally from animals to humans

A **zoonotic disease**, or **zoonosis**, is an infectious disease that is naturally transmissible from **vertebrate animals** to humans, whether through direct **contact** with an infected animal or its products, **ingestion** of contaminated animal products, an intermediate **vector**, or, for a small number of diseases, onward **human-to-human** transmission following an initial animal-to-human event.

The **animal reservoir** of a zoonotic disease may be **domestic** livestock or pets, or **wild** animals, and identifying the specific reservoir and mode of transmission for a given zoonosis is essential to designing effective control measures, since, unlike diseases confined to human hosts, zoonoses generally cannot be eliminated through human-directed measures alone while the animal reservoir persists.

Fill in the blank: A zoonotic disease is an infectious disease naturally transmissible from vertebrate _____ to humans.

3.4.2 examples of zoonotic diseases

Important zoonotic diseases of relevance in Nigeria and globally include **rabies**, transmitted through the bite of an infected dog or other mammal, **anthrax**, acquired through contact with infected livestock or their products, and **avian influenza**, transmitted from infected poultry, each illustrating a different reservoir and route of transmission within the broad category of zoonotic disease.

Certain diseases of **global epidemic importance**, addressed further in the final Series of this course, including **Ebola** virus disease, are also believed to originate from an animal reservoir, generally thought to involve **bats** or other wildlife, before spreading further through human-to-human transmission once introduced into a human population, underscoring the important connection between zoonotic disease and epidemics of global concern.

Fill in the blank: Rabies is a zoonotic disease transmitted through the bite of an infected _____.

3.4.3 prevention and control of zoonotic diseases

Prevention of zoonotic diseases relies on measures directed at the **animal reservoir**, including **vaccination** of domestic animals such as dogs against rabies, safe handling and thorough **cooking** of animal products, and control of contact between humans and potentially infected **wildlife**, together with prompt **treatment** or **post-exposure prophylaxis** following a known exposure, such as an animal bite.

Effective zoonotic disease control increasingly relies on a coordinated **One Health** approach, bringing together human health, animal health, and environmental sectors, since sustainable control of a zoonosis generally requires action within the **animal reservoir** itself, not human treatment alone, a principle that applies equally to the disease surveillance systems examined in the next Series of this course.

Fill in the blank: Effective zoonotic disease control increasingly relies on a coordinated approach across human, animal, and environmental sectors, termed _____ Health.

Figure 3.4: A veterinary worker administering a rabies vaccination to a dog.

Pilot questions 3.4

11. Define a zoonotic disease and describe the possible routes of transmission from animals to humans. (Linked to SLO 3.7)
12. Explain why identifying the animal reservoir is essential to zoonotic disease control. (Linked to SLO 3.7)
13. Give two examples of zoonotic diseases and their animal reservoirs. (Linked to SLO 3.7)
14. Describe two measures used to prevent zoonotic diseases. (Linked to SLO 3.8)
15. Explain the One Health approach to zoonotic disease control. (Linked to SLO 3.8)

Series Summary

This Series examined **vector-borne and zoonotic diseases**, beginning with the general mechanism of vector-borne transmission and its dependence on vector ecology, before turning to **malaria**, its life cycle within the **Anopheles** mosquito and human host, and the vector control, chemoprevention, and prompt treatment measures used against it, and then to **onchocerciasis**, its transmission by the **Simulium** blackfly near fast flowing rivers, its progressive skin and, most seriously, ocular manifestations, and the central role of mass ivermectin distribution in its control.

We then examined **schistosomiasis**, its water-borne life cycle involving a freshwater snail host, and its control through school-based praziquantel administration and safe water provision, before concluding with the mechanism, examples, and **One Health** control of **zoonotic diseases**. Having worked through this Series, you should now be equipped to describe the epidemiology and control of the major vector-borne and zoonotic diseases of importance in Nigeria, in preparation for the surveillance systems addressed in the next Series of this course.

Glossary of Terms

- **Vector:** a living organism that transfers an infectious agent from an infected host or reservoir to a susceptible one.
- **Biological transmission:** vector-borne transmission in which the agent undergoes part of its life cycle within the vector.
- **Malaria:** a disease caused by Plasmodium parasites, transmitted by the bite of an infected Anopheles mosquito.
- **Onchocerciasis:** river blindness, caused by Onchocerca volvulus and transmitted by the Simulium blackfly.
- **Microfilariae:** larval forms of a filarial worm that migrate through tissues, including the skin and eye.
- **Schistosomiasis:** bilharzia, caused by Schistosoma flukes requiring a freshwater snail intermediate host.
- **Cercariae:** free swimming larval forms of Schistosoma capable of directly penetrating human skin.
- **Haematuria:** blood in the urine, a classic feature of Schistosoma haematobium infection.
- **Zoonotic disease:** an infectious disease naturally transmissible from vertebrate animals to humans.
- **Animal reservoir:** the animal population that maintains and transmits a zoonotic disease agent.
- **Rabies:** a zoonotic disease transmitted through the bite of an infected animal, most often a dog.
- **One Health:** a coordinated approach to disease control across human, animal, and environmental health sectors.

Concept Check Questions [Series 3]

Objective questions

11. Vector-borne transmission in which an agent undergoes part of its life cycle within the vector is termed _____ transmission.
12. Malaria is transmitted by the bite of an infected female _____ mosquito.
13. Onchocerciasis is transmitted by the bite of an infected blackfly of the genus _____.
14. Schistosomiasis requires a specific freshwater _____ as an intermediate host.
15. A zoonotic disease is naturally transmissible from vertebrate _____ to humans.

Short-answer questions

16. Describe the life cycle of malaria within the mosquito and human host.
17. Explain why prevention is emphasised over treatment of established onchocerciasis.
18. Describe how cercariae infect a new human host in schistosomiasis.
19. Give two examples of zoonotic diseases and their animal reservoirs.
20. Explain the One Health approach to zoonotic disease control.

Long-answer questions

21. Discuss vector-borne transmission and the epidemiology and control of malaria. (Linked to SLO 3.1, SLO 3.2)
22. Discuss the causative agent, clinical features, and control of onchocerciasis. (Linked to SLO 3.3, SLO 3.4)
23. Discuss the life cycle, clinical features, and control of schistosomiasis. (Linked to SLO 3.5, SLO 3.6)
24. Discuss the mechanism and examples of zoonotic diseases. (Linked to SLO 3.7)
25. Discuss the prevention and control of zoonotic diseases, including the One Health approach. (Linked to SLO 3.8)

Answers to Concept Check Questions [Series 3]

Objective questions

31. Biological.
32. Anopheles.
33. Simulium.
34. Snail.
35. Animals.

Short-answer questions

36. Parasites multiply in the liver, then invade red blood cells, producing periodic fever; a biting mosquito can become infected in turn.
37. Because ocular damage is largely irreversible once established, so sustained community prevention is prioritised.
38. Cercariae released by infected snails directly penetrate the skin of a person in contact with infested water.
39. Rabies (dogs) and anthrax (livestock), among others.
40. One Health coordinates human, animal, and environmental health sectors, since control generally requires action within the animal reservoir.

Long-answer questions

41. **Basic response:** Vector-borne transmission occurs when a vector such as a mosquito transfers an agent between hosts, and malaria, caused by Plasmodium and transmitted by Anopheles mosquitoes, is controlled through vector control, chemoprevention, and prompt diagnosis and treatment.

Value-added response: Vector control measures such as insecticide treated bednets and indoor residual spraying target the mosquito directly, while prompt treatment with artemisinin-based combination therapy both prevents severe disease and reduces onward transmission.

42. **Basic response:** Onchocerciasis, caused by Onchocerca volvulus and transmitted by the Simulium blackfly near fast flowing rivers, produces itchy skin nodules and, over years, progressive and irreversible visual impairment.

Value-added response: Because ocular damage is irreversible once established, control emphasises sustained mass community-directed treatment with ivermectin, distributed annually across affected communities, alongside vector control targeting blackfly breeding sites.

43. **Basic response:** Schistosomiasis, caused by Schistosoma flukes requiring a freshwater snail host, is transmitted when free swimming cercariae penetrate the skin of a person in contact with infested water, producing haematuria or chronic intestinal disease depending on species.

Value-added response: Control rests on periodic mass drug administration with praziquantel, typically through school-based deworming given the high burden among school-age children, together with snail control and provision of safe water and sanitation.

44. **Basic response:** A zoonotic disease is naturally transmissible from vertebrate animals to humans through contact, ingestion, a vector, or, for some diseases, subsequent human-to-human spread, with examples including rabies, anthrax, and avian influenza.

Value-added response: Diseases of global epidemic importance such as Ebola are also believed to originate from an animal reservoir, generally involving wildlife such as bats, before spreading further through human-to-human transmission.

45. **Basic response:** Prevention of zoonotic diseases includes vaccination of domestic animals, safe handling and cooking of animal products, and control of contact with potentially infected wildlife, together with post-exposure prophylaxis following exposure.

Value-added response: Because zoonoses generally cannot be eliminated through human-directed measures alone while the animal reservoir persists, effective control increasingly relies on a coordinated One Health approach across human, animal, and environmental sectors.

Answers to Pilot Questions [Series 3]

Part 3.1

11. Biological transmission involves development within the vector; mechanical transmission is simple surface carriage without development.
12. Because vector ecology, not human behaviour alone, determines where and when transmission occurs.
13. Anopheles mosquito and Plasmodium parasites.
14. Insecticide treated bednets and indoor residual spraying.
15. Prompt treatment reduces the pool of infected persons available to infect further mosquitoes.

Part 3.2

11. Onchocerca volvulus, transmitted by the Simulium blackfly.
12. Because the blackfly vector breeds in fast flowing, well oxygenated rivers near such communities.
13. Itchy skin nodules and chronic dermatitis, and progressive visual impairment leading to blindness.
14. Because ocular damage is largely irreversible once established.
15. Ivermectin kills microfilariae and, given regularly, reduces transmission and eye disease risk across a community.

Part 3.3

11. Schistosoma haematobium and Schistosoma mansoni, requiring a freshwater snail intermediate host.
12. Cercariae released from infected snails directly penetrate the skin of a person in contact with infested water.
13. S. haematobium causes haematuria and urinary tract damage; S. mansoni causes intestinal symptoms and organ enlargement.
14. Because chronic organ damage develops gradually and haematuria may be mistaken for normal in endemic communities.
15. School-based deworming targets school-age children, who carry a particularly high burden of infection.

Part 3.4

11. A disease naturally transmissible from vertebrate animals to humans, via contact, ingestion, a vector, or subsequent human spread.
12. Because control measures directed at humans alone cannot eliminate a disease while its animal reservoir persists.
13. Rabies (dogs) and anthrax (livestock).
14. Vaccination of domestic animals and safe handling and cooking of animal products.
15. One Health coordinates human, animal, and environmental health sectors to address the animal reservoir directly.

References and Attributions [Series 3]

- Park, K. (2021). Park's Textbook of Preventive and Social Medicine (26th ed.). Banarsidas Bhanot.
- World Health Organization (2023). World malaria report. WHO Press.
- World Health Organization (2021). Onchocerciasis and schistosomiasis fact sheets. WHO Press.
- Federal Ministry of Health, Nigeria (2020). National Malaria Elimination Programme strategic plan.

Figures, Plates, Tables, and Boxes

- Figure 3.1: A health worker hanging an insecticide-treated bednet over a sleeping area. AI-generated using the prompt: "A single clean, realistic illustration of a health worker hanging an insecticide-treated bednet over a simple household bed, calm domestic setting, soft

natural lighting, no text overlays, no multiple panels, accurate and respectful depiction, no graphic detail."

- Figure 3.2: A community health volunteer distributing ivermectin tablets to villagers. AI-generated using the prompt: "A single clean, realistic illustration of a community health volunteer handing tablets to a villager at a simple outdoor community gathering point, calm rural setting, natural daylight, no text overlays, no multiple panels, respectful and accurate depiction, no graphic detail."
- Table 3.3: Comparing malaria, onchocerciasis, and schistosomiasis. AI-generated using the prompt: "Create a clean reference table titled Comparing Vector-Borne and Water-Borne Parasitic Diseases, listing feature, malaria and onchocerciasis, and schistosomiasis. Simple clinical reference table style with outside border."
- Figure 3.4: A veterinary worker administering a rabies vaccination to a dog. AI-generated using the prompt: "A single clean, realistic illustration of a veterinary worker administering a vaccination to a calm dog held by its owner at a simple outdoor community setting, natural daylight, no text overlays, no multiple panels, respectful and accurate depiction, no graphic detail."

Series 4: Disease Surveillance, Elimination, and Eradication of Priority Endemic Diseases in Nigeria

- **Part 4.1: Concepts of Disease Control, Elimination, and Eradication**
  - Sub Part 4.1.1: Disease control
  - Sub Part 4.1.2: Disease elimination
  - Sub Part 4.1.3: Disease eradication
- **Part 4.2: Disease Surveillance and Notification**
  - Sub Part 4.2.1: Principles of disease surveillance
  - Sub Part 4.2.2: Disease notification
  - Sub Part 4.2.3: Integrated Disease Surveillance and Response (DSN) in Nigeria
- **Part 4.3: Epidemiology and Control of HIV in Nigeria**
  - Sub Part 4.3.1: Causative agent and transmission of HIV
  - Sub Part 4.3.2: Natural history and clinical features of HIV infection
  - Sub Part 4.3.3: Prevention and control of HIV
- **Part 4.4: Integrating Surveillance and Control: Outbreak Response**
  - Sub Part 4.4.1: Outbreak investigation
  - Sub Part 4.4.2: Role of surveillance data in guiding control decisions
  - Sub Part 4.4.3: Challenges in disease surveillance and control in Nigeria

Introduction

In the last Series, we explored **vector-borne and zoonotic diseases**, including malaria, onchocerciasis, schistosomiasis, and zoonoses. We now turn to the broader concepts of **disease control, elimination, and eradication**, to the **surveillance systems** that detect and monitor communicable diseases in Nigeria, and to the epidemiology and control of **HIV**, one of the important diseases identified in this course. Picture a state epidemiologist reviewing a weekly stack of notification forms from health facilities, searching for early warning signs of an unusual cluster of cases. Recognising such signals promptly, and knowing what level of disease control is

realistically being pursued for a given disease, are essential surveillance and programme planning skills, and it is these skills that form the focus of this Series.

The aim of this Series is to equip you with the knowledge required to distinguish disease control, elimination, and eradication, to describe the principles of disease surveillance and notification in Nigeria, and to describe the epidemiology and control of HIV.

This Series begins with the **concepts of disease control, elimination, and eradication**, before turning to **disease surveillance and notification**. Next, we examine the **epidemiology and control of HIV**, before concluding with **integrating surveillance and control through outbreak response**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 4.1:** distinguish disease control, elimination, and eradication
- **SLO 4.2:** describe the requirements for disease elimination and eradication
- **SLO 4.3:** describe the principles of disease surveillance and the purpose of disease notification
- **SLO 4.4:** describe the Integrated Disease Surveillance and Response system, or DSN, in Nigeria
- **SLO 4.5:** describe the causative agent, transmission, and natural history of HIV infection
- **SLO 4.6:** describe the prevention and control of HIV
- **SLO 4.7:** describe the key steps in outbreak investigation, and
- **SLO 4.8:** describe the role of surveillance data in guiding disease control decisions and the challenges facing disease surveillance in Nigeria.

4.1 Concepts of Disease Control, Elimination, and Eradication

4.1.1 disease control

Reducing disease to a locally acceptable level

Disease control refers to the reduction of disease **incidence**, **prevalence**, **morbidity**, or **mortality** to a locally acceptable level as a result of deliberate efforts, without necessarily implying that transmission has been completely interrupted, meaning continued **intervention** is generally

required to maintain this reduced level of disease, since the causative agent and, usually, ongoing transmission still persist within the population.

Most communicable disease programmes discussed throughout this course, including those for **malaria** and **tuberculosis**, discussed in earlier Series, currently operate at the level of disease control, meaning sustained programme activity, rather than a single time-limited campaign, remains necessary to prevent disease burden from returning to its previous, uncontrolled level.

Fill in the blank: Disease control refers to the reduction of disease to a locally acceptable level without necessarily interrupting _____.

4.1.2 disease elimination

Disease elimination refers to the reduction to **zero** of the incidence of a specified disease in a defined **geographical area**, as a result of deliberate efforts, with continued measures required to prevent **re-establishment** of transmission, since the causative agent may still exist and cause disease elsewhere in the world, meaning imported cases remain possible and ongoing surveillance, discussed later in this Series, remains essential even after elimination has been achieved.

Elimination is generally a more **achievable** target than complete eradication for a specific country or region, and several diseases discussed in this course, including onchocerciasis in some countries, have been targeted for elimination as a **public health problem** within defined geographical areas, representing a major milestone even where the causative agent has not been eliminated globally.

Fill in the blank: Disease elimination refers to the reduction to zero of the incidence of a disease in a defined geographical _____.

4.1.3 disease eradication

Disease eradication refers to the permanent reduction to **zero** of the worldwide incidence of infection caused by a specific agent, as a result of deliberate efforts, such that continued intervention measures are no longer needed, since the agent itself has been permanently removed from circulation everywhere, the most complete and ambitious level of disease control possible.

Smallpox remains the only human disease successfully **eradicated** to date, and diseases considered biologically feasible candidates for future eradication generally share features such as having **no animal reservoir**, a **reliable diagnostic test**, and an effective **intervention**, such as a vaccine, capable of interrupting transmission completely, criteria that many communicable diseases discussed throughout this course do not currently meet.

Fill in the blank: The only human disease successfully eradicated to date is _____.

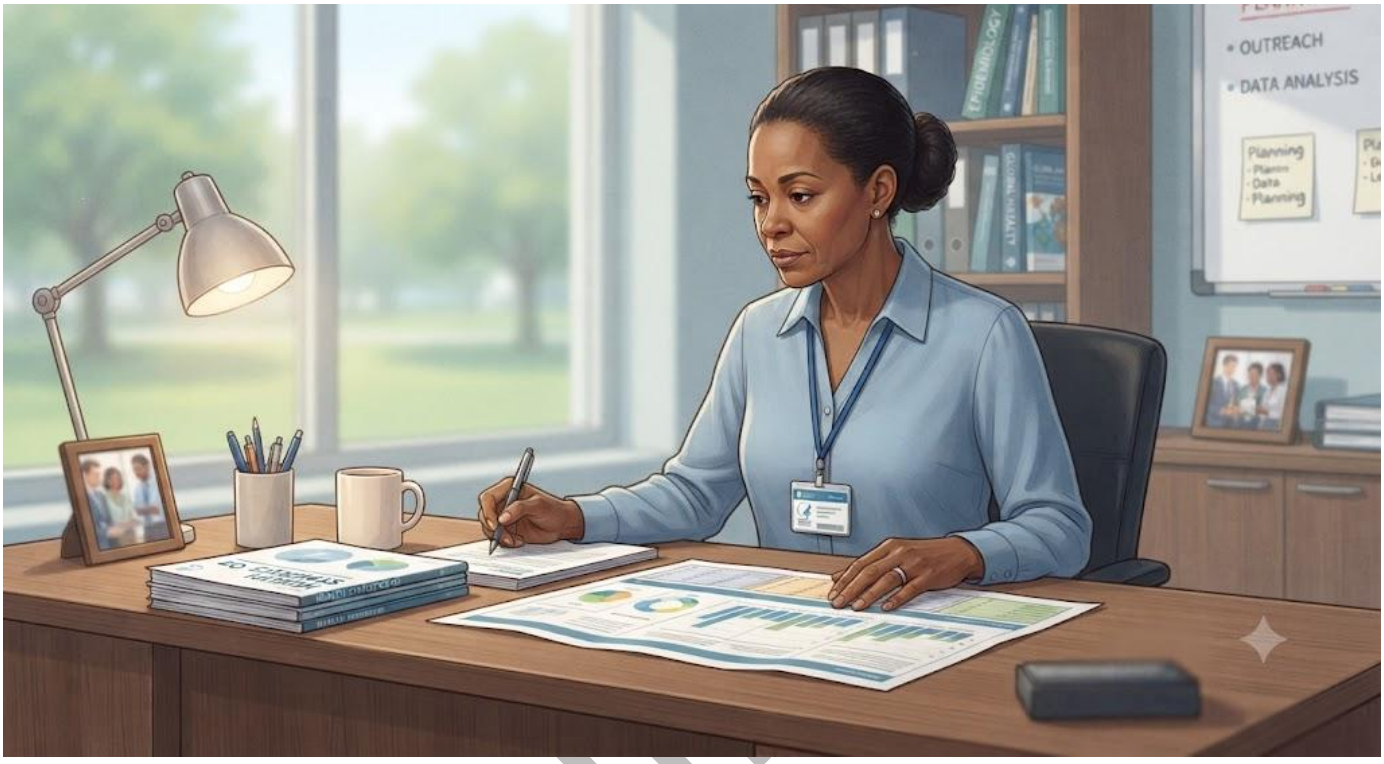

Figure 4.1: A public health officer reviewing a national disease control programme report at a desk.

Pilot questions 4.1

16. Define disease control and give an example of a disease currently at this level. (Linked to SLO 4.1)
17. Define disease elimination and explain why continued surveillance remains necessary after it is achieved. (Linked to SLO 4.1)
18. Distinguish disease elimination from disease eradication. (Linked to SLO 4.1)
19. Identify the only human disease successfully eradicated to date. (Linked to SLO 4.2)
20. List three features that make a disease biologically feasible for eradication. (Linked to SLO 4.2)

4.2 Disease Surveillance and Notification

4.2.1 principles of disease surveillance

Continuous, systematic collection of health data for action

Disease surveillance is the ongoing, systematic **collection**, **analysis**, and **interpretation** of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely **dissemination** of this data to those responsible for prevention and control, since surveillance data that is collected but never acted upon fails to serve its essential public health purpose.

Effective surveillance depends on data that is **timely**, **accurate**, **complete**, and **representative** of the population under observation, and surveillance systems in Nigeria, discussed further later in this Part, combine routine reporting from health facilities with, for certain priority diseases, specific **case-based** reporting requiring immediate notification, discussed in the following sub-Part, rather than routine periodic summary alone.

Fill in the blank: Disease surveillance is the ongoing, systematic collection, analysis, and interpretation of health data for public health _____.

4.2.2 disease notification

Disease notification is the formal reporting of specified **notifiable diseases** by health workers to public health authorities, generally required by **law**, and is designed to trigger prompt public health action, such as case investigation or outbreak response, for diseases of particular public health importance, distinguishing notifiable diseases from the very much larger number of conditions not subject to this specific reporting requirement.

In Nigeria, notifiable diseases include conditions with clear **epidemic potential**, such as **cholera**, discussed earlier in this course, **Ebola**, and **measles**, among others, and the **timeliness** of notification is of particular importance for such diseases, since delayed reporting can allow an outbreak to spread substantially before public health authorities are even aware that one is under way.

Fill in the blank: Disease notification is the formal reporting of specified notifiable diseases to public health authorities, generally required by _____.

4.2.3 integrated disease surveillance and response (DSN) in Nigeria

Nigeria implements disease surveillance principally through the **Integrated Disease Surveillance and Response**, or **IDSR**, strategy, operationalised nationally as the **Disease Surveillance and Notification**, or **DSN**, system, which integrates surveillance for multiple priority diseases into a single, unified reporting structure extending from individual **health facilities** through **local government areas** and **states** to the **federal** level.

The DSN system defines specific priority diseases requiring **immediate** notification, generally within 24 hours of detection, given their outbreak potential, alongside others requiring only **routine**, typically weekly or monthly, reporting, and this tiered structure allows the system to balance the need for rapid response to urgent threats against the practical burden of comprehensive routine reporting across the entire health system.

Fill in the blank: Nigeria's Disease Surveillance and Notification system extends from health facilities through local government areas and states to the _____ level.

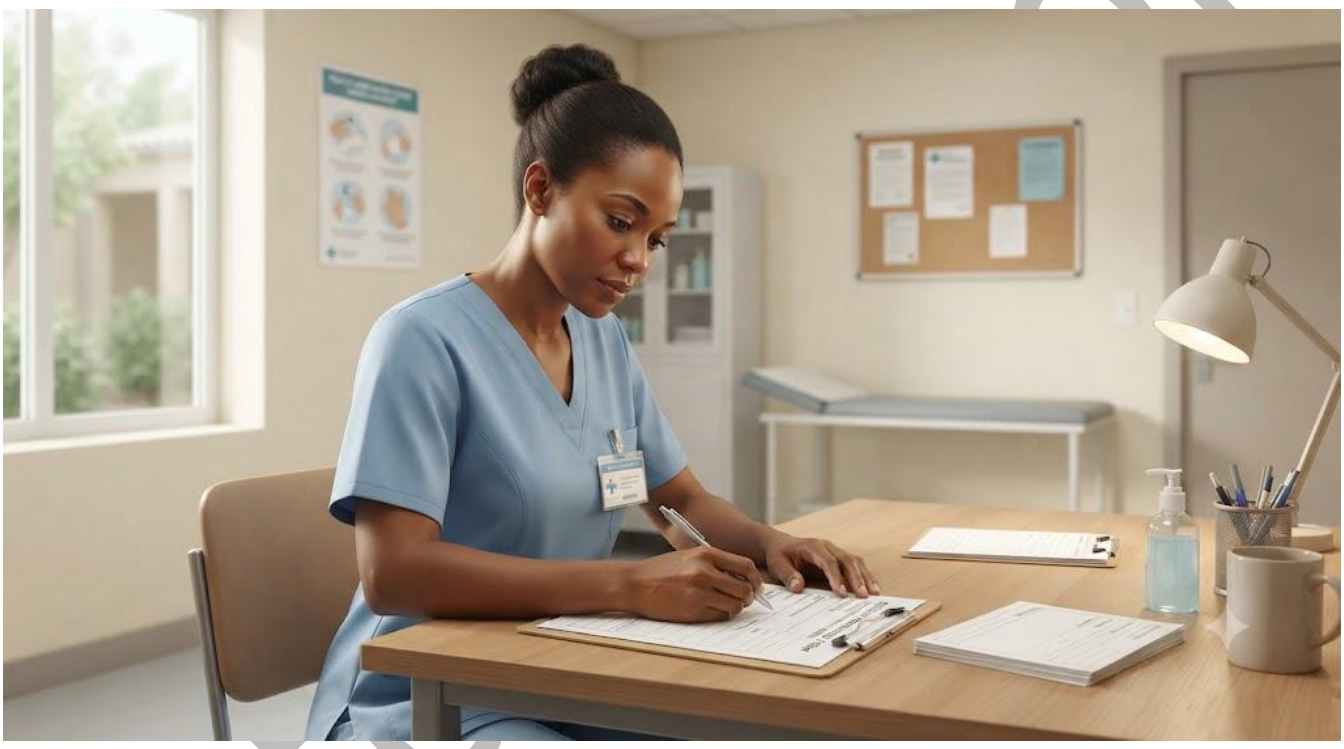

Figure 4.2: A health worker completing a disease notification form at a health facility.

Pilot questions 4.2

16. Define disease surveillance and describe the qualities effective surveillance data should have. (Linked to SLO 4.3)
17. Define disease notification and explain its purpose. (Linked to SLO 4.3)
18. Give two examples of notifiable diseases in Nigeria. (Linked to SLO 4.3)
19. Describe the structure of the DSN system in Nigeria, from facility to federal level. (Linked to SLO 4.4)
20. Distinguish immediate notification from routine reporting within the DSN system. (Linked to SLO 4.4)

4.3 Epidemiology and Control of HIV in Nigeria

4.3.1 causative agent and transmission of HIV

A retrovirus transmitted through specific body fluids

Human immunodeficiency virus, or **HIV**, is a **retrovirus** that progressively damages the **immune system**, principally by infecting and depleting **CD4 cells**, and remains a disease of major public health importance in Nigeria, transmitted through specific body fluids, principally **blood**, **semen**, **vaginal fluids**, and **breast milk**, but not through casual everyday contact.

The principal routes of HIV transmission are **unprotected sexual intercourse**, **mother-to-child transmission**, occurring during pregnancy, delivery, or breastfeeding, and **blood-borne** exposure, including unsafe injection practices or transfusion of unscreened blood, representing the **contact** and blood-borne transmission routes introduced earlier in this course, applied here to a disease of particular significance in the Nigerian context.

Fill in the blank: HIV is transmitted through specific body fluids, principally blood, semen, vaginal fluids, and breast _____.

4.3.2 natural history and clinical features of HIV infection

Following initial infection, many individuals experience a brief **acute retroviral illness**, resembling a nonspecific viral infection, followed by a prolonged **clinically latent** period, often lasting many years, during which the individual remains largely asymptomatic despite ongoing viral replication and progressive **CD4 cell** decline, unless **antiretroviral therapy**, discussed in the next sub-Part, is initiated.

In the absence of effective treatment, progressive immune damage eventually leads to **acquired immunodeficiency syndrome**, or **AIDS**, characterised by susceptibility to specific **opportunistic infections** and certain malignancies that a healthy immune system would normally control, including, importantly, an increased risk of **tuberculosis**, discussed in an earlier Series, reflecting the significant overlap between the two epidemics in Nigeria.

Fill in the blank: In the absence of effective treatment, progressive immune damage from HIV eventually leads to acquired immunodeficiency syndrome, or _____.

4.3.3 prevention and control of HIV

Prevention of HIV includes **condom** use during sexual intercourse, **HIV testing** and counselling, **pre-exposure prophylaxis** for individuals at substantial ongoing risk, safe **blood transfusion** practices, including universal screening of donated blood, and **prevention of mother-to-child**

transmission programmes, providing antiretroviral therapy to HIV positive pregnant women and their infants.

Control of established HIV infection rests principally on lifelong **antiretroviral therapy**, which effectively suppresses viral replication, restores immune function, and, importantly, when viral load is fully suppressed, prevents onward **sexual transmission** to an uninfected partner, meaning that, in an important sense, effective HIV treatment now also functions as a powerful prevention tool at population level.

Fill in the blank: Effective antiretroviral therapy that fully suppresses viral load prevents onward sexual _____ of HIV.

Table 4.3: Comparing disease control, elimination, and eradication.

Feature	Control / Elimination	Eradication
Geographical scope	Local area or country	Worldwide
Continued intervention needed	Yes (control); yes, to prevent re-establishment (elimination)	No, once achieved
Example	Malaria (control); onchocerciasis (elimination, some areas)	Smallpox

Pilot questions 4.3

16. Identify the causative agent of HIV and describe its principal routes of transmission. (Linked to SLO 4.5)
17. Describe the stages in the natural history of HIV infection, from acute infection to AIDS. (Linked to SLO 4.5)
18. Explain why tuberculosis is of particular significance among people living with HIV. (Linked to SLO 4.5)
19. Describe two measures used to prevent HIV transmission. (Linked to SLO 4.6)
20. Explain how antiretroviral therapy functions as both treatment and prevention. (Linked to SLO 4.6)

4.4 Integrating Surveillance and Control: Outbreak Response

4.4.1 outbreak investigation

A structured response confirming and characterising an outbreak

Outbreak investigation begins with **verifying** the diagnosis and confirming the existence of a genuine **outbreak**, meaning an occurrence of disease cases clearly in excess of normal expectation, followed by establishing a **case definition** and systematically identifying and counting cases, before describing the outbreak in terms of **person**, **place**, and **time**, a structured approach drawing directly on the surveillance principles discussed earlier in this Series.

Further steps include developing and testing a **hypothesis** regarding the likely source and mode of transmission, often through structured epidemiological studies, and implementing appropriate **control measures** without necessarily waiting for the investigation to be fully complete, since prompt action, once a plausible source or transmission route is identified, is often more valuable to affected communities than further delay for complete scientific certainty.

Fill in the blank: Outbreak investigation begins with verifying the diagnosis and confirming the existence of a genuine _____.

4.4.2 role of surveillance data in guiding control decisions

Routine **surveillance data**, discussed earlier in this Series, provides the essential **baseline** against which an unusual increase in cases can be recognised as a potential outbreak in the first place, and continued surveillance during an outbreak allows public health authorities to monitor its **trend**, evaluate whether control measures are proving effective, and determine when the outbreak has genuinely been brought under control.

Beyond individual outbreaks, sustained surveillance data over time guides broader **programme decisions**, such as whether a disease control programme should be intensified, whether a disease has become a realistic candidate for **elimination**, discussed earlier in this Series, or whether resources should be redirected toward an emerging priority, illustrating the continuous, essential link between surveillance and effective decision-making at every level of the health system.

Fill in the blank: Continued surveillance during an outbreak allows authorities to monitor its trend and evaluate whether control measures are proving _____.

4.4.3 challenges in disease surveillance and control in Nigeria

Disease surveillance and control in Nigeria face significant practical challenges, including **under-reporting** from health facilities, particularly in remote or under-resourced areas, delays in **data transmission** from peripheral facilities to higher levels, and limited **laboratory capacity** for confirming certain diagnoses, each of which can compromise the timeliness and completeness of surveillance data essential to effective response.

Additional challenges include inadequate **funding** for sustained programme implementation, workforce **shortages**, particularly of trained epidemiologists and laboratory personnel, and the genuine logistical difficulty of maintaining programme activity, including surveillance, across insecure or difficult-to-access areas, meaning that strengthening the underlying **health system** itself remains an essential, if less visible, component of effective disease surveillance and control.

Fill in the blank: Significant challenges to disease surveillance in Nigeria include under-reporting, delays in data transmission, and limited laboratory _____.

Figure 4.4: A rapid response team meeting to plan an outbreak investigation.

Pilot questions 4.4

16. List the key steps in an outbreak investigation. (Linked to SLO 4.7)
17. Explain why control measures may be implemented before an outbreak investigation is fully complete. (Linked to SLO 4.7)
18. Explain how surveillance data helps recognise the onset of an outbreak. (Linked to SLO 4.8)
19. Describe how surveillance data guides broader disease programme decisions. (Linked to SLO 4.8)
20. List three challenges facing disease surveillance and control in Nigeria. (Linked to SLO 4.8)

Series Summary

This Series examined the concepts of **disease control, elimination, and eradication**, distinguishing control's ongoing local reduction, elimination's reduction to zero within a defined

area requiring continued vigilance against re-establishment, and eradication's permanent, worldwide removal of an agent, achieved to date only for smallpox, before turning to **disease surveillance and notification**, examining the qualities of effective surveillance data, the purpose of formal notification for priority diseases, and the structure of Nigeria's Integrated Disease Surveillance and Response, or DSN, system extending from health facility to federal level.

We then examined the **epidemiology and control of HIV**, before concluding with **outbreak investigation** and the essential role of surveillance data in guiding both immediate outbreak response and broader disease programme decisions, together with the practical challenges facing surveillance and control in Nigeria. Having worked through this Series, you should now be equipped to distinguish these key public health concepts and describe how surveillance underpins effective disease control, in preparation for the diseases of global importance addressed in the final Series of this course.

Glossary of Terms

- **Disease control:** reduction of disease to a locally acceptable level without necessarily interrupting transmission.
- **Disease elimination:** reduction to zero of disease incidence in a defined geographical area.
- **Disease eradication:** permanent reduction to zero of the worldwide incidence of a specific agent.
- **Disease surveillance:** the ongoing, systematic collection, analysis, and interpretation of health data for public health action.
- **Disease notification:** the formal, legally required reporting of specified notifiable diseases to public health authorities.
- **DSN:** Disease Surveillance and Notification, Nigeria's integrated disease surveillance system.
- **HIV:** human immunodeficiency virus, a retrovirus that progressively damages the immune system.
- **AIDS:** acquired immunodeficiency syndrome, the advanced stage of untreated HIV infection.
- **Antiretroviral therapy:** lifelong medication that suppresses HIV replication and restores immune function.
- **Outbreak:** an occurrence of disease cases clearly in excess of normal expectation.
- **Outbreak investigation:** the structured process of confirming, characterising, and responding to an outbreak.
- **Case definition:** a standard set of criteria used to determine whether a person should be classified as a case.

Concept Check Questions [Series 4]

Objective questions

16. Disease control refers to reducing disease to a locally acceptable level without necessarily interrupting _____.
17. Disease elimination refers to reduction to zero of disease incidence in a defined geographical _____.
18. The only human disease successfully eradicated to date is _____.
19. Disease notification is generally required by _____.
20. In the absence of effective treatment, HIV infection eventually leads to acquired immunodeficiency syndrome, or _____.

Short-answer questions

21. Distinguish disease elimination from disease eradication.
22. Describe the structure of the DSN system in Nigeria, from facility to federal level.
23. Describe the principal routes of HIV transmission.
24. List the key steps in an outbreak investigation.
25. List three challenges facing disease surveillance and control in Nigeria.

Long-answer questions

26. Discuss disease control, elimination, and eradication, distinguishing between them. (Linked to SLO 4.1, SLO 4.2)
27. Discuss the principles of disease surveillance and notification and the DSN system in Nigeria. (Linked to SLO 4.3, SLO 4.4)
28. Discuss the epidemiology, natural history, and control of HIV. (Linked to SLO 4.5, SLO 4.6)
29. Discuss the key steps in outbreak investigation. (Linked to SLO 4.7)
30. Discuss the role of surveillance data in guiding disease control decisions and the challenges facing surveillance in Nigeria. (Linked to SLO 4.8)

Answers to Concept Check Questions [Series 4]

Objective questions

46. Transmission.
47. Area.
48. Smallpox.

49. Law.
50. AIDS.

Short-answer questions

51. Elimination is reduction to zero within a defined area, requiring continued vigilance; eradication is permanent worldwide removal of the agent.
52. It extends from health facilities through local government areas and states to the federal level.
53. Unprotected sexual intercourse, mother-to-child transmission, and blood-borne exposure.
54. Verify the diagnosis, confirm the outbreak, define and count cases, describe by person, place, and time, test a hypothesis, and implement control measures.
55. Under-reporting, delays in data transmission, and limited laboratory capacity, among others.

Long-answer questions

56. **Basic response:** Disease control reduces disease to a locally acceptable level without necessarily interrupting transmission; elimination reduces incidence to zero within a defined area; eradication permanently removes an agent worldwide, achieved to date only for smallpox.

Value-added response: Most current communicable disease programmes operate at the level of control, requiring sustained activity, while elimination still requires continued surveillance against re-established transmission from elsewhere, since the agent may persist globally.

57. **Basic response:** Disease surveillance is the ongoing, systematic collection, analysis, and interpretation of health data for public health action, while notification is the formal, legally required reporting of specified priority diseases, integrated in Nigeria through the DSN system extending from facility to federal level.

Value-added response: The DSN system distinguishes diseases requiring immediate notification within 24 hours from those requiring only routine reporting, balancing rapid response to urgent threats against the practical burden of comprehensive routine surveillance.

58. **Basic response:** HIV, a retrovirus transmitted through blood, semen, vaginal fluids, and breast milk, progressively damages the immune system through CD4 cell depletion, eventually causing AIDS in the absence of treatment.

Value-added response: Lifelong antiretroviral therapy suppresses viral replication, restores immune function, and, when viral load is fully suppressed, prevents onward sexual transmission, meaning effective treatment now also functions as a powerful prevention tool.

59. **Basic response:** Outbreak investigation begins with verifying the diagnosis and confirming a genuine outbreak, followed by case definition, case counting, and description by person, place, and time, before hypothesis testing and implementation of control measures.

Value-added response: Control measures are often implemented once a plausible source or transmission route is identified, without necessarily waiting for the investigation to be fully complete, since prompt action is often more valuable than further delay.

60. **Basic response:** Surveillance data provides the baseline against which an outbreak is recognised, allows monitoring of its trend during response, and guides broader programme decisions such as whether to intensify control or pursue elimination.

Value-added response: Significant practical challenges in Nigeria, including under-reporting, data transmission delays, limited laboratory capacity, inadequate funding, and workforce shortages, mean that strengthening the underlying health system remains essential to effective surveillance.

Answers to Pilot Questions [Series 4]

Part 4.1

16. Reduction of disease to a locally acceptable level; malaria is currently at the level of control.
17. Because the agent may still exist elsewhere, so imported cases and re-established transmission remain possible.
18. Elimination is reduction to zero within a defined area; eradication is permanent worldwide removal of the agent.
19. Smallpox.
20. No animal reservoir, a reliable diagnostic test, and an effective intervention such as a vaccine.

Part 4.2

16. The ongoing, systematic collection, analysis, and interpretation of health data; it should be timely, accurate, complete, and representative.
17. The formal reporting of notifiable diseases to trigger prompt public health action.
18. Cholera and measles, among others.
19. It extends from health facilities through local government areas and states to the federal level.
20. Immediate notification is required within 24 hours for priority diseases; routine reporting occurs weekly or monthly.

Part 4.3

16. HIV, a retrovirus, transmitted through unprotected sex, mother-to-child transmission, and blood-borne exposure.
17. Acute retroviral illness, a prolonged clinically latent period, and, untreated, progression to AIDS.
18. Because HIV substantially increases the risk of progression to active tuberculosis disease.
19. Condom use and prevention of mother-to-child transmission programmes.
20. Fully suppressed viral load prevents onward sexual transmission, so treatment also functions as prevention.

Part 4.4

16. Verify diagnosis, confirm outbreak, define and count cases, describe by person, place, and time, test hypothesis, implement control measures.
17. Because prompt action is often more valuable than waiting for complete scientific certainty.
18. Routine surveillance provides a baseline against which an unusual increase in cases can be recognised.
19. It shows whether a programme should be intensified or a disease is a realistic candidate for elimination.
20. Under-reporting, data transmission delays, and limited laboratory capacity.

References and Attributions [Series 4]

- Park, K. (2021). Park's Textbook of Preventive and Social Medicine (26th ed.). Banarsidas Bhanot.
- Federal Ministry of Health, Nigeria (2019). National Technical Guidelines for Integrated Disease Surveillance and Response (3rd ed.).
- UNAIDS (2023). Global HIV and AIDS statistics fact sheet.
- World Health Organization (2020). Disease eradication and elimination: criteria and progress. WHO Press.

Figures, Plates, Tables, and Boxes

- Figure 4.1: A public health officer reviewing a national disease control programme report at a desk. AI-generated using the prompt: "A single clean, realistic illustration of a public health officer reviewing printed reports and charts at an office desk, calm professional setting, soft indoor lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."
- Figure 4.2: A health worker completing a disease notification form at a health facility. AI-generated using the prompt: "A single clean, realistic illustration of a health worker completing a notification form at a simple facility desk, calm clinical setting, soft natural lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."
- Table 4.3: Comparing disease control, elimination, and eradication. AI-generated using the prompt: "Create a clean reference table titled Comparing Control, Elimination, and Eradication, listing feature, control and elimination, and eradication. Simple clinical reference table style with outside border."
- Figure 4.4: A rapid response team meeting to plan an outbreak investigation. AI-generated using the prompt: "A single clean, realistic illustration of a small public health rapid response team meeting around a table with notes and a map, calm professional setting, soft indoor lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."

Series 5: Global Health Programmes and Control of Diseases of International Importance

- **Part 5.1: The WHO Special Programme for Tropical Diseases**
    - Sub Part 5.1.1: Background and objectives of the special programme
    - Sub Part 5.1.2: Neglected tropical diseases targeted by the programme
    - Sub Part 5.1.3: Achievements and strategies of the programme
- **Part 5.2: Ebola Virus Disease**
    - Sub Part 5.2.1: Causative agent and transmission of Ebola
    - Sub Part 5.2.2: Clinical features and case fatality of Ebola
    - Sub Part 5.2.3: Prevention and control of Ebola
- **Part 5.3: COVID-19**
    - Sub Part 5.3.1: Causative agent and transmission of COVID-19
    - Sub Part 5.3.2: Clinical features and spectrum of COVID-19
    - Sub Part 5.3.3: Prevention and control of COVID-19
- **Part 5.4: Global Health Security and Preparedness**
    - Sub Part 5.4.1: International Health Regulations and global health security
    - Sub Part 5.4.2: Public health emergency of international concern
    - Sub Part 5.4.3: Lessons for pandemic preparedness and response

Introduction

In the last Series, we explored disease control, elimination, and eradication, surveillance and notification in Nigeria, and the epidemiology of HIV. We now conclude this course with the **WHO special programme for tropical diseases** and the control of **diseases of global importance**, specifically **Ebola** and **COVID-19**. Picture a national public health emergency operations centre activated overnight in response to reports of an unusual haemorrhagic illness at a border community, with international partners already being notified within hours. Understanding how the world organises itself, through dedicated programmes and formal legal frameworks, to detect and respond to such threats of global concern is the final piece of the epidemiological foundation built throughout this course.

The aim of this Series is to equip you with the knowledge required to describe the WHO special programme for tropical diseases, and to describe the epidemiology, control, and global health security response relevant to diseases of global importance such as Ebola and COVID-19.

This Series begins with the **WHO special programme for tropical diseases**, before turning to **Ebola virus disease**. Next, we examine **COVID-19**, before concluding with **global health security and preparedness**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 5.1:** describe the background, objectives, and targeted diseases of the WHO special programme for tropical diseases
- **SLO 5.2:** describe the achievements and strategies of the special programme
- **SLO 5.3:** describe the causative agent, transmission, and clinical features of Ebola virus disease
- **SLO 5.4:** describe the prevention and control of Ebola virus disease
- **SLO 5.5:** describe the causative agent, transmission, and clinical spectrum of COVID-19
- **SLO 5.6:** describe the prevention and control of COVID-19
- **SLO 5.7:** describe the International Health Regulations and the concept of a public health emergency of international concern, and
- **SLO 5.8:** describe the key lessons for pandemic preparedness and response.

5.1 The WHO Special Programme for Tropical Diseases

5.1.1 background and objectives of the special programme

A coordinated global response to neglected diseases of poverty

The **Special Programme for Research and Training in Tropical Diseases**, commonly known as **TDR**, is a collaborative programme co-sponsored by several international agencies alongside the **World Health Organization**, established to coordinate global **research**, **training**, and control efforts directed at tropical diseases that disproportionately affect **poor** and **marginalised** populations in low and middle-income countries, including Nigeria.

The programme's central objectives include supporting **research** into new diagnostics, drugs, and vector control tools, strengthening local **research capacity** within affected countries themselves,

and, importantly, translating research findings into practical, field-applicable control strategies, reflecting a recognition that diseases affecting predominantly poor populations often receive insufficient research investment through ordinary market-driven mechanisms alone.

Fill in the blank: The WHO special programme for tropical diseases is commonly known by the abbreviation _____.

5.1.2 neglected tropical diseases targeted by the programme

Diseases targeted by the special programme fall within the broader category of **neglected tropical diseases**, or **NTDs**, and include **onchocerciasis** and **schistosomiasis**, both discussed in an earlier Series of this course, together with other conditions such as **lymphatic filariasis**, **leprosy**, and **trypanosomiasis**, or sleeping sickness, each historically receiving disproportionately limited global research attention relative to the substantial burden of disability and suffering they cause.

These diseases share several common features, including a strong association with **poverty** and inadequate **water**, sanitation, and housing, a tendency to cause chronic **disability** rather than acute mortality, and historical **under-investment** in research and control relative to their true public health burden, features that together justify the coordinated, dedicated global attention the special programme provides.

Fill in the blank: Diseases targeted by the special programme, including onchocerciasis and schistosomiasis, fall within the category of neglected tropical diseases, or _____.

5.1.3 achievements and strategies of the programme

Key strategies employed by the special programme and its partners include **preventive chemotherapy**, delivered through mass drug administration campaigns such as those for onchocerciasis discussed earlier in this course, **vector control**, **case management** for diseases requiring individual treatment, and sustained **intersectoral collaboration**, given that many neglected tropical diseases require action well beyond the health sector alone, including water, sanitation, and veterinary services.

Notable achievements attributable to this coordinated global effort include substantial progress toward the **elimination** of onchocerciasis as a public health problem in several countries, discussed in an earlier Series, and significant reductions in the global burden of several other neglected tropical diseases, though considerable challenges, including sustained **funding** and reaching the most remote affected communities, remain.

Fill in the blank: Preventive chemotherapy, delivered through mass drug administration campaigns, is a key strategy employed by the special _____.

Figure 5.1: Researchers reviewing tropical disease surveillance data in a research institute office.

Pilot questions 5.1

21. Describe the objectives of the WHO special programme for tropical diseases. (Linked to SLO 5.1)
22. Define a neglected tropical disease and give two examples. (Linked to SLO 5.1)
23. Describe the common features shared by neglected tropical diseases. (Linked to SLO 5.1)
24. Describe two strategies employed by the special programme and its partners. (Linked to SLO 5.2)
25. Describe one achievement attributable to the special programme's coordinated global effort. (Linked to SLO 5.2)

5.2 Ebola Virus Disease

5.2.1 causative agent and transmission of Ebola

A severe viral haemorrhagic fever of zoonotic origin

Ebola virus disease is a severe, often fatal illness caused by **Ebola virus**, a member of the **filovirus** family, believed to originate from an animal reservoir, generally thought to involve **fruit bats**, consistent with the zoonotic transmission discussed in an earlier Series of this course, with

initial human infection typically following contact with an infected animal, and subsequent spread occurring through **human-to-human** transmission.

Human-to-human transmission occurs through **direct contact** with the **blood**, **body fluids**, or **secretions** of an infected person, whether living or deceased, or with surfaces and materials contaminated with these fluids, meaning that traditional **burial practices** involving direct contact with a deceased person, and healthcare workers caring for infected patients without adequate protection, have historically been particularly significant sources of onward transmission during outbreaks.

Fill in the blank: Ebola virus disease is believed to originate from an animal reservoir generally thought to involve fruit _____.

5.2.2 clinical features and case fatality of Ebola

Ebola virus disease typically presents with sudden onset of **fever**, severe **weakness**, **muscle pain**, **headache**, and **sore throat**, followed by **vomiting**, **diarrhoea**, and, in more severe cases, both internal and external **bleeding**, or haemorrhage, from which the broader category of viral **haemorrhagic fever** takes its name, though not every case develops prominent bleeding.

The **case fatality rate** of Ebola virus disease varies considerably between outbreaks, but has historically been substantial, at times exceeding **50 percent** in the absence of effective supportive care, making it one of the most severe diseases of global importance addressed in this course, and underscoring why even a small number of cases can trigger a major international public health response.

Fill in the blank: The case fatality rate of Ebola virus disease has historically, at times, exceeded _____ percent.

5.2.3 prevention and control of Ebola

Prevention and control of Ebola outbreaks rests on rapid **case identification** and **isolation**, discussed in an earlier Series of this course, rigorous **infection prevention and control** measures in healthcare settings, safe and dignified **burial practices** that avoid direct contact with the deceased, and thorough **contact tracing** to identify and monitor persons potentially exposed to a confirmed case.

Additional tools now available include effective **Ebola vaccines**, used in **ring vaccination** strategies targeting contacts of confirmed cases and their contacts during an active outbreak, together with improved **supportive care**, including careful fluid and electrolyte management, which has measurably reduced case fatality in more recent outbreaks compared with earlier ones.

Fill in the blank: Ebola vaccines are used in ring vaccination strategies targeting contacts of confirmed _____.

Figure 5.2: A healthcare worker in full personal protective equipment caring for a patient in an isolation unit.

Pilot questions 5.2

21. Identify the causative agent of Ebola virus disease and its believed animal reservoir. (Linked to SLO 5.3)
22. Describe how human-to-human transmission of Ebola occurs. (Linked to SLO 5.3)
23. Describe the characteristic clinical features of Ebola virus disease. (Linked to SLO 5.3)
24. Explain why traditional burial practices have historically contributed to Ebola transmission. (Linked to SLO 5.4)
25. Describe the role of ring vaccination in Ebola outbreak control. (Linked to SLO 5.4)

5.3 COVID-19

5.3.1 causative agent and transmission of COVID-19

A novel respiratory virus causing a global pandemic

COVID-19 is caused by **severe acute respiratory syndrome coronavirus 2**, or **SARS-CoV-2**, a novel coronavirus first identified in late 2019, which spread rapidly worldwide to become a **pandemic**, transmitted principally through **respiratory droplets** and smaller airborne particles, consistent with the airborne transmission mechanism discussed in an earlier Series of this course, particularly in crowded, poorly ventilated indoor settings.

A distinctive and epidemiologically significant feature of COVID-19 is substantial transmission from **pre-symptomatic** and even **asymptomatic** infected individuals, discussed as a general concept in an earlier Series of this course, which considerably complicated control efforts, since case identification based on symptoms alone was insufficient to interrupt transmission occurring before, or entirely without, any recognisable illness.

Fill in the blank: COVID-19 is caused by severe acute respiratory syndrome coronavirus 2, commonly abbreviated as _____.

5.3.2 clinical features and spectrum of COVID-19

COVID-19 produces a remarkably wide **clinical spectrum**, ranging from entirely **asymptomatic** infection through mild illness with **fever**, **cough**, and **loss of smell or taste**, to severe **pneumonia**, **respiratory failure**, and death, with **older age** and certain underlying medical conditions consistently associated with substantially higher risk of severe disease and mortality across affected populations.

This wide clinical spectrum, together with the substantial pre-symptomatic and asymptomatic transmission described in the previous sub-Part, meant that a very large proportion of total transmission during the pandemic could not be prevented through **symptom-based screening** alone, a key epidemiological lesson that distinguished the control challenge posed by COVID-19 from that posed by diseases such as Ebola, discussed earlier in this Series, where symptomatic illness more reliably precedes significant infectiousness.

Fill in the blank: A very large proportion of total COVID-19 transmission could not be prevented through symptom-based _____ alone.

5.3.3 prevention and control of COVID-19

Prevention and control measures deployed against COVID-19 included **non-pharmaceutical interventions**, such as **physical distancing**, use of **face masks**, improved **ventilation**, and, at various points, more restrictive measures including school and workplace closures, alongside the unprecedented rapid development and deployment of effective **COVID-19 vaccines** within roughly a year of the pandemic's onset.

Sustained control additionally required extensive **testing** capacity, robust **contact tracing** systems, and clear, trusted **risk communication** with the general public, and the overall pandemic response highlighted, with particular force, both the value of the surveillance and outbreak response principles discussed in the previous Series of this course, and the importance of the coordinated global health security arrangements examined in the final Part of this Series.

Fill in the blank: Prevention of COVID-19 included non-pharmaceutical interventions such as physical distancing, face masks, and improved _____.

Table 5.3: Comparing Ebola virus disease and COVID-19.

Feature	Ebola virus disease	COVID-19
Main transmission route	Direct contact with body fluids	Respiratory droplets and airborne particles
Pre-symptomatic transmission	Uncommon	Substantial
Case fatality rate	Historically high (at times over 50%)	Generally lower, but highly variable by age and risk group

Pilot questions 5.3

21. Identify the causative agent of COVID-19 and its principal route of transmission. (Linked to SLO 5.5)
22. Explain why pre-symptomatic and asymptomatic transmission complicated COVID-19 control. (Linked to SLO 5.5)
23. Describe the clinical spectrum of COVID-19. (Linked to SLO 5.5)
24. List three non-pharmaceutical interventions used against COVID-19. (Linked to SLO 5.6)
25. Explain why COVID-19 could not be controlled through symptom-based screening alone. (Linked to SLO 5.6)

5.4 Global Health Security and Preparedness

5.4.1 international health regulations and global health security

A binding legal framework for cross-border health threats

The **International Health Regulations**, or **IHR**, adopted by member states of the **World Health Organization**, constitute a legally binding international framework requiring countries to develop core surveillance and response **capacities**, and to promptly report events that may constitute a public health risk of **international** concern, extending the national surveillance and notification principles discussed in an earlier Series of this course to the global level.

Global health security refers more broadly to the collective activities required to minimise the danger and impact of acute public health events that endanger the health of populations across national borders, and depends on strong **national** surveillance and response systems, of the kind discussed in an earlier Series of this course, functioning effectively together within this shared international legal and coordination framework.

Fill in the blank: The legally binding international framework requiring countries to develop core surveillance and response capacities is known as the International Health _____.

5.4.2 public health emergency of international concern

A **public health emergency of international concern**, or **PHEIC**, is a formal declaration made by the **Director-General** of the World Health Organization, following advice from an independent **Emergency Committee**, when an event is determined to constitute a serious, unusual, or unexpected public health risk requiring a coordinated **international** response, representing the highest level of alert available under the International Health Regulations.

Both the West African **Ebola** outbreak and the **COVID-19** pandemic, discussed earlier in this Series, were declared public health emergencies of international concern, and such a declaration serves both to mobilise **international resources** and attention toward the affected countries and to encourage coordinated, evidence-based measures rather than uncoordinated, potentially excessive unilateral actions by individual countries.

Fill in the blank: A public health emergency of international concern is formally declared by the Director-General of the _____.

5.4.3 lessons for pandemic preparedness and response

Recent experience with Ebola and COVID-19 has reinforced several key lessons for pandemic preparedness, including the essential importance of strong routine **surveillance** systems, discussed in an earlier Series of this course, capable of detecting unusual events early, sustained investment in **health system** capacity, including laboratory and workforce capacity, even during periods without an active emergency, and the value of pre-established international **coordination** mechanisms rather than improvised arrangements built only once a crisis has already begun.

Further lessons include the critical importance of clear, timely, and trusted **risk communication** with affected communities, the need for **equitable** access to vaccines, treatments, and other countermeasures across countries of differing income levels, and the recognition that, given the inherently **interconnected** nature of global travel and trade, sustained investment in preparedness represents a shared responsibility that benefits every country, including Nigeria, rather than a burden falling only on the country where a given outbreak first begins.

Fill in the blank: A key lesson for pandemic preparedness is the need for equitable access to vaccines, treatments, and other _____.

Figure 5.4: Officials at a national public health emergency operations centre coordinating a response.

Pilot questions 5.4

21. Describe the purpose of the International Health Regulations. (Linked to SLO 5.7)
22. Define a public health emergency of international concern and identify who declares one. (Linked to SLO 5.7)
23. Give two examples of events declared a public health emergency of international concern. (Linked to SLO 5.7)
24. Describe two key lessons for pandemic preparedness drawn from Ebola and COVID-19. (Linked to SLO 5.8)
25. Explain why sustained investment in preparedness is described as a shared international responsibility. (Linked to SLO 5.8)

Series Summary

This final Series examined **global health programmes and diseases of international importance**, beginning with the **WHO special programme for tropical diseases**, its coordinated support for research, training, and control of neglected tropical diseases such as onchocerciasis and schistosomiasis, and its key achievements and strategies, before turning to **Ebola virus disease**, its zoonotic origin, its severe clinical course and historically high case fatality, and the case identification, isolation, safe burial, and ring vaccination measures used to control it, and then to **COVID-19**, its airborne transmission, its remarkably wide clinical spectrum, the particular challenge posed by substantial pre-symptomatic and asymptomatic transmission, and the combination of non-pharmaceutical interventions and rapidly developed vaccines used against it.

We concluded with **global health security and preparedness**, examining the International Health Regulations, the concept of a public health emergency of international concern, and the key lessons this course's discussion of Ebola and COVID-19 offers for future pandemic preparedness. Having worked through this Series, and indeed this entire course, you should now possess a comprehensive foundation in the epidemiology and control of communicable diseases, from the basic principles introduced in Series 1 through the specific transmission routes, priority endemic diseases, surveillance systems, and diseases of global importance addressed throughout COM 501.

Glossary of Terms

- **TDR:** the Special Programme for Research and Training in Tropical Diseases, co-sponsored by the WHO.
- **Neglected tropical disease:** a disease disproportionately affecting poor populations and historically under-resourced in research and control.
- **Ebola virus disease:** a severe, often fatal viral haemorrhagic fever caused by Ebola virus.
- **Ring vaccination:** a strategy vaccinating the contacts of a confirmed case and their contacts during an outbreak.
- **SARS-CoV-2:** the coronavirus responsible for COVID-19.
- **Pandemic:** an epidemic occurring over a very wide geographical area, typically across multiple countries or continents.
- **Non-pharmaceutical interventions:** prevention measures, such as physical distancing and masks, not involving drugs or vaccines.
- **International Health Regulations:** a legally binding WHO framework requiring core surveillance and reporting capacities.
- **PHEIC:** public health emergency of international concern, the highest level of alert under the International Health Regulations.

- **Global health security:** collective activities to minimise the danger and impact of acute public health events across borders.
- **Emergency Committee:** an independent WHO advisory body that recommends whether to declare a PHEIC.
- **Risk communication:** clear, timely, and trusted communication with the public during a public health event.

Concept Check Questions [Series 5]

Objective questions

21. The WHO special programme for tropical diseases is commonly known by the abbreviation _____.
22. Ebola virus disease is believed to originate from an animal reservoir generally thought to involve fruit _____.
23. COVID-19 is caused by severe acute respiratory syndrome coronavirus 2, commonly abbreviated as _____.
24. The legally binding international framework requiring core surveillance capacities is the International Health _____.
25. A public health emergency of international concern is declared by the Director-General of the _____.

Short-answer questions

26. Define a neglected tropical disease and give two examples.
27. Describe how human-to-human transmission of Ebola occurs.
28. Explain why pre-symptomatic and asymptomatic transmission complicated COVID-19 control.
29. Define a public health emergency of international concern and identify who declares one.
30. Describe two key lessons for pandemic preparedness drawn from Ebola and COVID-19.

Long-answer questions

31. Discuss the background, objectives, and achievements of the WHO special programme for tropical diseases. (Linked to SLO 5.1, SLO 5.2)
32. Discuss the epidemiology, clinical features, and control of Ebola virus disease. (Linked to SLO 5.3, SLO 5.4)
33. Discuss the epidemiology, clinical spectrum, and control of COVID-19. (Linked to SLO 5.5, SLO 5.6)

34. Discuss the International Health Regulations and the concept of a public health emergency of international concern. (Linked to SLO 5.7)
35. Discuss the key lessons for pandemic preparedness and response drawn from this Series. (Linked to SLO 5.8)

Answers to Concept Check Questions [Series 5]

Objective questions

61. TDR.
62. Bats.
63. SARS-CoV-2.
64. Regulations.
65. World Health Organization.

Short-answer questions

66. A disease disproportionately affecting poor populations, historically under-resourced in research; examples include onchocerciasis and schistosomiasis.
67. Through direct contact with the blood, body fluids, or secretions of an infected person, living or deceased, or contaminated surfaces.
68. Because case identification based on symptoms alone was insufficient to interrupt transmission occurring before, or without, illness.
69. A formal WHO declaration of a serious international public health risk, made by the Director-General following advice from an Emergency Committee.
70. The importance of strong routine surveillance and sustained health system investment, and the value of pre-established international coordination.

Long-answer questions

71. **Basic response:** The WHO special programme for tropical diseases, TDR, coordinates global research, training, and control efforts for neglected tropical diseases such as onchocerciasis and schistosomiasis, which disproportionately affect poor populations.

Value-added response: Key strategies include preventive chemotherapy, vector control, and intersectoral collaboration, achieving substantial progress toward onchocerciasis elimination in several countries, though funding and reaching remote communities remain ongoing challenges.

72. **Basic response:** Ebola virus disease, caused by a filovirus with a likely bat reservoir, produces severe illness with fever, bleeding in some cases, and historically high case fatality, spread through direct contact with infected body fluids.

Value-added response: Control rests on rapid case identification and isolation, safe burial practices, contact tracing, and, more recently, ring vaccination and improved supportive care, which has measurably reduced case fatality in recent outbreaks.

73. **Basic response:** COVID-19, caused by SARS-CoV-2 and transmitted via respiratory droplets and airborne particles, produces a wide clinical spectrum from asymptomatic infection to severe pneumonia and death, with substantial pre-symptomatic and asymptomatic transmission.

Value-added response: Control combined non-pharmaceutical interventions such as distancing and masks with rapidly developed vaccines, alongside extensive testing, contact tracing, and risk communication, since symptom-based screening alone was insufficient.

74. **Basic response:** The International Health Regulations require countries to build core surveillance and response capacities and report internationally significant events, with a PHEIC being the highest level of alert, declared by the WHO Director-General on Emergency Committee advice.

Value-added response: Both the West African Ebola outbreak and COVID-19 were declared PHEICs, mobilising international resources and encouraging coordinated, evidence-based responses over uncoordinated unilateral action.

75. **Basic response:** Key lessons include the importance of strong routine surveillance capable of early detection, sustained health system investment even without an active emergency, and pre-established international coordination mechanisms.

Value-added response: Further lessons include the need for clear, trusted risk communication, equitable access to vaccines and treatments across countries, and recognition that preparedness is a shared responsibility given the interconnected nature of global travel and trade.

Answers to Pilot Questions [Series 5]

Part 5.1

21. To coordinate global research, training, and control efforts for tropical diseases affecting poor populations.
22. A disease disproportionately affecting poor populations and historically under-resourced; onchocerciasis and schistosomiasis.

23. Association with poverty and poor water and sanitation, chronic disability, and historical under-investment.
24. Preventive chemotherapy through mass drug administration, and vector control.
25. Substantial progress toward onchocerciasis elimination as a public health problem in several countries.

Part 5.2

21. Ebola virus, a filovirus, with fruit bats as the believed animal reservoir.
22. Through direct contact with blood, body fluids, or secretions of an infected person, living or deceased.
23. Sudden fever, weakness, muscle pain, headache, sore throat, vomiting, diarrhoea, and, in severe cases, bleeding.
24. Because they involve direct contact with the body of a deceased infected person.
25. It vaccinates contacts of confirmed cases and their contacts to rapidly build protection around a case.

Part 5.3

21. SARS-CoV-2, transmitted principally through respiratory droplets and airborne particles.
22. Because infected persons could transmit the virus before, or without ever developing, recognisable symptoms.
23. Ranges from asymptomatic infection through mild illness to severe pneumonia, respiratory failure, and death.
24. Physical distancing, face masks, and improved ventilation.
25. Because a large proportion of transmission occurred from persons with no symptoms to screen for.

Part 5.4

21. To require countries to build core surveillance and response capacities and report significant public health events.
22. A serious international public health risk declared by the WHO Director-General, following Emergency Committee advice.
23. The West African Ebola outbreak and the COVID-19 pandemic.
24. Strong routine surveillance for early detection, and sustained health system investment even without an active emergency.
25. Because global travel and trade are interconnected, so preparedness benefits every country, not only where an outbreak begins.

References and Attributions [Series 5]

- World Health Organization (2024). Special Programme for Research and Training in Tropical Diseases (TDR): overview.
- World Health Organization (2021). Ebola virus disease fact sheet. WHO Press.
- World Health Organization (2023). COVID-19 epidemiological update. WHO Press.
- World Health Organization (2005, amended). International Health Regulations (3rd ed.).

Figures, Plates, Tables, and Boxes

- Figure 5.1: Researchers reviewing tropical disease surveillance data in a research institute office. AI-generated using the prompt: "A single clean, realistic illustration of two researchers reviewing charts and maps together at an office desk in a research institute, calm professional setting, soft indoor lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."
- Figure 5.2: A healthcare worker in full personal protective equipment caring for a patient in an isolation unit. AI-generated using the prompt: "A single clean, realistic clinical illustration of a healthcare worker in full protective equipment attending to a patient in a clean isolation unit, calm clinical setting, soft lighting, no text overlays, no multiple panels, respectful and accurate depiction, no graphic medical detail."
- Table 5.3: Comparing Ebola virus disease and COVID-19. AI-generated using the prompt: "Create a clean reference table titled Comparing Ebola and COVID-19, listing feature, Ebola virus disease, and COVID-19. Simple clinical reference table style with outside border."
- Figure 5.4: Officials at a national public health emergency operations centre coordinating a response. AI-generated using the prompt: "A single clean, realistic illustration of officials working together at a public health emergency operations centre with maps and communication equipment, calm professional setting, soft indoor lighting, no text overlays, no multiple panels, accurate and professional depiction, no graphic detail."