



# Introduction to Basic Microbiology

## Session 3



# Objectives

By the end of this module, the participants will be able to:

- Define key terminologies used in microbiology
- Describe main groups of microorganisms
- Describe different modes of transmission of infectious agents
- Discuss Multidrug Resistant organisms (MROs)



# Introduction

- The science of microbiology revolves around two themes:  
Understanding **basic life processes**, and  
Applying our understanding of microbiology for **the benefit of humankind**
- Microbiology has two important functions related to the prevention and control of infections:
  - **Clinical**: identify pathogens and their susceptibility to treatment
  - **Epidemiological**: identify pathogens causing disease or outbreak in a population and potential sources for these pathogens.



# Key Terminologies

- **Microbiology** –
  - Study of organisms that make up normal flora and transient flora, and how these organisms impact the health and safety of the host
- **Infectious dose**
  - Number of organisms needed to successfully infect
- **Latent period**
  - Exposure to infectiousness interval
- **Incubation period**
  - Interval from exposure to clinical symptoms
- **Infectivity**
  - The ability to infect a host



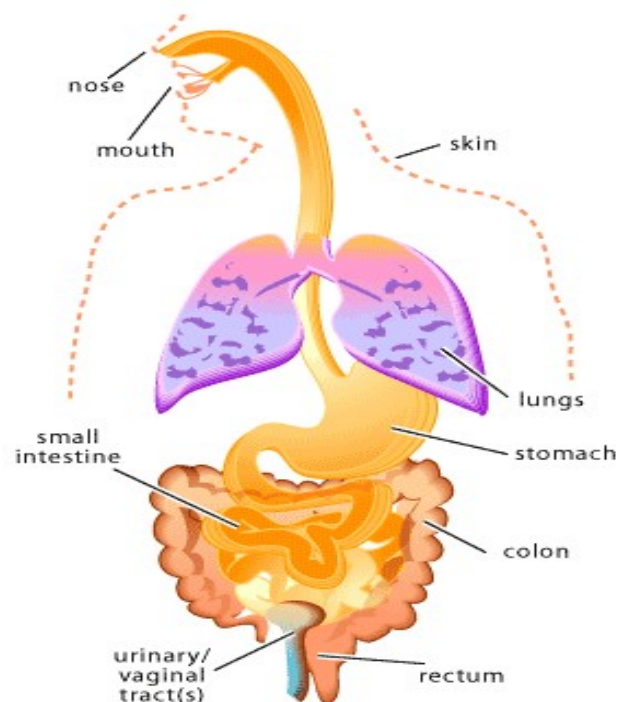
# Terminologies (cont.)

- **Infectious period**
  - Interval during which host can transmit infection
- **Reproductive rate**
  - Ability of an agent to spread in populations
- **Pathogenicity**
  - The ability to cause disease in the host
- **Virulence**
  - The ability to cause severe disease in the host
- **Immunogenicity**
  - The ability to induce an immune response in the host
- **Outbreak**
  - happens when a disease occurs in greater numbers than expected in a community or region or during a season



# Normal Human Flora

- Many of the microbes in and on our body are good and help to protect us from infection and aid in digestion
- When microbes live harmlessly in and on our body it is called **COLONISATION**
- Exposure to microbes does not always result in an infection





# Pathogenesis of Infection

To cause disease, microbes need:

- Contamination – Gain access to the host
- Adherence – Attachment to the host
- Colonization - Replicate in the host
- Invasion – Entry into tissues
- Damage-Produce toxins or other agents that cause host harm



# Microbes and Infection

When microbes find a new host and start to multiply;

- A balance can develop between colonised microbes and humans –(normal flora)
- Microbes can cause disease – called an infection
  - If source of microbe is patient's own flora –called an endogenous infection
  - If source of microbe is flora from outside the patient's body – called exogenous infection





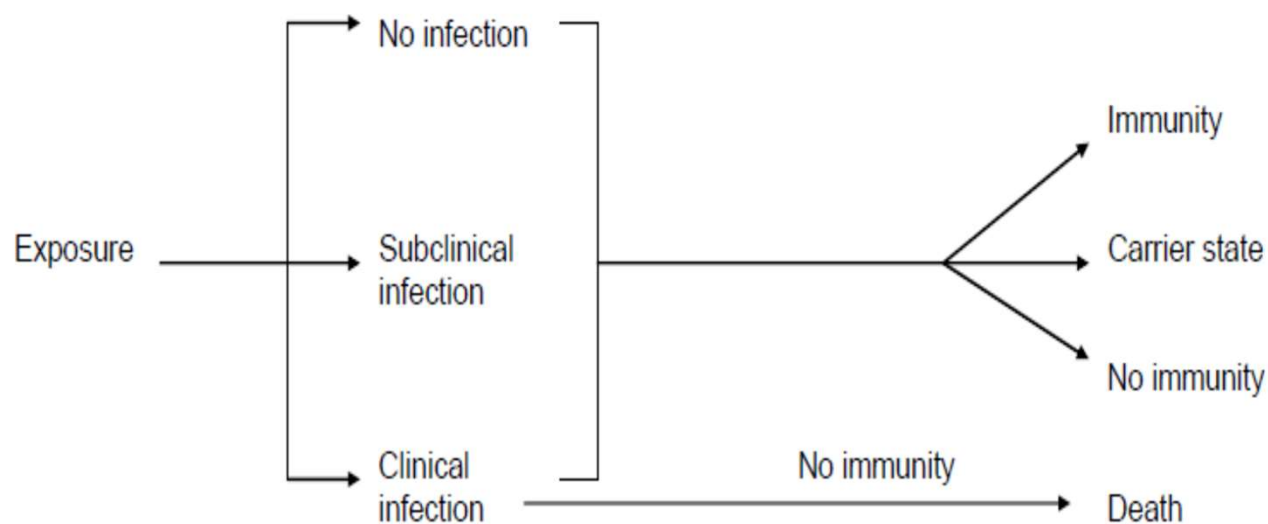
# Infection

Process of microbes entering, surviving and multiplying in its host and cause clinical signs and symptoms





# Different Outcomes of an Exposure To an Infectious Agent





# Classification of Infectious Agents

- Bacteria
- Viruses
- Fungi
- Parasites
- Rickettsia
- Chlamydia
- Prions

## Slide 11

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**NO2** Interchanged slide 11 and 12  
Noel Odhiambo, 10/28/2019



# Mode of Transmission

- Direct
  - Droplet
  - Aerosol
  - Skin to skin
- Indirect
  - Fomites (clothes, blankets, door handles etc.)
  - Vectors (e.g. mosquitoes)
  - Food and water
  - Intermediate hosts (e.g., snails, mosquito)

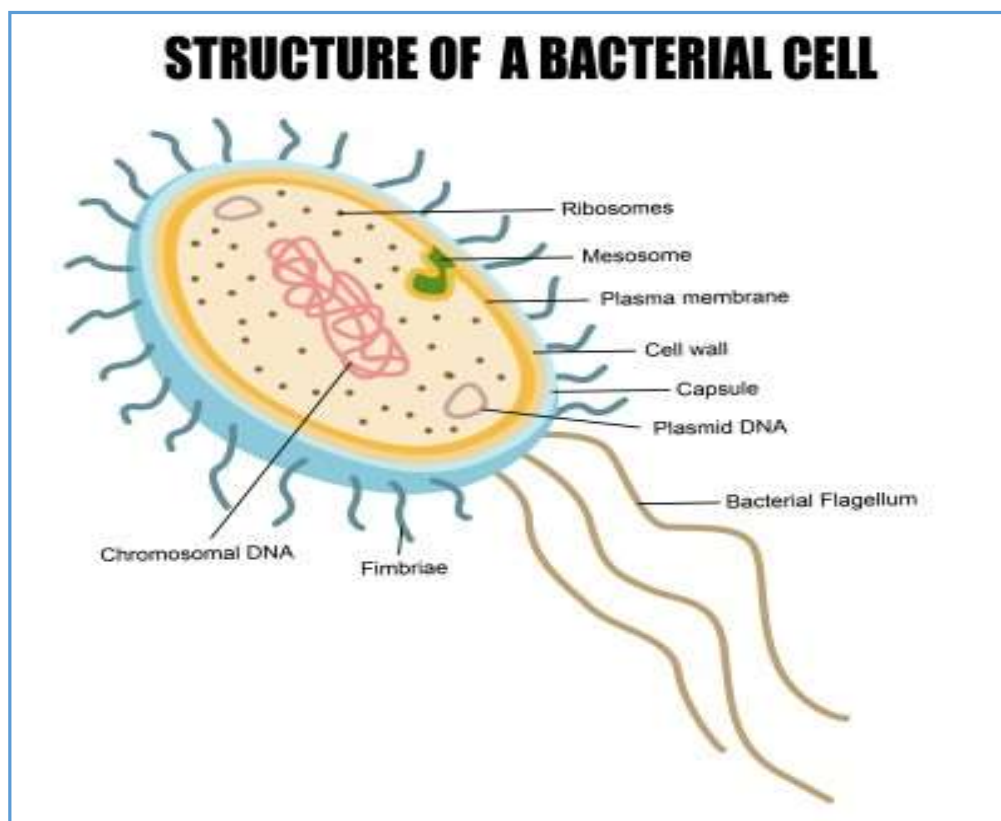


# Bacteria

- Cause the majority of infections associated with healthcare settings
- Can survive on appropriate media, stain gram-positive or gram-negative
- Can multiply if the appropriate environment is provided (e.g., on or inside a host, or on culture media in a laboratory)



# Bacterial Cell Structure



## Slide 14

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**NO3**      **Notes added**  
Noel Odhiambo, 10/28/2019





# Bacterial Identification

- Microscopy-wet preparation and gram staining
- Culture



# Gram Staining

Bacteria are classified by their gram stain characteristics

## **Gram positive** organisms:

- Have a thick cell wall made of peptidoglycan
- Stain blue when challenged with the Gram stain technique

## **Gram negative** organisms:

- Have a thinner cell wall and an additional outer layer made up of polysaccharides
- Stain red when challenged with the Gram stain

**Gram staining provides fast accurate guidance to the type of bacteria involved in an infection**



# Classification of Bacteria

Cocci  
(spherical)



*Staphylococcus aureus*



*Streptococcus pneumoniae*



*Streptococcus pyogenes*

Bacilli  
(rods)



*Bacillus anthracis*



*Haemophilus influenzae*

Curved or  
spiral



*Vibrio cholerae*



*Borrelia burgdorferi*

Gram-positive

Gram-negative



# Viruses

- Viruses are obligate intracellular organisms
- Only replicate intracellularly
- Classified as DNA or RNA
- Complete infectious virus outside of a cell wall is termed a virion



## Virus (cont.)

- The virion consists of the specific nucleic acid (DNA or RNA) surrounded by a protein coat (capsid) hence referred to as DNA or RNA virus
- Some viruses are enveloped while others are non enveloped (naked)
- Viruses as causative agents of HAIs are mostly encountered in paediatric wards
- Blood transmitted viruses (human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV) are very important viruses encountered in healthcare



# Fungi

- Fungi are organisms often found in the environment
- Non-motile filamentous, branching strands of connected cells
- Some yeasts, such as *Candida spp*, are classified as fungi

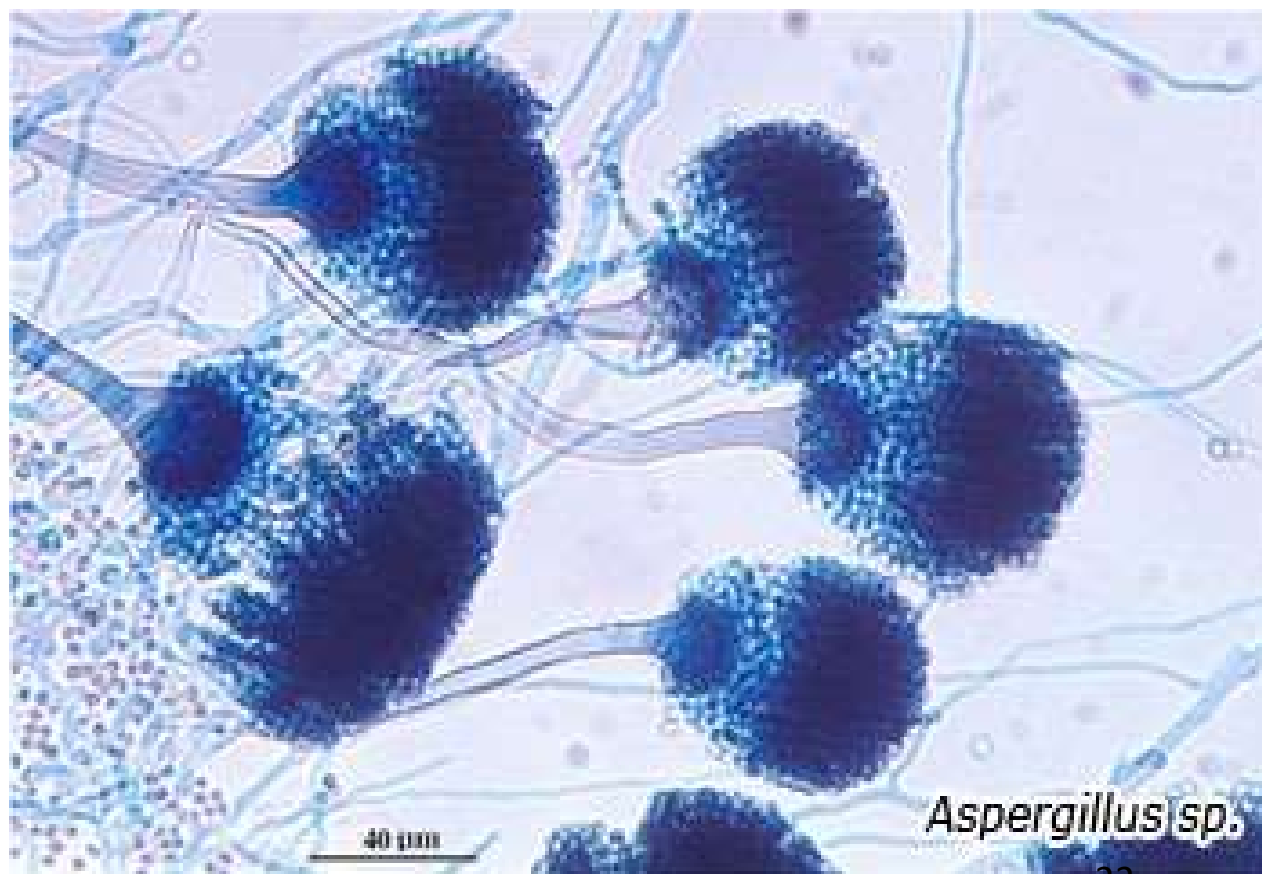


## Fungi (cont.)

- Can be part of normal flora as well as invasive opportunistic pathogens
- Usually resistant to many treatments and difficult to eradicate
- In general patients with fungal infections are not infectious to other patients
- Some Candida species can be transmitted from patient to patient on hands of healthcare workers



# Fungi



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# Parasites

- Include protozoa
  - Unicellular microorganisms
  - Live in nature or in human or animal host
  - Some of them cause infections
- Multicellular parasites
  - Worms, that can also cause infections (often called infestations)
- Cause frequent diseases in humans, especially in warm climates (e.g., malaria, shistosomiasis)
- Not often the cause of HAIs



# Rickettsia and Chlamydia

## Rickettsia

- Very small bacteria spread by ticks

## Chlamydia

- Bacteria lacking cell walls
- Not often the cause of HAI



# Prions

- Prions are proteinaceous particles
  - Do not contain any nucleic acid
- Connected to several severe neurologic diseases
- Highly resistant to usual disinfection and sterilisation methods
- Possibility of iatrogenic transmission
  - Through transplantation
  - Through instruments contaminated with brain tissue, dura or cerebrospinal fluid of infected person



# Multi-Drug Resistant Organisms (MDROs)

- Bacteria that acquire the ability to resist treatment against more than one antibiotic
- Infections caused by MDROs:
  - More difficult to treat and require more toxic antibiotics
  - Often result in poor patient outcomes
  - Cost more
- MDROs are readily transmitted in healthcare settings



## Causes of MDROs

- Antibiotic overuse
- Inappropriate antibiotic use
- Inadequate antibiotic doses
- Wrong route of administration
- Inadequate patient education



## **Effects of MDROs To the Health System**

- Risk of morbidity, mortality and disability to patients
- Increased length of stay
- Complications that may require admission to ICU
- Expensive antibiotics
- Increased utilization of other resources



# Controlling MDROs

- Having surveillance systems in place to identify and manage the risks presented by MDROs in health facilities
- Prompt reporting of any of these microorganisms by the laboratory to the Infection Control Practitioner (ICP) and physician



# MDROs

## Gram Positive Organisms

### *Staphylococcus aureus*

- Healthcare-associated MRSA
- Community-associated MRSA
- Vancomycin resistant organisms

### *Clostridium difficile*

- Named “difficile” because they were difficult to culture in the laboratory.





# Staphylococcus aureus

- ~ 20% of humans are persistently colonized (children > adults); ~ 60% are intermittently colonized
- Most often spread via contaminated hands





# Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- Resistant to beta-lactam antibiotics (all penicillins and cephalosporins)
- Identified based on antimicrobial susceptibility testing



# MRSA Clinical Spectrum





# “Types” of MRSA

- Healthcare-associated (HA-MRSA) infections
  - Causes healthcare-associated pneumonia, surgical wounds, and bloodstream infections
  - Risk factors: hospitalization, Long term care facilities, dialysis, surgery
  - Resistant to many antimicrobials
  - Skin infections common



## **“Types” of MRSA (cont’d)**

- Community-associated (CA-MRSA)
  - Skin infections common
  - No recent hospitalization, dialysis, surgery, long-term care facility (e.g., nursing home)
  - Susceptible to most antibiotics except beta-lactam antibiotics and erythromycin



## *Clostridium difficile* (*C. diff*)

- Named due to difficulty to isolate in the lab (Latin *difficile* = difficult)
- Spore-forming, anaerobic, gram-positive bacillus
- Fecal-oral transmission
  - Hands of healthcare personnel
  - Contaminated inanimate objects
- Two major reservoirs:
  - Infected humans (symptomatic or colonized)
  - Inanimate objects



# Risk Factors for *C. diff* Infection

- Antimicrobial exposure
- Acquisition of *C. diff*
- Advanced age
- Underlying illness
- Immunosuppression
- Tube feedings
- Gastric acid suppression
- Use of nasogastric or gastrostomy feeding tubes
- Use of proton-pump inhibitors

*Main modifiable  
risk factors*



## *C. diff* and Antibiotic Use

- > 90% cases occur during or after antibiotic therapy



- All antibiotics implicated
  - Broad spectrum agents are more likely associated





# Clinical Manifestations of *C.diff*



Asymptomatic  
colonization



**Asymptomatic  
colonization may  
be protective  
against *C.diff***

Diarrheal  
illness



- **Fever**
- **Cramping abdominal pain**
- **Increased frequency of loose, watery, unformed bowel movements not due to another cause**
- **Recent history of antibiotic exposure**

Pseudomembranous colitis  
Toxic megacolon



# Gram Negative MDROs

- *Pseudomonas aeruginosa*
- *Acinetobacter baumannii*
- *Klebsiella pneumoniae*
- *E.coli*

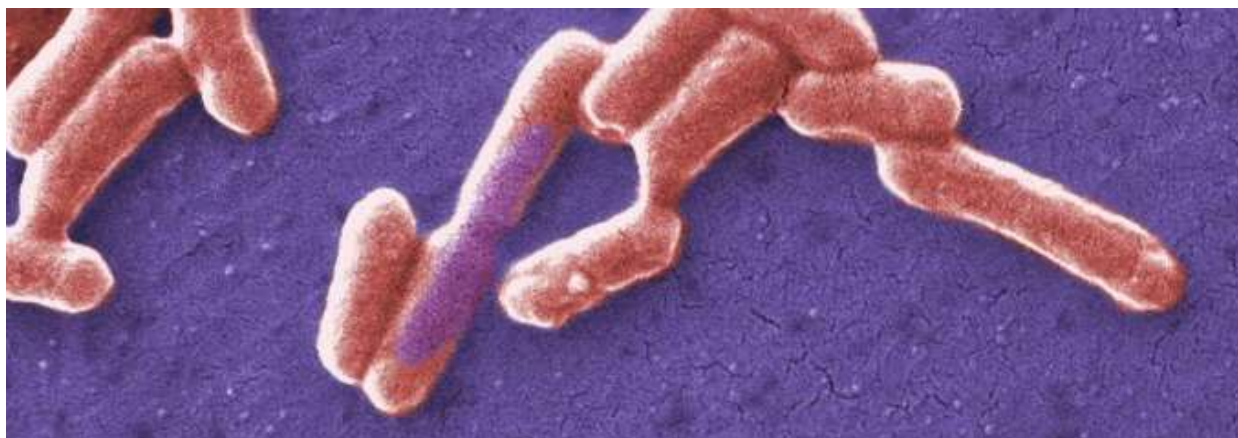


# Enterobacteriaceae

- Large family of gram-negative bacteria
- Common species
  - *Klebsiella pneumoniae*
  - *Escherichia coli*
  - *Enterobacter cloacae*
  - *Enterobacter aerogenes*



# Carbapenem-Resistant *Enterobacteriaceae* (CRE)





# Carbapenems

- Class of antibiotics
  - Ertapenem
  - Imipenem
  - Meropenem
  - Doripenem
- Mainstay of treatment targeting resistant gram-negative bacilli



# CRE

- Resistant to  $\geq 3$  classes of antibiotics, including carbapenems
- Resistance mechanisms
  - Enzymes that inactivate carbapenems
    - Klebsiella pneumoniae carbapenemase (*KPC*)
    - New Delhi Metallo  $\beta$ -lactamase (NDM-1)
    - Located on chromosomes or plasmids (mobile genetic elements)



# What Types of Infections Do CREs Cause?

- Urinary tract, intestinal or abdominal, respiratory tract, and wound infections
- Most frequently isolated from urine, sputum, or blood
- Bloodstream infections are associated with higher rates of death than infection at other sites



# Who Is At Increased Risk for Infection With CREs?

Hospitalized patients with:

- Co-morbid conditions
- Frequent or prolonged hospitalization
- Invasive devices
- Antimicrobial exposure (vancomycin, fluoroquinolones, penicillins, and extended-spectrum cephalosporins)







# Summary

- MDROs are a growing challenge in all areas of healthcare
- Early identification of MDROs and implementation of infection prevention and control measures is effective in limiting transmission
- Patient education is an important MDRO prevention measure in ambulatory care
- Compliance with infection prevention measures is essential
- Proper combating of MDROs and implementation of infection prevention and control measures are effective in limiting transmission.



# Thank You Questions ?





## References

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