**Kingdom of Saudi Arabia**
**Ministry of Health**
**General Directorate of Infection Prevention and Control**


## Healthcare Associated Infections (HAIs)

# Outbreak Management Manual

**January 2022**

**V. 6**

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# Message of the General Director

This manual, (January 2022 edition) of the (Outbreak Management of Healthcare Associated Infections), prepared by GDIPC – Outbreak Management Department. The current edition aimed at guiding healthcare workers especially infection preventionists who manage health care associated infections across different levels of Healthcare Facilities in Saudi Arabia.

It helps early detection and notification, proper investigation, management and control of outbreaks. This manual is considered to be an essential strategy for management of healthcare associated infection outbreaks in Ministry of Health and non- Ministry of Health Hospitals.

I do encourage health care workers to follow and implement this manual with great care, for it is expected to have a beneficial effect in reducing the number of outbreaks, morbidity and mortality.

My sincere thanks are due to members of the Outbreak Management Department for their contributions and hard efforts in formulating, editing, reviewing, submitting and publishing this manual.

**Dr. Khalid H. AlAnazi**

General director of infection Prevention and Control, GDIPC, MOH

# Abbreviations

| | |
|---|---|
| **AIDS** | Acquired Immunodeficiency Syndrome |
| **ATP** | Adenosine Tri-Phosphate |
| **BAL** | Bronchoalveolar Lavage |
| **C. diff** | Clostridium Difficile |
| **CAP** | Community Acquired Pneumonia |
| **CAUTI** | Catheter-Associated Urinary Tract Infection |
| **CDC** | Centers For Disease Control and Prevention |
| **CLABSI** | Central Line Associated Bloodstream Infection |
| **COVID-19** | Coronavirus Disease 2019 |
| **CRE** | Carbapenem-Resistant Enterobacteriaceae |
| **CSF** | Cerebrospinal Fluid |
| **DNA** | Deoxyribonucleic Acid |
| **EIA** | Enzyme Immunoassay |
| **ELISA** | Enzyme-Linked Immunoassay |
| **ESBL** | Extended-Spectrum Beta-Lactamases |
| **FFP2** | Filtering Face Pieces Offer Protection |
| **GDIPC** | General Directorate for Infection Prevention & Control |
| **HAI** | Healthcare-Associated Infections |
| **HAIO** | Hospital-Associated Infection Outbreaks |
| **HAP** | Hospital Acquired Pneumonia |
| **HBsAg** | Hepatitis B Surface Antigen |
| **HCWs** | Health Care Workers |
| **HEPA** | High-Efficiency Particulate Air |
| **HAV** | Hepatitis A Virus |
| **HBV** | Hepatitis B Virus |
| **HCV** | Hepatitis C Virus |
| **HIV** | Human Immunodeficiency Virus |
| **HVAC** | Heating, Ventilation, and Air Conditioning. |
| **IC** | Infection Control |

| | |
|---|---|
| **ICP** | Infection Control Practitioner |
| **ICU** | Intensive Care Unit |
| **ILI** | Influenza Like Illness |
| **IP** | Infection Preventionist |
| **IPC** | Infection Prevention and Control |
| **IT** | Information Technology |
| **IV** | Intravenous |
| **MDRO** | Multiple Drug Resistant Organisms |
| **MDR-TB** | Multidrug-Resistant Tuberculosis |
| **MERS-CoV** | Middle East Respiratory Syndrome Coronavirus |
| **MMR** | Measles, Mumps, and Rubella |
| **MOH** | Ministry of Health |
| **MRSA** | Methicillin-Resistant Staphylococcus Aureus |
| **MSSA** | Methicillin-Sensitive Staphylococcus Aureus |
| **N95** | Non-Oil 95 Percent Efficiency Mask |
| **OMAP** | Outbreak Management Action Plan |
| **OMT** | Outbreak Management Team |
| **OR** | Operating Room |
| **PCR** | Polymerase Chain Reaction |
| **PPE** | Personal Protective Equipment |
| **RHD** | Regional Health Directorate |
| **RNA** | Ribonucleic Acid |
| **RSV** | Respiratory Syncytial Virus |
| **SARI** | Acute Respiratory Infection |
| **SARS** | Severe Acute Respiratory Syndrome |
| **SDS** | Safety Data Sheet |
| **SOP** | Standard Operating Procedure |
| **SSI** | Surgical Site Infection |
| **TB** | Tuberculosis |
| **TSB** | Tryptic Soy Broth |
| **UTI** | Urinary Tract Infection |

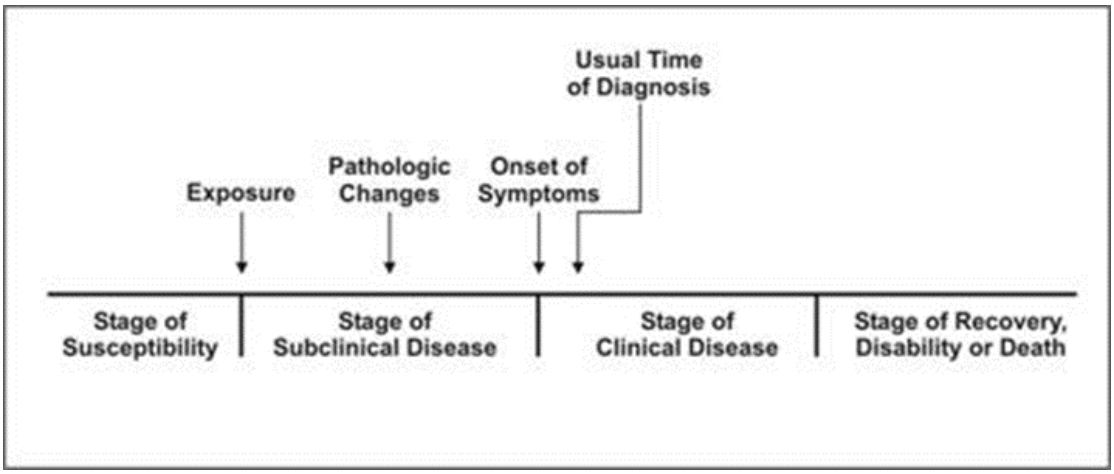
| | |
|---|---|
| **UVR** | Ultraviolet Rays |
| **VAP** | Ventilator-Associated Pneumonia |
| **VRE** | Vancomycin-Resistant Enterococci |
| **VZV** | Varicella Zoster Virus |
| **WHO** | World Health Organization |

# Table of Contents

# Introduction to epidemiology of infectious diseases

**Natural course of disease**

- It refers to the progression of a disease process in an individual over time, in the absence of treatment




**Impacts of pathogens:**

| Infection | Colonization |
|---|---|
| ○ Infection is the entry and multiplication of organisms in the tissue of a host.<br>○ Infection may be clinical or subclinical and may not produce identifiable disease.<br>○ However, it is usually accompanied by measurable host response(s), either through the appearance of specific antibodies or through cell-mediated reaction(s) | ○ The multiplication of a microorganism at a body site or sites without any overt clinical expression or detected immune reaction in the host at the time that the microorganism is isolated.<br>○ Colonization may or may not be a precursor of infection.<br>○ Colonization may be a form of carriage and is a potential source of transmission.<br>○ Commensal or normal flora are microorganisms present in or on a body site without causing clinical infection |

**Types of patients:**

| Case | Carrier |
|---|---|
| ○ The case is a person who have the pathogen multiplying (infected) and meet the case definition of a specific disease<br>○ Clinical case is a term that refers to overt disease when the signs and symptoms are apparent<br>○ Subclinical case is a term that refers to in apparent (subclinical) infection, an immune response can occur without overt clinical disease. | ○ A carrier is a person in whom organisms are present and may be multiplying, but who shows no clinical response to their presence.<br>○ The carrier state may be permanent, with the organism always present; intermittent, with the organism present for various periods; or temporary, with carriage for only a brief period.<br>○ Carriers may shed microorganisms during incubation period and during convalescence |

**Timelines for infection and disease**

| Infection-wise | Disease-wise |
|---|---|
| **Latent period**: time interval from exposure to infection to infectiousness | **Incubation period:** time from exposure to infection to the development of symptomatic disease |
| **Infectious period:** time during which the host is infectious | **Symptomatic period:** period in which symptoms of the disease are present |

**Case definition:**

- It is a set of uniform criteria used to define a disease for surveillance purpose. Case definition in an outbreak situation can be divided into three categories:
    - **Suspected/possible case:** clinical signs and symptoms without epidemiologic link or laboratory confirmation
    - **Probable case:** clinical signs and symptoms with epidemiologic link (been exposed to a confirmed case, eaten the same food, stayed in the same ward, etc.) to a confirmed case
    - **Confirmed case:** the diagnosis is confirmed by appropriate laboratory analysis of appropriate specimen(s) with or without clinical signs and symptoms and epidemiologic link

**Index case:**

- The first case among a number of similar cases that are epidemiologically related

**Case finding:**

- It is a method of identifying patients with HAIs through a combination of reviewing medical records, asking questions directed to patients or HCWs, and checking laboratory, imaging, or other relevant data, if available.

**Environmental sampling:**

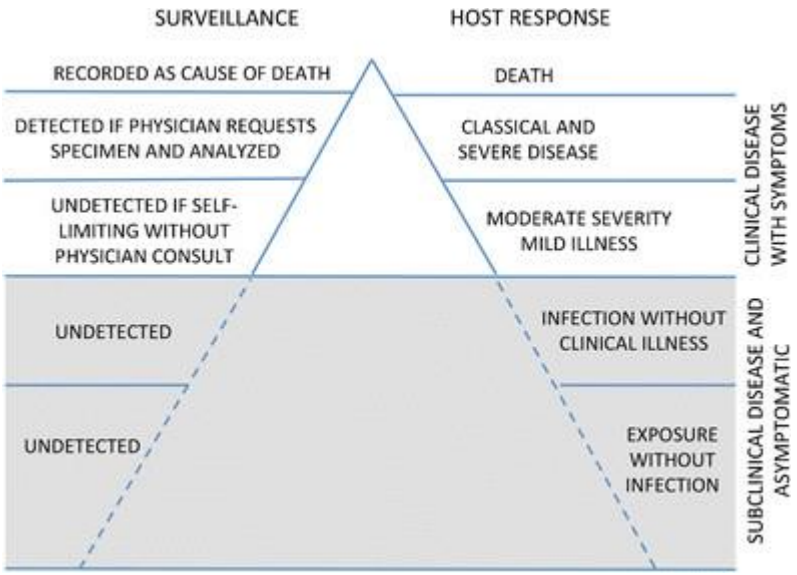
- It is the collection of samples from the health care environment or equipment (rather than from humans) that are cultured for microorganisms.

**Levels of disease occurrence**

- Sporadic level: occasional cases occurring at irregular intervals
- Endemic level: persistent occurrence with a low to moderate level
- Hyper endemic level: persistently high level of occurrence
- Epidemic or outbreak: occurrence clearly in excess of the expected level for a given time period and location
- Pandemic: epidemic spread over several countries or continents, affecting a large number of people

**Expression of Infectious Disease**

- When a susceptible host is exposed to a source of infection, a wide range of quantitative responses may occur.
- These range subclinically from exposure without successful attachment or multiplication of the bacterial organism, to colonization without tissue injury, to infection that evokes a host immune response but no clinical disease.
- These are often depicted as “iceberg concept of infections”, with the largest number of responses occurring sub clinically, below the waterline of clinical recognition.
- The existence of these in apparent events can be recognized only by laboratory means such as isolation of the organism or measurement of the immune response.



**Health care-associated infection (HAI):**

- It is an infection that occurs in a patient as a result of care at a health care facility that was not present at the time of admission to the facility.
- To be considered an HAI, the infection must begin on or after the third day of admission (the day of admission is day 1).
- The term “health care-associated infection” replaces the formerly used “nosocomial” or “hospital” infection because evidence has shown that these infections can affect patients in any setting where they receive health care.

**Outbreak:**

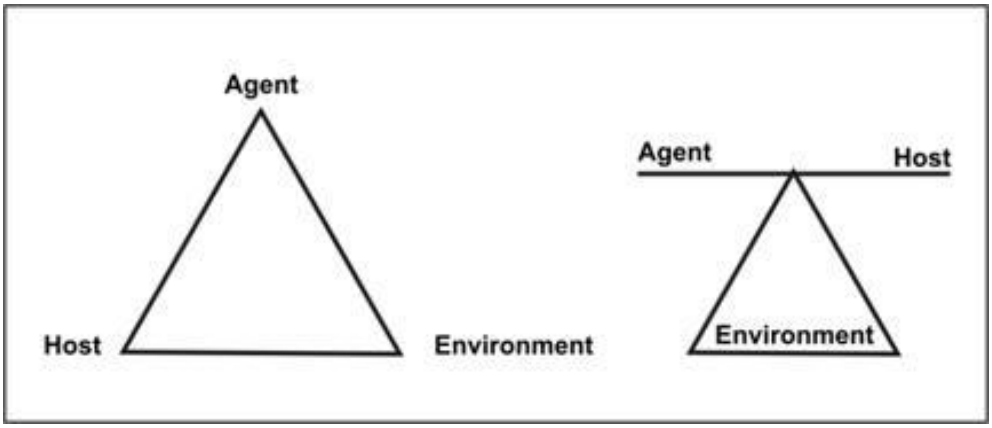
- It is the occurrence of a disease in a population above the normally expected rates at any given time or location.
- If the expected number of cases of a disease in a specific hospital is 8 per year, and 16 occur in 1 year, this is considered as an epidemic. It should be noted that an epidemic is not defined on the absolute number of cases but on the number of cases in comparison to what is expected".

**HAI outbreak:**

- It is an increase in the number of HAI events among patients or staff over and above the expected number of cases.
- However, for the sake of early detection, if there are more than 2 cases of HAIs with the same organism, linked to the same exposure, at any given location within 3 days, it will be considered an outbreak.
- In some rare, emergent, and high-risk pathogens, one pathogen is enough to declare an outbreak e.g. viral haemorrhagic fever or Candida Auris.
- Outbreaks in healthcare facilities are often multifactorial including breaches in infection control or clinical practices, contaminated devices, infected or colonized patients and /or HCWs.
- For more details, see Outbreak Classification Matrix.

**Epidemiological triad:**

- A model for depicting disease causation and it consists of an external agent, a susceptible host, and an environment that brings the host and agent together.
    - **Infectious agents** are microorganisms with the ability to cause disease
    - **Susceptible host** is a person who cannot resist a microorganism invading the body, multiplying, and resulting in infection.
    - **The environment** provides the mutual background on which agent–host interactions take place and contains the factors that influence the spread of infection
    - Note: Epidemiological triad may include vectors, which are living organisms that can transmit infectious diseases between humans or from animals to humans. They may be infected or just a carrier



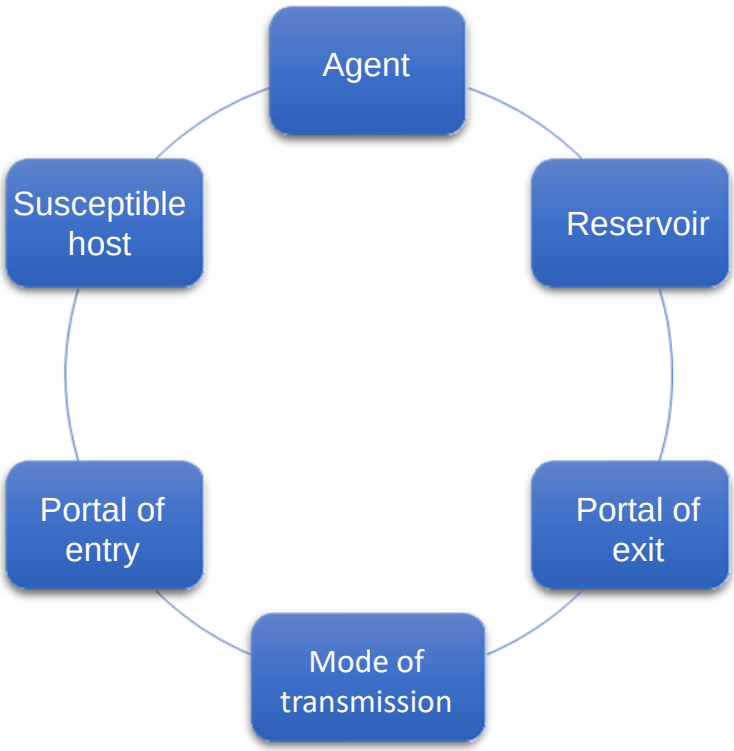

**Hill's causal criteria (modified by Leon Gordis 1990):**

- Temporal relationship (exposure occurs before diagnosis of disease)
- Strength of the association (stronger association is more likely to be causal)
- Biologic plausibility (consistent with current knowledge of disease pathology)
- Dose–response relationship (the higher the exposure the higher the risk of disease)
- Replication of the findings (similar findings from different studies)
- Effect of removing the exposure (stopping exposure decrease the risk of disease)
- Specificity of the association (specific exposure is associated with only one disease)
- Extent to which alternate explanations have been considered
- Consistency with other knowledge.

**Chain of infection**:

The chain of infection is a model to display interconnected steps that describe how a pathogen is causing an infection. Chain of infection includes:

- **Causative agent** is the pathogen (germ) that causes diseases
- **Reservoir** includes places in the environment where the pathogen lives (this includes people, animals and insects, medical equipment, and soil and water)
- **Portal of exit** is the way the infectious agent leaves the reservoir (through open wounds, aerosols, and splatter of body fluids including coughing, sneezing, and saliva)
- **Mode of transmission** is the way the infectious agent can be passed on (through direct or indirect contact, ingestion, or inhalation)
- **Portal of entry** is the way the infectious agent can enter a new host (through broken skin, the respiratory tract, mucous membranes, and catheters and tubes)
- **Susceptible host** can be any person (the most vulnerable of whom are receiving healthcare, are immunocompromised, or have invasive medical devices including lines, devices, and airways)



**Infectious Agent:**

- Infectious agents are microorganisms with the ability to cause disease:
  - Bacteria: tuberculosis, plague, or anthrax
  - Viruses: influenza, yellow fever or AIDS
  - Fungi: candidiasis or histoplasmosis.
  - Parasites: malaria and toxoplasmosis
- Mode of infections:
  - Endogenous infections: caused by body flora in immuno-compromised patients
  - Exogenous infections: caused by organisms from outside environment
- **Ability to survive:** The ability of the agent to remain viable in the environment until contact with the host which is affected by:
  - Ability to resist the effects of heat, drying, UV light, and chemical agents, including antimicrobials (See Appendix 1)
  - Ability to compete with other microorganisms
  - Ability to independently multiply in the environment or to develop and multiply within another (vector) host
- **Infectivity:** the capacity of agent to enter and multiply in a susceptible host producing infection or disease, is affected by:
  - The virulence: ability to grow and multiply
  - The invasiveness: ability to enter tissue
  - The pathogenicity: ability to cause clinical disease in the infected host
  - The toxigenicity: ability to produce toxins
  - Dose: number at entry site of the host
- **Resistance:** Ability of agent to survive adverse environmental conditions (hepatitis agents generally very resistant whereas influenza viruses are typically fragile). Note: "resistance" is also applied to the host.
- **Antigenicity:** Ability of agent to induce antibody production in the host (e.g. re-infection with measles virus is very rare). The related term "immunogenicity" refers to infection's ability to produce specific immunity.

**Reservoir of infection:**

- Any animate or inanimate niche in the environment in which an infectious agent may survive and multiply to become a source of transmission to a susceptible host
- The reservoir typically harbors the infectious agent without injury to itself and serves as a

source from which other individuals can be infected.

- The infectious agent primarily depends on the reservoir for its survival.
- It is from the reservoir that the infectious substance is transmitted to a human or another susceptible host.
- Examples from healthcare setting
  - Human reservoir
    - ✓ Healthcare worker carriage of staphylococci in the anterior nares
    - ✓ MRSA in the nares, groin, or axilla of patients
  - Inanimate reservoir
    - ✓ Pseudomonas species or Legionella in air-conditioning humidification systems
    - ✓ Clostridium difficile spores on inpatient work surfaces
    - ✓ Serratia marcescens growing in contaminated soap or hand lotion preparations

**Mode of Transmission**

- Mode of transmission is the method of transfer by which the organism moves from host to susceptible individual
- Transmission could be direct or indirect

| Direct | Indirect |
|---|---|
| ○ Droplet contact: coughing or sneezing (1 meter)<br>○ Direct physical contact to infected person secretions, blood, stool/urine (This method includes sexual contact)<br>○ Trans-placental infection: from mother to the fetus | ○ Airborne transmission - if the microorganism can remain in the air for long periods (TB, varicella, measles)<br>○ Indirect contact - usually by touching contaminated surface<br>○ Fecal-oral transmission - usually from contaminated food or water sources<br>○ Vector borne transmission - carried by insects or other animals<br>○ Iatrogenic Transmission: Transmission due to contaminated medical procedures |

**Mode of Transmission with examples**

| Type of transmission | Disease/pathogen |
|---|---|
| **Airborne transmission**<br>o Transmission via aerosols (airborne particles <5μm) that contain organisms in droplet nuclei or in dusts<br>o Can spread via ventilation systems<br>o Precautions: Single negative pressure room and respirator (e.g. N 95) mask | o Tuberculosis<br>o Chickenpox<br>o Measles<br>o Herpes zoster<br>o SARS<br>o Smallpox<br>o Pulmonary plague<br>o Legionella<br>o Fungal spores |
| **Droplet transmission**<br>o Transmission via sneezes or coughs<br>o Also during suctioning<br>o Droplets are relatively large (>5 μm) and can be projected up to about one meter<br>o Precautions: Masks, cover mouth, stand clear, and other droplet precautions | o Bacterial Meningitis<br>o Respiratory viruses<br>o Influenza<br>o Mumps<br>o Whooping cough<br>o Diphtheria<br>o Group A streptococcus<br>o MERS |
| **Fecal-oral transmission**<br>o Transmission via ingestion of contaminated food and water drinks<br>o This included some victor-borne, swimming pools and even oral sex<br>o Precautions: hand hygiene, food sanitations, adequate sewage treatment, water chlorination, cleaning, and proper hygiene. | o Rotavirus<br>o Enteroviruses<br>o Clostridium difficile<br>o Hepatitis A<br>o Poliomyelitis<br>o Cholera<br>o Salmonella<br>o Shigella<br>o Parasites |

| Type of transmission | Disease/pathogen |
|---|---|
| **Waterborne transmission**<br>o Ingestion of contaminated water<br>o Contact with or the inhalation of aerosols<br>o Precautions:<br>✓ Water disinfection and shock treatment<br>✓ Periodic cleaning and maintenance of showers, baths and sinks<br>✓ Installing disinfection systems and filters<br>o Avoiding the installation of other potential sources of infection such as decorative pools and fountains. | o Pseudomonas aeruginosa,<br>o Legionella pneumophila<br>o Burkholderia cepacia<br>o Stenotrophomonas maltophilia<br>o Acinetobacter<br>o Non-tubercular mycobacteria |
| **Direct contact transmission**<br>o Direct physical contact between infected or colonized individual and susceptible host<br>o Examples of transmission: touching, kissing, sexual contact, contact with oral secretions, or contact with body lesions<br>o Precautions: Hand hygiene, masks, & condoms | o Sexually transmitted diseases<br>✓ HIV/AIDS<br>✓ Chlamydia<br>✓ Genital warts<br>✓ Gonorrhea<br>✓ Hepatitis B<br>✓ Syphilis<br>o Common cold<br>o Ebola |
| **Indirect contact transmission**<br>o Contact with reservoir as contaminated surfaces or objects, or to vectors such as mosquitoes, flies, mites, fleas, rodents or dogs<br>o No direct human-to-human contact<br>o Precautions: Sterilizing instruments, disinfect surfaces, and other contact precautions | o MDRO<br>✓ MRSA<br>✓ VRE<br>✓ Gram negatives<br>o RSV<br>o Norwalk virus<br>o Rhinovirus<br>o |

| Type of transmission | Disease/pathogen |
|---|---|
| **Vector borne transmission**<br>○ Transmission may be mechanical or biologic transmission<br>○ Mechanical vector such as housefly can cause food-born diseases<br>○ Biological vectors such as mosquitoes and fleas are often responsible for blood-borne diseases<br>Precautions: barriers (window screens, bed nets), insect sprays, killing animals | ○ Mosquitoes<br>✓ Dengue fever<br>✓ Rift Valley fever<br>✓ Yellow fever<br>✓ Malaria<br>✓ West Nile fever<br>○ Sandflies<br>✓ Leishmaniosis<br>○ Fleas<br>✓ Plague<br>✓ Rickettsiosis<br>○ Aquatic snails<br>Schistosomiasis |

**Susceptible Host:**

- Susceptible Host: A person who cannot resist a microorganism invading the body, multiplying, and resulting in infection.
- A combination of reductions in host defense and the ability of an agent to cause infection are typical of acquisition of opportunistic infections in immunocompromised patients
- Susceptibility and response of a host to an agent are influenced by intrinsic or extrinsic factors

- Body's Defense Mechanism
  - Barriers: intact skin, tears of eyes, cough, sneeze, respiratory cilia, stomach acids, and vaginal secretions
  - Immune response:
    - ✓ Non-specific: neutrophils and monocytes
    - ✓ Specific: cellular (T cells) and humoral (B cells)

| Intrinsic factors | Extrinsic factors |
|---|---|
| ○ Age at infection<br>○ Sex<br>○ Race<br>○ Nutritional status<br>○ Birth weight<br>○ Comorbid conditions<br>○ Immune status<br>○ Immunosuppression associated with other infections, diseases, or therapy<br>○ Vaccination or immunization status<br>○ Previous experience with this or similar agents<br>○ The psychologic state of the host | ○ Invasive medical or surgical procedures<br>○ Medical devices, such as intravenous catheters, urinary catheter, or mechanical ventilators<br>○ Duration of antimicrobial therapy<br>○ Duration of hospitalization<br>○ Exposure to hospital personnel.<br>○ Sexual practices and contraception<br>○ Behavior as smoking or alcohol intake |

**Breaking the Chain of Infection:**

- **Control or elimination of infectious agents:**
  - Rapid identification and isolation of source
  - Applying barrier precautions
  - Disinfection and sterilization of items and equipment
  - Environmental cleanliness
- **Control of reservoir:**
  - Using disposable equipment
  - Disinfection and sterilization of non-disposable equipment
  - Identifying and controlling infections in carriers
- **Control of Portal of Exit:**
  - Proper control of secretions and excretion
  - Environmental sanitations (waste disposal)
- **Control of transmission:**
  - Hand hygiene
  - Source isolation
  - Aseptic techniques and proper device care
  - Control of air flow
  - Proper food handling
  - Environmental sanitations
- **Control of Portal of Entry:**
  - Aseptic techniques and proper device care
- **Control of susceptible host:**
  - Identifying high risk patients
  - Treating underlying disease

**Herd immunity:**

- Resistance of a group to an attack by a disease to which a large proportion of members of the group are immune.
- Once a high proportion of all people in the community are immune, the likelihood is small that an infected person will encounter a susceptible person.
- Due to herd immunity, highly protective immunization can occur without requiring 100% immunization rates (estimated 94% immunity for measles to interrupt the chain of transmission). Thus, vaccination programs do not always have to be 100% comprehensive
- For herd immunity to work,
  - Disease agent must be restricted to a single host species, and
  - Transmission must be relatively direct from one member of host species to another (e.g. no reservoir outside the human host in which the organism can exist such as birds or mosquitoes)
  - Herd immunity operates optimally when there is random mixing of the population.

**Levels of prevention:**

**Primary prevention:**

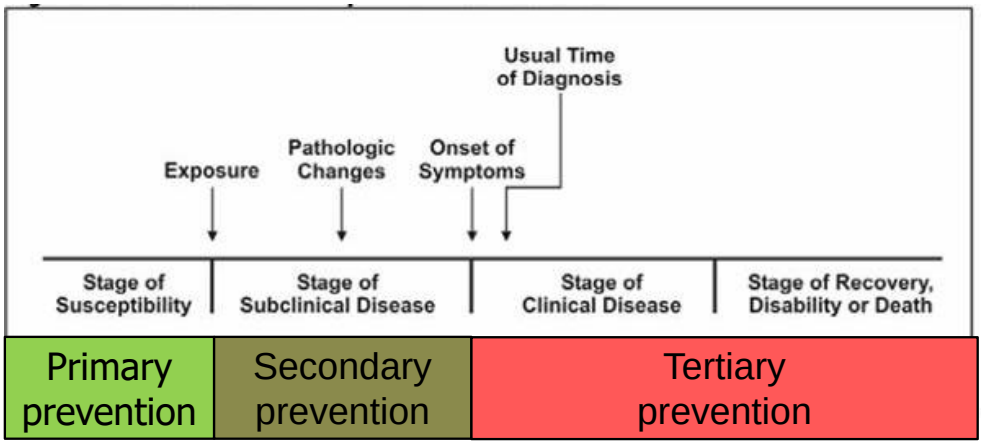
- Measures taken to prevent the development of a disease in a person who is well and does not have the disease in question (by eliminating or reducing the disease risk factors)
- Example: immunizing a healthy baby against infectious diseases

**Secondary prevention:**

- Measures taken to identify people who have already developed a disease, at an early stage in the disease's natural history, through screening and early intervention.
- Example: Surveillance culture to detect MRSA carriers to reduce HAI in ICU patients

**Tertiary prevention:**

- Measures taken to care of persons with already established disease, with attempts made to restore to highest function, minimize the negative effects of disease, and prevent disease-related complications.
- Example: Treating pulmonary tuberculosis to prevent complication and restore work ability



# Steps of investigation of an outbreak

**Steps of initial investigation of an outbreak**

1. Recognize potential outbreak
2. Confirm presence of outbreak
3. Alert key individuals
4. Perform literature review
5. Establish a preliminary case definition
6. Develop method for case findings
7. Perform descriptive epidemiology
8. Implement initial control measures
9. Identify potentially implicated health practices
10. Consider environmental sampling
11. Communicating Information about Outbreaks

**Steps of follow up investigation of an outbreak**

1. Refine the case definition
2. Continue case finding
3. Review regularly control measures
4. Consider if analytic study should be performed

# Steps of initial investigation of an outbreak

## 1- Recognize potential outbreak

- A potential outbreak may be identified by:
  - Laboratory reports
  - Many outbreaks are first recognized by front-line HCWs (nurses and physicians working in the affected unit) and then brought to the attention of Infection Prevention and Control (IPC) staff who investigate the outbreak
  - Surveillance system. However, since targeted surveillance rarely done continuously in the same place, the possibility of regular surveillance to detect surveillance is low

## 2- Confirm presence of outbreak

- **How to confirm the presence of outbreak:**
  - Compare the observed (the current) number of cases with the expected (previous) number of cases (same location during the last few years) to detect the occurrence of more cases of disease than expected
- **Sources expected rates:**
  - Laboratory reports: for some pathogens, like Salmonella and E. coli O157
  - Local hospital discharge records or local mortality statistics for hospitalized infections
  - Ministry of Health (MOH) surveillance reports for notifiable disease
  - If local data are not available, you may conduct a telephone survey of physicians to determine whether they have seen more cases of the disease than usual.
- **Pseudo-outbreak:**
  - It is generally applied to situations in which there's a rise in positive laboratory findings (e.g. positive microbiology cultures) without a similar increase in the number of related clinical cases.
  - It may be also caused by a change in the surveillance system/ laboratory methods resulting in misclassification of non-infected cases as infection or identification of cases that were always present but previously missed by surveillance

- **Causes of rise positive laboratory findings:**

  **I- Laboratory factors**

  - Introduction of new test, which was previously unavailable locally.
  - Improved laboratory techniques for identification.
  - Introduction of new laboratory test with poor specificity and/or sensitivity.
  - Contamination during processing in the laboratory, e.g. due to contamination of media or cross contamination of specimen during processing.

  **II- Non-laboratory factors**

  - Incorrect diagnosis of clinical entity
  - Contamination during collection if the correct procedure for collection of specimens is not followed
  - Use of water of poor microbiological quality in the washer disinfectors. Example. misdiagnosis of tuberculosis has been reported due to contamination of the endoscope with environmental mycobacteria (e.g. Mycobacterium chelonae) from the rinse water

- **Example of rise positive laboratory findings:**
  - A hospital in Croatia identified an increase in the number of respiratory samples positive for Mycobacterium gordonae in 2009. (Zlojtro et al. 2015)
  - An outbreak investigation revealed that the samples were being contaminated with M. gordonae from tap water during collection.
  - Guidelines for correct sputum collection were issued.
- **Causes of overcalling cases:**
  - Changes in local reporting procedures
  - Changes in the case definition
  - Increased interest because of local or national awareness
  - Improvements in diagnostic procedures
- If, after investigation, an outbreak is not confirmed then the IPC team must inform the clinical team who have reported the outbreak and provide reassurance

### 3- Alert key individuals

- It is important to make supervisors and hospital leadership aware of the presence of an outbreak situation so that resources can be made available and communication with staff and the community can be managed.
- In addition, the microbiology laboratory and staff working in the area where the outbreak is occurring should be alerted to look out for new cases, and to collect and save the appropriate samples for the investigation.
- Alerting key individuals in the hospital is essential to halting hospital outbreak, especially those of large scale, serious outbreaks, and those need unusually high resources
- **Example of alerting key individuals:**
    - When health care-associated Ebola Virus Disease was identified in a United States hospital, investigators worked with leadership, hospital staff, community members, and public health authorities to identify/isolate contacts, communicate with the public, process samples, detect transmission methods, implement measures to halt the outbreak (screening and adequate isolation/Transmission-Based Precautions), and reinforce IPC practices (training in use of personal protective equipment).
    - The outbreak was halted through prompt identification and evaluation of potential cases and meticulous IPC practices

### 4- Perform literature review

- Literature reviews help identify possible sources of the outbreak by answering the question: Where has the organism/problem been found previously?
- A literature review can also guide the investigators in where and how to look for the cause and provide strategies to stop the outbreak.
- The following resources may be of help to those in limited-resource settings:
    - National Library of Medicine (http://www.nlm.nih.gov/)
    - US Centers for Disease Control and Prevention (CDC) (www.cdc.gov/) provides an abundance of information ranging from current outbreaks and immunizations to disease-specific subject matter.
    - Worldwide Database for Nosocomial Outbreaks (www.outbreak-database.com)
    - The World Health Organization (WHO) Global Outbreak Alert and Response Network (http://www.who.int/ihr/alert_and_response/outbreak-network/en/).

## 5- Establish a preliminary case definition

- **Develop a case definition which may include:**
  - Persons: description of affected individuals
  - Time: range for when the illnesses occurred
  - Place: geographic range, such as residency in a state or region
  - Agent: pathogen or toxin, if known
  - Symptoms: certain symptoms typical for that pathogen or toxin

| Element | Descriptive Feature | Example |
|---|---|---|
| Laboratory | Pathogen, serotype | E. coli O157:H7 |
| Symptoms | Acute GIT illness | 3 or more loose stools in a 24 hour period |
| Person | Age group | children under 5 years old |
| | Sex | Males |
| | Occupation | HCWs at hospital A |
| | Exclusion criteria | persons with chronic diarrhea |
| Place | Geographic location | resident or visitor to ward B |
| | Water source | residents connected to water line C |
| Time | Illness onset | onset of illness on or after January 1, 2020 |

- **Example of preliminary case definition**
  - Three cases of new HIV infection among hemodialysis patients at a hemodialysis unit in Saudi Arabia were investigated to determine if there was an HAI outbreak.
  - The investigators developed the following case definition:
  - A case was defined as a patient among those undergoing treatment at hemodialysis unit 1, during November and December 2011, who seroconverted to HIV-positive status and whose self-reported behaviors did not include HIV risk factors and whose spouse was seronegative for HIV.

- **Categories of case definition:**

| Case category | General features |
|---|---|
| Confirmed | Laboratory confirmation of agent |
| Probable | Typical clinical features of illness<br>**AND**<br>Partial laboratory results (confirmation pending)<br>**OR**<br>Epidemiologic link to a laboratory-confirmed case |
| Suspect | Typical clinical features of illness<br>**AND**<br>Missing laboratory and epidemiologic information |

- **Primary versus secondary cases**
  - It is important to distinguish between primary and secondary cases.
  - Primary cases are directly exposed to the outbreak source, while secondary cases are defined as individuals who contracted the illness through exposure to a primary case, rather than the outbreak source itself (e.g., household contacts who become infected).
  - Secondary cases should be included in defining the scope of the outbreak, but are not included in an analytic study to identify the source of the outbreak; only primary cases would be included in a study.

- **Sensitivity versus specificity in a case definition**
  - Ideally, a case definition will include all cases (high sensitivity) but exclude any person who does not have the illness (high specificity).
  - A sensitive case definition will detect many cases (true positives) but may also count as cases individuals who do not have the disease (false positives).
  - A more specific case definition is more likely to include only persons who truly have the disease under investigation (reduce false positives) but also more likely to miss some cases (false negatives).
  - There are no rules about how sensitive or specific a case definition should be.
  - At the start of an outbreak, use a broad case definition (more sensitive) and then narrow the case definition down (more specific) at a later date when more information is available from the clinical and laboratory investigation

| | **Sensitive case definition** | **Specific case definition** |
|---|---|---|
| Advantages | Increase chances of finding cases ("true positives"); able to find as much information as possible on true cases early on, rather than having to go back and find cases later (which may have implications for food recall). | Improve case classification (i.e., minimize "false positives"); strengthen subsequent analytical tests or studies; may be more resource efficient. |
| Disadvantages | May capture individuals who are not actually part of the outbreak ("false positives"); may be resource intensive. | May miss cases ("true positives"). |
| Example | Three or more loose stools in a 24 hour period | Laboratory confirmed case of E. coli O157:H7 |

## 6- Develop a method for case finding

- **Methods of case finding:**
  - The investigator conducts a planned search for cases using case definitions to identify new or additional cases of an infection or disease.
  - Looking both backward and forward in time may be necessary to identify new cases as well as additional cases from the past using the time frame in the case definition.
  - Signs and symptoms of the infection or positive laboratory results from the case definition may be used to trigger further investigation to see if a patient matches the case definition.
  - A simple data collection form (line list) is usually developed to collect information on possible cases.
  - The line list may include few variables or be comprehensive. The benefits should be weight against the efforts required to collect the data.
  - The line list data will be used in plotting the epidemic curve later
- **Sources for cases findings:**
  - Assemble information from medical charts, microbiology reports, pharmacy reports, and logbooks from affected areas.
  - Surveillance culture for high-risk groups. However, benefits should be weight against the cost. This may be done for short period to determine the burden of colonized patients which will help you take a decision about extending the surveillance culture or not
  - Reviewing regular surveillance reports
  - Asking local clinical and laboratory professionals to report cases of the particular illness more quickly, as soon as they suspect the diagnosis
  - Reviewing emergency room records for similar illnesses
  - Sometimes, alert the public to seek medical advice if they had symptoms compatible with the case definition
- **Data variables to be collected:**
  - These data may vary from outbreak to outbreak but may include:
    - ✓ Identifying information: ID, name, and telephone number
    - ✓ Items from the case definition
    - ✓ Demographic information (age, sex, date and reason for admission, diagnosis,

date of surgery or procedures, antibiotics, etc.)

- ✓ Location information (admission, discharge, and transfer)
- ✓ Clinical data (onset of signs and symptoms, frequency and duration, treatments, medical devices)
- ✓ Outcome information (hospitalization, ICU care, ventilator, and death).
- ✓ Risk factor information: differ from disease to disease

- **Example of respiratory outbreak line list:**

☐ Staff Data  Date Line List Started: _____  Name of Facility: _____

☐ Resident/Patient Data  Floor/Unit: _____  Outbreak Number: 3895- 20___ - _____  Fax to TPH Liaison at: (416) _____ - _____

| Case Identification | | | | | Symptoms | | | | | | | | | | Laboratory Specimens | | | | Prophylaxis/Vaccination/ Treatment | | | | Complications | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Case Number | Name (Last, First) | Room number (Resident) Role - Area worked (Staff) | Gender (M/F/Other) | Date of Birth (yyyy/mm/dd) (Residents only) | Onset date of first symptom (mm/dd) | Abnormal temperature (°C) | Cough (D = Dry, P = Productive) | Runny nose/sneezing | Nasal Congestion/Stuffy Nose | Myalgia | Malaise | Sore Throat/Hoarseness | Headache | ADL affected by illness? Y/N | NP Swab (date of collection mm/dd) | Result & Date (mm/dd) | Other Specimen (Type/Date of collection mm/dd) | Result and Date (mm/dd) | Antiviral Date (mm/dd) | Flu Vaccine (mm/dd) | Pneumococcal Vaccine (mm/yy) | Antibiotic (mm/dd) | Date of Recovery | Pneumonia (CXR = CXR confirmed, C = Clinical) | Hospitalized (Y/N) | Deceased (Y/N) | Last Day at Facility (mm/dd) | Notes |
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Case Definition:  Causative Agent(s):

ADL = Activities of Daily Living

## 7- Perform descriptive epidemiology

- **Descriptive epidemiology:**
  - Characterizing an outbreak by time, place, and person using epidemic curve
  - Calculating the attack rate
- **Epidemic curve:**
  - It plots the cases in an outbreak based on the time of onset of illness.
  - Done by drawing a histogram of the number of cases (on the y-axis) by their date of onset (on the x-axis)
- **Advantages of epidemic curve:**
  - Can identify the exact period of the outbreak
  - Can identify the probable period of exposure
  - Can determine the epidemic pattern; common source, propagated, or both
  - When combined with other information gathered in the course of the investigation, can help identify the possible exposure
- **Calculating the attack rate**
  - Attack rate: It is a form of incidence that measures the proportion of persons in a defined population who had an acute health event during a limited time period (e.g., during an outbreak).

$$\text{Attack Rate} = \frac{\text{Number of new cases of disease during specified time interval}}{\text{Population at start of time interval}} \times 100$$

  - The attack rate can also be calculated stratified by relevant characteristics such as sex, age, location, or specific exposure (ventilation, catheterization, operating rooms, and occupational exposure).
  - At the end of the descriptive analysis, it should be possible to:
    - ✓ Formulate a hypothesis on the type of infection (exogenous, endogenous)
    - ✓ Tentatively identify the source and route of infection
    - ✓ Suggest and implement initial control measures.

## 8- Implement initial control measures

- **Implement initial control measures**
  - Take action and implement infection control measures without delay
  - Full implementation of infection control measures as recommended by the IPC
  - Special cleaning and disinfection procedures.
  - Depending on the type of pathogen, incubation period, and susceptibility, consider isolation of patients, staff, and visitors and initiate contact tracing, as appropriate
  - Determine patients/staff at risk of becoming ill and offer appropriate treatment, e.g. antimicrobial agents, active and/or passive immunization
  - It is always appropriate to educate or reinforce HCWs about IPC precautions and to develop a plan to ensure ongoing compliance with them
  - Closure of catering facilities, if considered appropriate.
  - Closure of health care facilities, if necessary.

- **Measures required according to the type of transmission**

| Precautions | Disease | Measures |
|---|---|---|
| Airborne precautions | Open/active pulmonary tuberculosis (TB), measles, and chicken pox | ○ Place patient in a single negative pressure room<br>○ The air should be discharged to the outdoors (better) or specially filtered (HEPA Filter) before it is circulated to other areas of the health care facility.<br>○ Keep doors closed all the time |
| Droplet precautions | Pneumonias, pertussis, diphtheria, influenza type B, mumps, and meningitis | ○ Implement standard precautions.<br>○ Place patient in a single room (or in a room with another patient infected by the same pathogen).<br>○ Wear a surgical mask when working within 1-2 meters of the patient. |
| Contact precautions | Colonization or infection with multiple-resistant organisms, enteric infections and skin infections | ○ Implement standard precautions<br>○ Place patient in a single room (or in a room with another patient infected by the same pathogen).<br>○ Wear clean, non-sterile gloves when entering the room. |
| Standard precautions | A group of infection prevention practices that apply to all patients, regardless of infection status. | ○ Hand hygiene compliance<br>○ Use of personal protective equipment (e.g., gloves, gowns, masks)<br>○ Safe use and disposal of sharps<br>○ Environmental cleaning<br>○ Safe patient equipment and instruments/devices<br>○ Respiratory hygiene and cough etiquette |

## 9- Identify potentially implicated health practices

- **How to identify potentially implicated health practices**
  - An outbreak can be stopped by identifying and interrupting the chain of transmission.
  - Information from the literature review on the type of pathogen and infection, and review of the cases in the line list, may help identify which health care practices to focus on.
  - Discussing the outbreak and possible causes with staff is also essential.
  - Investigations are more productive if investigators are seen as partnering with the staff rather than attempting to find someone to blame
  - Observations should at first be done without a detailed data collection form and should focus on workflow and practices that are different from best practices, recommended IPC guidelines, and hospital policies.
  - General IPC practices such as hand hygiene and Standard Precautions should be observed
  - It can be helpful to ask about shortcuts and methods that have been created by staff to work around perceived barriers to make workflow easier
- **Example of useful questions to ask during observations**
  - Do you always do this procedure in the way I observed? Are there situations that might require that you do it differently?
  - Have you seen other people do it differently?
  - What are the challenges with maintaining good techniques?
  - What do you think is causing or contributing to the outbreak?
  - What procedures or medications might I be missing because they are not in the chart or are done infrequently?

## 10- Consider environmental sampling

- **When to consider environmental sampling**
  - If environmental sampling is an option, very careful consideration should be given before deciding upon this course of action due to cost, lack of standards for interpretation, and the high possibility of inconclusive results (see Appendix 2)
  - Isolation of an organism from the environment rarely explains an outbreak
  - Environmental sampling should be pursued only if there is strong epidemiological evidence indicating that a possible source or reservoir of organisms exists
  - Often environmental sampling may not be possible due to lack of lab capacity or supplies and it is not essential.
  - On the other hand, if environmental sampling is indicated and possible, a positive result matching the pathogen causing the outbreak can be very satisfying
- **Interpreting negative environmental sampling**
  - It is important to note that if negative results occur it will not be known if that the environment can be ruled out or if the sampling failed for some reason.
  - There are many reasons why sampling the environment might not reveal a source pathogen, even if it is present.
    - ✓ Inadequate collection or culture technique
    - ✓ The pathogen was already removed by cleaning or only present transiently.
    - ✓ The sample was taken from the wrong place.
- **Recommendations that can improve environmental sampling:**
  - Perform these cultures after making the line list and doing observations so that they can focus on items that seem the most likely to be implicated. Environmental cultures should never be the first step in an outbreak investigation.
  - Before obtaining any environmental cultures, talk with microbiology laboratory personnel to determine whether they are able to process the cultures that will be obtained and discuss the optimal methods of obtaining them.
  - Culture only items that are possible vectors of transmission.
  - Culture the items that make the most sense as the likely reservoir for the organism. For example, outbreaks of Pseudomonas should focus on liquid items, whereas outbreaks of Acinetobacter should focus on surfaces.

## 11- Communicating information about outbreaks

- **Communicate early:**
  - If an outbreak is identified, it is important to communicate early and clearly.
  - Notify the MOH as per recommendation, specially in case of
    - ✓ Meeting the MOH outbreak criteria of notification
    - ✓ New or emergent pathogen that is first identified in the healthcare facility
    - ✓ Outbreak with the source is suspected or traced to an iatrogenic
    - ✓ Outbreak that are deemed not manageable by the facility
  - Keep the staff, patients, relative, and visitors informed and assured
  - Flag the electronic medical system in certain conditions (such as MDRO), to allow other staff deal with the patient using appropriate infection control measures
  - Communication between health care facilities in case of transfer, to enable the receiving institution to put in place appropriate precautions
  - Communication between laboratory and clinicians to provide instant information about the organism and resistance
  - Communication between pharmacy and clinicians to provide instant information about appropriate medication and to modify formulary if required
  - It is also essential that spokesperson not the members of staff would communicate directly with the media.
- **Write preliminary and final confidential outbreak reports**
  - The report must summarize full investigations, lessons learnt, and recommendations to prevent a recurrence in the future
  - The report must be sent to the senior management and other appropriate personnel/authorities for action
- **When to declare that the outbreak is over**
  - The point at which an outbreak can be declared over depends on the nature of the outbreak (type of microorganism).
  - Consult GDIPC.
  - There appears to be no consistency as to when an outbreak of norovirus should be declared over. However, it has been recommended declaring that an outbreak is over when two incubation periods for the organism have passed since the end of symptoms in the last case.

## Common mistakes in outbreak investigations

- **An assumption that an outbreak exists when it really does not.** An apparent increase in cases over a short period is often only normal variation; therefore, where possible, confirm the diagnosis, search for additional cases, and determine whether the increase is real before concluding that an outbreak is occurring.
- **Environmental sampling when not indicated.** Isolation of an organism from the environment rarely explains an outbreak.
- **Mistaken interpretation of environmental samples:** The presence of organisms from multiple sites usually suggests that these sites became colonized from another source and were not the cause of the outbreak. Negative cultures do not justify ruling out the site as source of the outbreak. There could be many reasons the cultures were negative
- **Prevention measures not implemented immediately.** As soon as an outbreak is suspected, patient care practices that could be responsible should be evaluated and any problems identified and corrected, without waiting for results from an investigation.
- **Other similar situations and related practices not evaluated.** When a problem with reprocessing instruments or specific patient care practices is identified, often the same faults exist elsewhere in the facility; all similar situations and related practices should be evaluated and corrected as soon as possible.

# Steps of follow up investigation of an outbreak

### 1. Refine the case definition:

- As the outbreak continues, the outbreak case definition may need to be refined
- We can refine the case definition with the new information that becomes available with time, or with additional diagnostic information.
- In the early stage of an outbreak investigation, the aim is to detect as many cases as possible; this requires a more sensitive case definition (e.g. a person with three or more loose stools in a 24-hour period).
- As the outbreak evolves and more information becomes available, case definitions can be refined to be more specific using additional laboratory or epidemiologic restrictions.
- These restrictions help to avoid misclassification (false positive) and are useful for hypothesis testing.
- The use of subtyping methods to differentiate strains or subtypes of pathogens enables more precise and efficient outbreak detection and source tracking
- Changing the case definition can have a considerable impact on the data collected and the interpretation.
    - For example, during the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, the case definition changed from a clinical-based case definition (limited information at the outset) to the addition of a laboratory component. The result was a large decrease in the number of reported confirmed cases, as expected with a more specific case definition.
    - In early case definitions of COVID-19, travel history was added to detect all possible exposed cases. Later, the travel history lose importance

### 2. Continue Case Finding and Surveillance

- Case finding and surveillance should be continued through the duration of the outbreak investigation.
- Methods of case finding and surveillance will vary for each outbreak, but may consist one or all of the following point-prevalence screening, admission screening, discharge screening, retrospective laboratory surveillance, prospective laboratory surveillance, self-report, etc.

### 3. Review Control Measures Regularly

- All interventions that are implemented during the investigation should be reviewed for necessity and monitored for compliance.
- Additionally, any interventions that are difficult to maintain or are labor and resource intensive should be reviewed frequently to determine when those interventions can be discontinued. Examples of this type of intervention include cohorting patients on a special unit, using specialized PPE (as in MERS-CoV) or dedicating staff to case patient care only. These interventions cannot be sustained over long periods of time due to disruption of facility workflow and throughput and due to cost in terms of time and resources.

### 4. Consider if analytic study should be performed

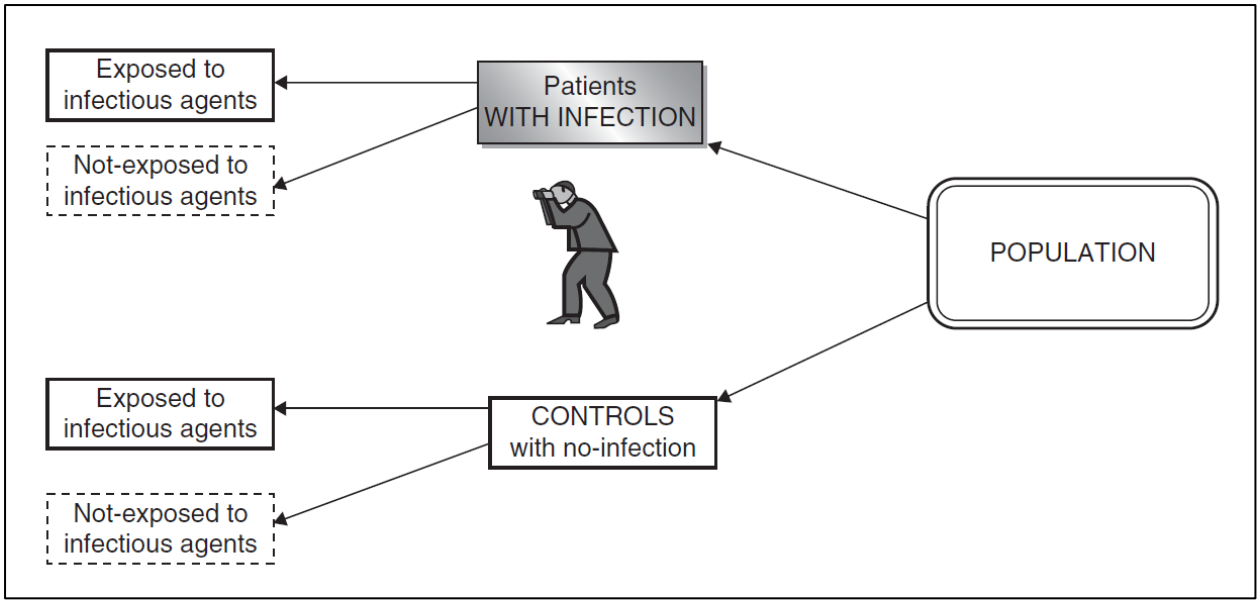
- Analytic studies typically should be used to test hypotheses, not generate them.
- However, in certain situations, collecting data quickly about patients and a comparison group can be a way to explore multiple hypotheses.
- In almost all situations, generating hypotheses before designing a study will help you clarify your study objectives and ask better questions.
- Studies can be time- and resource-intensive, and a hastily constructed study might not answer the correct questions.
- There are two types of analytic studies can be done: case-control and cohort studies
- In larger outbreaks, a case–control method may be the most efficient way of testing a hypothesis
- If a single hospital ward is affected, a retrospective cohort study should be done
- Case–control or cohort studies can be used in outbreak investigations to compare rates of infection in various populations in order to determine which exposures or risk factors are most likely responsible for the infection.

# Post-outbreak analytic studies

- There are two types of analytic studies can be done: case-control and cohort studies

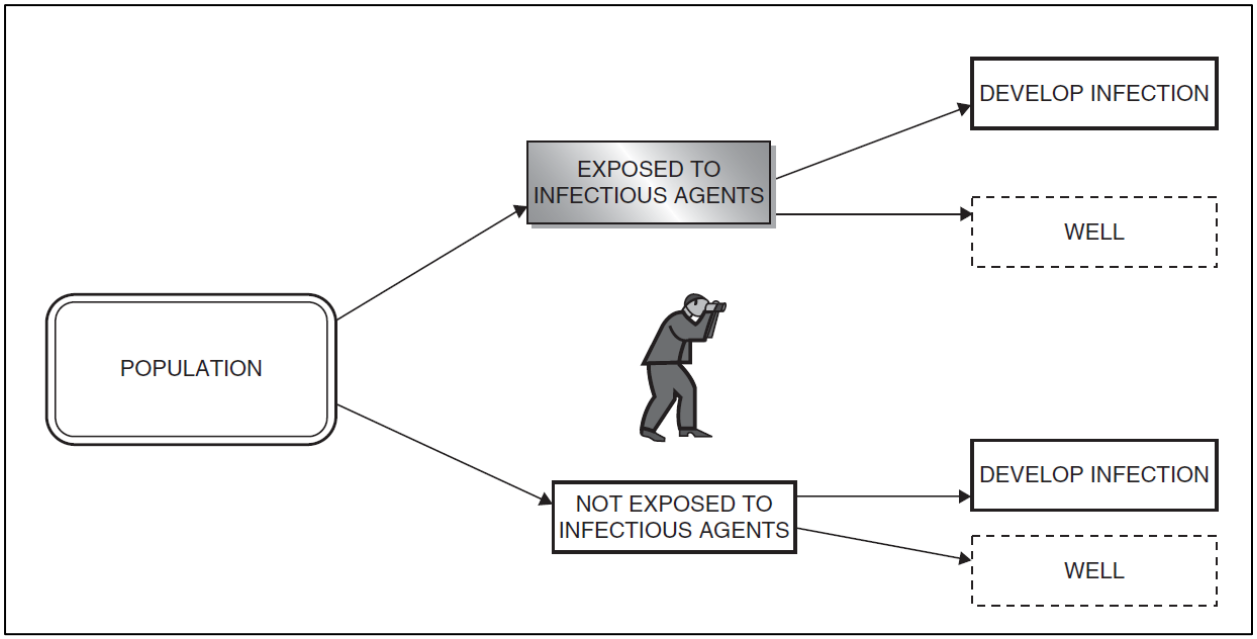
**Case–control study**:

- It is analytical epidemiological studies whose aim is to investigate the association between disease and suspected causes and are usually cross-sectional or retrospective in nature
- In case–control study, people with an outcome (an infection or a disease) are identified and their medical and social history examined retrospectively in an attempt to identify exposure to potential infectious agent or risk factors.
- Case–control study is the method most commonly used to investigate outbreaks because it is relatively inexpensive to conduct, is usually of short duration, and requires relatively few study subjects
- A matched control group free from the disease or infection is also identified and data collected from them in an identical fashion.



## Cohort study

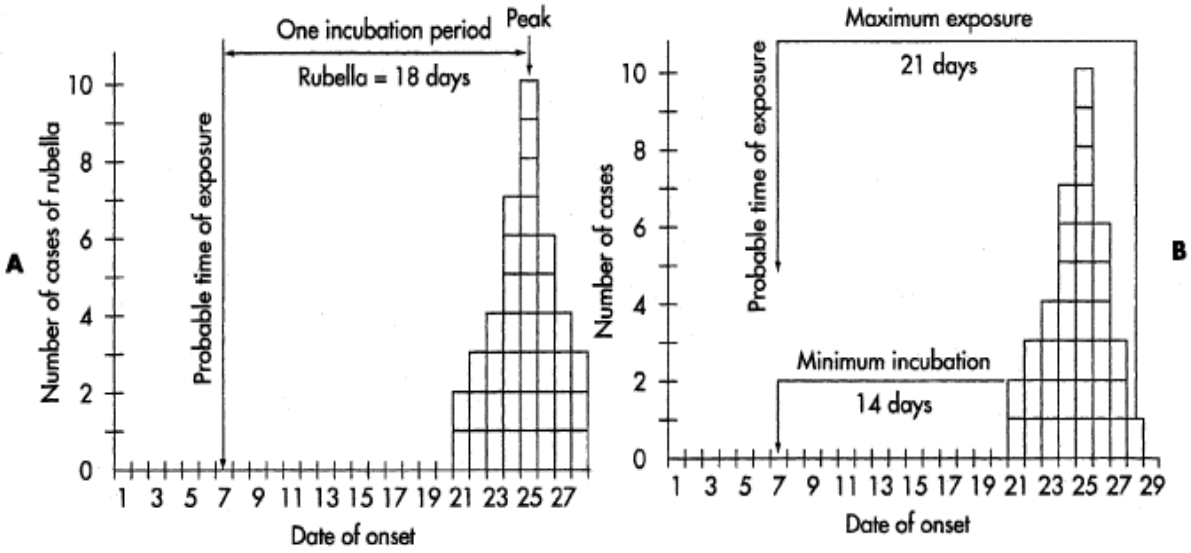
- Cohort study is observational study usually carried out over a long period of time, and designed to investigate the etiology of diseases or outcomes.
- The aim of such studies is to investigate the link between a hypothetical cause and a defined outcome.
- Prior to undertaking a cohort study, investigators should seek statistical advice regarding the number of subjects needed in each group.
- Cohort study starts with a hypothesis that the outcome (an infection or a disease) is caused by exposure to an infectious agent or event (risk factor).
- Subjects exposed to the suspected risk factor (cases) and similar groups that have not been exposed (control) are identified.
- Often, a complete population sample (cohort) is followed prospectively over a period of time (usually a number of years) to identify the incidence of the outcome in both groups.
- Cohort studies can be prospective or retrospective.
- The occurrence of disease among persons with different exposures is compared to assess whether the exposures are associated with increased risk for disease.



# Use of Epidemic Curve in outbreak

- **Epidemic curve:**
  - It plots the cases in an outbreak based on the time of onset of illness.
  - Done by drawing a histogram of the number of cases (on the y-axis) by their date of onset (on the x-axis)
- **Steps for making an epidemic curve**
  - Create a horizontal axis (X-axis) with increments of continuous time. Start with each increment being 1 day, but depending on the period over which the outbreak occurred, these might need to be changed to intervals of days/weeks/months. No time should be left out of the graph as the pattern of cases over time will be important
  - Create a vertical access (Y axis) with continuous whole numbers starting from 0. This will be the number of cases.
  - On the line list, find the case that occurred first and if no other cases occurred on that day, insert a bar that reaches to the number 1 on the Y-axis (or if more than one case, make the bar higher to show the number of cases occurring on that day).
  - For each day, add up the number of cases on the line list and insert a bar on the graph reaching that number. Note: The bars for consecutive days should be touching each other. Since the time is continuous, there should not be any gap between the bars.
  - Show confirmed and suspected cases in different colors or shading. If there are confirmed and suspected cases on the same day, distinguish between them by showing them on the same bar but in different colors or shading, with the confirmed cases at the bottom and suspected cases stacked on top.
- **Advantages of epidemic curve:**
  - Can identify the exact period of the outbreak
  - Can identify the probable period of exposure
  - Can determine the epidemic pattern; common source, propagated, or both
  - When combined with other information gathered in the course of the investigation, can help identify the possible exposure

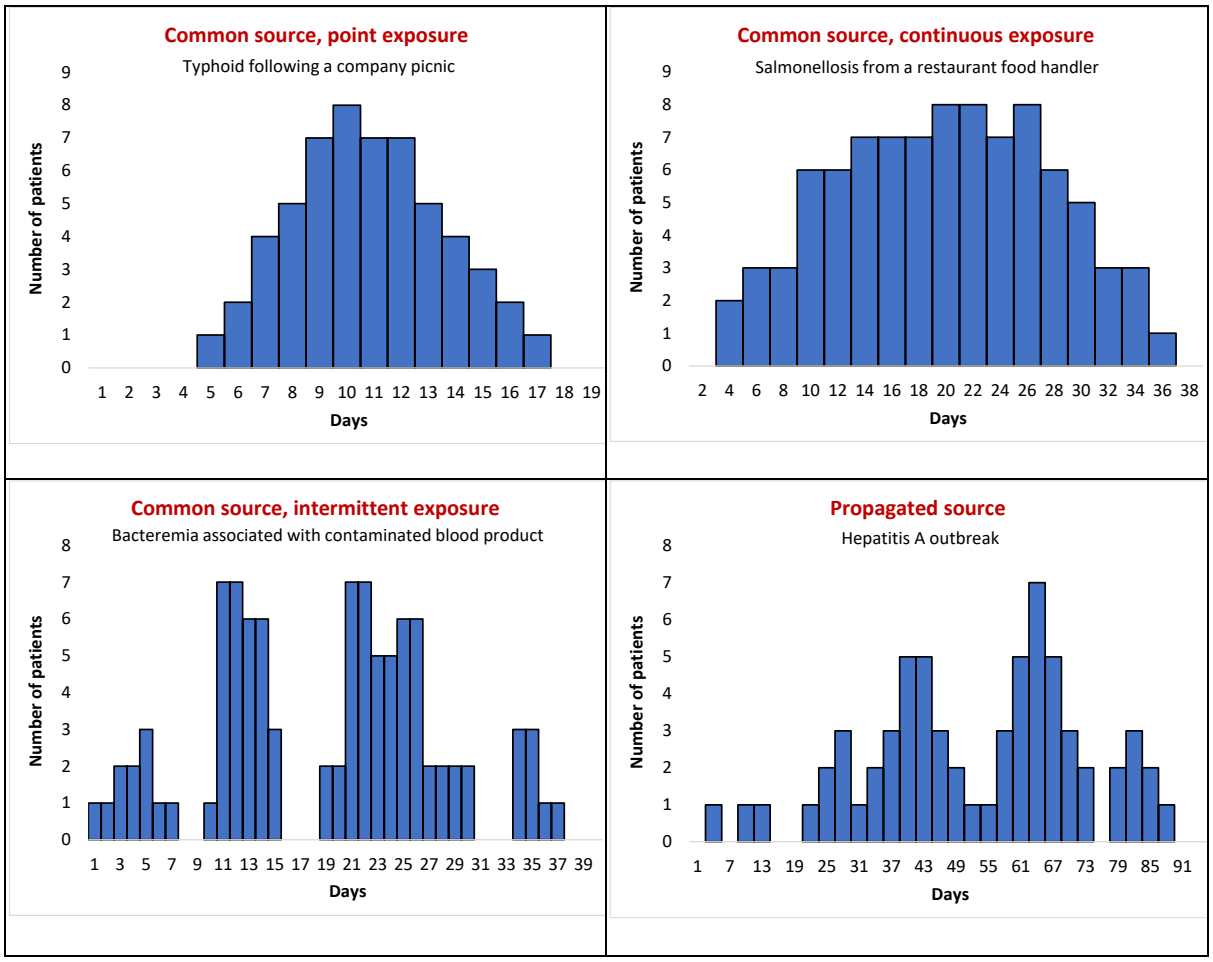
- **How the epidemic curve determines the exact period of the outbreak?**
  - Simple plotting will determine the start, peak, and end of outbreak
  - The magnitude of an outbreak can be assessed easily with a glance of the epi curve.
  - The time trend, or the distribution of cases over time, will give an indication of where the outbreak is in its course. Are cases still rising or has the outbreak already peaked? Does it appear that the outbreak is over? How long has it been since the last case occurred?
  - Outliers are cases that stand apart from the other cases. Outliers include the index case, which might be the source of the outbreak, and cases that occur well after other cases, which might indicate secondary spread of the illness.
- **How the epidemic curve determines the probable period of exposure?**
  - Can be done in common source outbreaks when the causative agent is known
  - Identify the mean or median incubation period or minimum and maximum incubation periods of the known agent from the literature
  - Use the peak of epidemic curve as the start point for the median incubation period
  - Use the first case in the epidemic curve as the start point for the minimum incubation period
  - Use the last case in the epidemic curve as the start point for the maximum incubation period
  - For example, the epidemic curve in the graph below was done for a common source outbreak of rubella. The median incubation period is known to be 18 days (minimum 14 days and maximum 21 days). Determining the probable period of exposure at day 7 using mean or median incubation period (A) or minimum and maximum incubation periods (B)




- **What are the epidemic patterns of outbreaks?**
  - Outbreaks can be classified according to their manner of spread within a population:
    - ✓ Common-source (exposed to the same infectious agent or toxin)
      - ➢ Point
      - ➢ Continuous
      - ➢ Intermittent
    - ✓ Propagated
    - ✓ Mixed
    - ✓ Other

| | **Common source outbreak** | **Propagated (ongoing) outbreak** |
|---|---|---|
| Source | Same or multiple exposure | Multiple exposures (person to person) |
| Transmission | Usually indirect | Usually direct |
| Pattern | Single, continuous, or intermittent | With and without secondary and tertiary cases |

- **How the epidemic curve determines epidemic pattern of the outbreak?**
  - **Common source, point exposure:** The epidemic curve has a steep up slope and a more gradual down slope (a lognormal curve). The majority of cases occur within one incubation period of the disease
  - **Common source, continuous exposure:** The epidemic curve has a plateau instead of a peak and the cases extend over one incubation period
  - **Common source, intermittent exposure:** Epidemic curve is irregularly jagged
  - **Propagated source:** Epidemic curve has a series of progressively taller peaks one-incubation period apart



# Epidemiology and Prevention of MDRO outbreaks

**Definition of Multiple drug resistant organisms (MDROs):**

- Pathogens that develop resistance to one or more commonly used antibiotics

**Types of MDROs**

**1. Gram positive MDROs:**

- **Methicillin-resistant Staphylococcus aureus (MRSA):** Includes S. aureus cultured from any specimen that tests oxacillin-resistant, cefoxitin-resistant, or methicillin-resistant by standard susceptibility testing methods
- **Vancomycin-resistant Enterococci (VRE):** Enterococcus faecalis, Enterococcus faecium, or Enterococcus species unspecified that is resistant to vancomycin, by standard susceptibility testing methods

**2. Gram negative MDROs:**

- **Carbapenem-resistant Enterobacteriaceae (CRE):** Any Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, or Enterobacter spp. testing resistant to imipenem, meropenem, doripenem, or ertapenem by standard susceptibility testing methods OR by production of a carbapenemase demonstrated using a recognized test (e.g., PCR or modified-Hodge test)
- **Cephalosporin-resistant Klebsiella:** Klebsiella oxytoca or Klebsiella pneumoniae testing non-susceptible (i.e., resistant or intermediate) to ceftazidime, cefotaxime, ceftriaxone, or cefepime
- **MDR Acinetobacter:** non-susceptible (resistant or intermediate) to at least one agent in at least 3 out of 6 antimicrobial classes (penicillins, aminoglycosides, cephalosporins, fluoroquinolones, carbapenems, and sulbactam)
  - ✓ Classes: Penicillins (Piperacillin, Piperacillin/Tazobactam), Aminoglycosides (Amikacin, Gentamicin, Tobramycin), Cephalosporins (Cefepime, Ceftazidime), Fluoroquinolones (Ciprofloxacin, Levofloxacin), Carbapenems (Imipenem, Meropenem, Doripenem), And
- **MDR Klebsiella or Pseudomonas:** non-susceptible (resistant or intermediate) to at least one agent in at least 3 out of 5 antimicrobial classes (penicillins, aminoglycosides, cephalosporins, fluoroquinolones, and carbapenems)

- **Extended-spectrum beta-lactamases (ESBL):**
  - ✓ ESBLs are enzymes that confer resistance to most beta-lactam antibiotics, including penicillins, cephalosporins, and the monobactam aztreonam
  - ✓ They are present in Enterobacteriaceae (such as Escherichia coli and Klebsiella) and other gram negatives (such as Pseudomonas aeruginosa)

### 3. Clostridium difficile

- A positive laboratory test result for C. difficile toxin A and/or B, (includes molecular assays [PCR] and/or toxin assays) tested on an unformed stool specimen (must conform to the container) OR A toxin-producing C. difficile organism detected by culture or other laboratory means performed on an unformed stool sample (must conform to the container).
- Not really resistant to drugs, so not actually a MDRO but they are treated like a MDRO because transmitted in the same way

**Presentation by onset time**

- Community-Onset (CO): MDRO specimens collected in an outpatient location or an inpatient location ≤3 days after admission to the facility (i.e., days 1, 2, or 3 of admission).
- Healthcare Facility-Onset (HO): MDRO specimens collected >3 days after admission to the facility (i.e., on or after day 4).

**Presentation by symptoms**

- Colonization
  - ✓ The multiplication of a microorganism at a body site or sites without any overt clinical expression or detected immune reaction in the host at the time that the microorganism is isolated.
  - ✓ Colonization may or may not be a precursor of infection.
  - ✓ Colonization may be a form of carriage and is a potential source of transmission
  - ✓ Does not require treatment
- Infection
  - ✓ The successful transmission of a microorganism to the host with subsequent multiplication, colonization, and invasion.
  - ✓ Infection may be clinical or subclinical and may not produce identifiable disease.

- ✓ However, it is usually accompanied by measurable host immune response(s), such as specific antibodies or cell-mediated reactions
- ✓ Requires treatmen

**Factors contributing to MDRO in healthcare setting**

- Selective pressure exerted by exposure to antimicrobial in the community
- Inappropriate and uncontrolled use of antimicrobial agents in healthcare setting
  - ✓ Increased use of antimicrobial prophylaxis
  - ✓ Increased use of poly microbial antimicrobial therapy
  - ✓ Administration of suboptimal doses
  - ✓ Administration for insufficient duration
  - ✓ Inappropriate choice of drug due to misdiagnosis, lack of microbiologic lab, and empirical treatment
  - ✓ Poor patient compliance
  - ✓ Lack of alternative appropriate antimicrobials
- Inadequate adherence to infection control measures
- Contact with colonized or infected patients (lack of isolation)
- Availability of vulnerable host
  - ✓ Severe underlying disease
  - ✓ Compromised host defenses such as dialysis, transplant, and oncology patients
  - ✓ Recent surgery
  - ✓ Indwelling medical devices
  - ✓ Transfer of the patient between institutions, specially suspected ones
  - ✓ Prolonged hospital stay

## Prevention of MDROs arranged according to CDC Guideline

1. **Structures and system administrative support**

- Make MDRO prevention and control an organizational patient safety priority.
- Provide administrative support, and both fiscal and human resources, to prevent and control MDRO transmission within the healthcare organization.
- Keep good communication and feedback to update on the progress and effectiveness of interventions
- Implement systems to communicate information about reportable MDROs
- Implement multidisciplinary measures to monitor and promote healthcare staff compliance
- Implement systems to designate and communicate information about patients known to be colonized or infected with a targeted MDRO
- Support participation of the facility or healthcare system in local, regional, and national coalitions to combat emerging or growing MDRO problems.
- Human resources: trained infection control practitioners and adequate staffing level
- IT measures to automate antimicrobial requests and control restriction
- Provide hand hygiene and environmental cleaning products
- Provide clinicians with antimicrobial susceptibility reports and analysis of current trends, updated at least annually, to guide antimicrobial prescribing practices.
- Written plan for implementation

2. **Education and training of healthcare workers**

- Provide training and education on risks and prevention of MDRO spreading during orientation and periodic educational updates for healthcare personnel.
- Do the assessment and evaluation of the staff's knowledge and skills by field observation and the online Infection Control module when available
- Provide clinicians with updated antimicrobial susceptibility reports and analysis of current trends, to guide antimicrobial prescription practices
- Increase the frequency of MDRO educational programs for those who work in areas with high MDRO rates. Additional review of wise utilization of antimicrobial agents:

3. **Judicious use of antimicrobials**

- Appropriate use of antimicrobials
  - ✓ Limit antimicrobial prescription
  - ✓ Use local antibiogram to effectively treat infections

- ✓ Treat infection, not contamination
- ✓ Treat infection, not colonization
- ✓ Stop treatment when infection is cured or unlikely
- ✓ Avoid excessive duration of treatment
- ✓ Use narrow spectrum agents and put restriction on broad spectrum and potent antibiotics

- Implement systems (e.g., computerized physician order entry, comment in microbiology susceptibility report, notification from a clinical pharmacist or unit director) to prompt clinicians to use the appropriate antimicrobial agent and regimen for the given clinical situation.
- Provide clinicians with antimicrobial susceptibility reports and analysis of current trends, updated at least annually, to guide antimicrobial prescribing practices.
- Monitor trends in the incidence of target MDROs in the facility over time using appropriate statistical methods to determine whether MDRO rates are decreasing and whether additional interventions are needed
- Establish a baseline (e.g., incidence) for targeted MDRO isolates by reviewing results of clinical cultures

**4. MDRO Surveillance**

- A critical component of any MDRO control program
  - ✓ Important patient safety component
  - ✓ Allows detection of newly emerging resistance pattern
  - ✓ Monitors epidemiologic trends in incidence of MDROs over time
  - ✓ Measures the effectiveness of interventions
- Establish systems to ensure that clinical microbiology laboratories (in-house and out-sourced) promptly notify infection control staff or a medical director/ designee when a novel resistance pattern for that facility is detected
- Use standardized laboratory methods and follow published guidance for determining antimicrobial susceptibility of targeted (e.g., MRSA, VRE, MDR-ESBLs) and emerging (e.g., VRSA, MDR-Acinetobacter baumannii) MDROs

❖ **MDRO screening**

- Screening is the collection of specimens from specific body sites known to be associated with colonization by a specific microorganism

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| MRSA | ✓ Nares, axilla, and groins |
| VRE | ✓ Rectal swab or<br>✓ Perianal swab |
| CRE | ✓ Stool sample or<br>✓ Rectal swab<br>AND, if indicated<br>✓ Urine (in the presence of a urinary catheter)<br>✓ Stoma swab (patient with colostomy or ileostomy)<br>✓ Wounds<br>✓ Catheter exit sites |
| ESBL | ✓ Stool sample or<br>✓ Rectal swab<br>AND, if indicated<br>✓ Urine (in the presence of a urinary catheter) |
| Acinetobacter | ✓ nostrils, pharynx, and skin surface |

- **Indication of screening:**
  - ✓ During an outbreak as a part of outbreak investigation and case finding
  - ✓ As part of infection control measures to manage the outbreak
  - ✓ As part of routine infection control measures, to find new cases before admission to ICU
- Screening specimens should be taken once the antibiotic has been discontinued for at least 48 hours to avoid false negative results
- Screening may not be appropriate in the following conditions:
  - ✓ Routine screening of well people admitted from the community is not recommended
  - ✓ Routine screening of staff is not recommended. If staff are epidemiologically linked to the transmission of a MDRO, review infection control practices and predisposing factors
  - ✓ If it is found incidentally that staff are colonized with MDROs, no work restrictions for these staff are required. Instead staff should receive education on standard precautions, particularly hand hygiene

- **Appropriate patients for screening:**

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| MRSA | ✓ Patients transferred from another hospital<br>✓ Patients with history of hospitalization one month before admission<br>✓ Patients who are previously infected or colonized with MRSA<br>✓ Before admission to ICU and oncology unit<br>✓ Scheduled for Cardiac Surgery, Orthopedic surgery, Neurosurgery and surgery with an implant.<br>✓ Patients on continuous ambulatory peritoneal dialysis<br>✓ Roommates of positive patients not on precautions for more than 72 hours |
| VRE | ✓ Patients who were previously VRE positive within the past 6-12 months.<br>✓ Roommates exposed to VRE-positive patients. |
| CRE | ✓ Roommates exposed to CRE-positive patients<br>✓ Active surveillance culture before admission in specific units |
| ESBL | ✓ Roommates exposed to ESBL-positive patients<br>✓ Active surveillance culture for specific at-risk units such as intensive care, burn, oncology-hematology, hemodialysis and organ transplant units |
| Acinetobacter | ✓ Active surveillance culture before admission in specific units |

**5. Infection control measures**

❖ **Prevent healthcare associated infection**

- Implementing standard precautions, particularly hand hygiene
- Implement contact precautions routinely for all patients infected with target MDROs and for patients that have been previously identified as being colonized with target MDROs (e.g., patients transferred from other units or facilities who are known to be colonized).
- Use masks according to Standard Precautions when performing splash-generating procedures (e.g., wound irrigation, oral suctioning, intubation)
- Implementing evidence-based best practices to prevent device-associated and procedure-associated HAIs
- Accurate and rapid diagnosis of infections and treatment of infectious etiology

- Reduce device utilization and improve insertion and post insertion care

❖ **Prevention of MDRO transmission**

- Strict hand hygiene and monitor HCWs compliance rate
- PPE: Wear gloves and gown when entering the room, removing before exiting
- Active surveillance cultures: to detect asymptomatic patients
- Use of isolation precautions: standard & contact for patients colonized or infected with MDRO
- Patient placement in hospital **:**
  - ✓ All Patients with MDROs should be placed in a single room.
  - ✓ When single patient rooms are not available, cohort patients with the same MDROs in the same room.
  - ✓ When cohort cases with the same MDRO are not possible, place MDRO patients in rooms with patients who are at low risk for acquiring an MDRO and who are likely to have shorts length of stay after discussion with ICP.
- Assign dedicated nurses and ancillary service staff to the care of MDROs patients only.
- Stop new admissions to the unit if transmission continues despite the implementation of the increased control measures.
- Enhanced environmental measures:
  - ✓ Clean and disinfect surfaces and equipment that may be contaminated with pathogens, including those that are in proximity to the case and frequently touched surfaces in the patient care setting on an extra frequent schedule compared to that for minimal touch surfaces.
  - ✓ Dedicate noncritical items to use on individual patients known to be infected or colonized with MDRO.
  - ✓ Designate cleaning equipment for contact isolation rooms.
  - ✓ Focus on cleaning and disinfection of frequently touched surfaces and equipment in the immediate vicinity of the patient.
  - ✓ Disinfect reusable medical equipment between patients

❖ **Precautions during the transportation of patients**

- Keep patient movement to a minimum if possible to prevent the transmission of MDROs.
- Perform tests at the bedside if possible.
- Inform the receiving department about the infectious status of the patient.
- Follow the procedures if the transportation is unavoidable.

- ✓ Give bath to the patient.
- ✓ Seal all open wounds with impermeable dressings.
- ✓ The patient must wear a new gown before transport.
- ✓ Both patient and HCWs should perform hand hygiene before leaving from the patient's room.
- ✓ Remove and discard of contaminated PPE and perform hand hygiene before transporting patients on contact precautions

- The patient NEVER wears yellow gown or gloves.
  - ✓ Transport staff should NOT wear yellow gown or gloves to transport patients, except when close contact is required during transport. at least one transporter should be not wear PPE in order to help with doors, elevators, etc.
  - ✓ If the patient bed and /or other equipment such as an IV pole accompany the patient the patient on the transport, the bedrails and equipment should be wiped down with hospital approved disinfectant prior to the transport.
- HCWs should wear PPE to handle the patient at the transport destination.
- Clean the testing and procedure area with hospital approved disinfectant after MDROs-patient leaves the area.
- Do all procedures in the patient's room if applicable.
- Do not allow sitter except if medically indicated.
- Educate the sitter to follow infection control precautions.
- Make sure all visitors of patients who are on contact isolation for MDROs should follow the isolation requirements. This means that visitors should use a gloves and gown when in the patient's room. A mask should also be worn if the organism is in the patient's sputum. When the visitor exits, the gown, gloves, and mask should be removed inside the room and hand washing with water and soap or alcohol-based hand cleanser should be performed. If visitors follow these requirements, there is no restriction on their movement in the hospital.
- Make sure isolation requirements are followed whenever possible in the case of visitors who sleep in the patient's room (i.e. parents staying with a child on isolation for MDROs).
- Put on a clean change of clothes and perform thorough hand hygiene must be followed by the visitors prior to exiting the patient's room if gowns and gloves are not worn (i.e. when sleeping or during prolonged hospitalizations). If these isolation requirements cannot be

met for any reason, then when leaving the patient's room the visitor should proceed directly out of the hospital without visiting other patients or any common-use areas.

- Reprocess ventilators used by patients with MDROs according to manufacturer recommendations.
- Designate respiratory therapist to provide care to patients with MDROs.
- Make sure patients with MDROs are seen last or at the end of the day if possible, including patient travelling to wound care room or physiotherapy rooms. Physical therapy/ Occupational therapy/ Speech therapy.

❖ **Manage MDROs positive patient as follows**

- Start contact precautions in addition to standard precautions and place contact precautions sign on the door.
- Practice strict hand washing.
- Cohort non-critical items to the patient (in the patient room).
- Minimize the amount of supplies in the patient room.
- Use isolation cart outside the patient room.
- Limit patient's activity outside the room for treatment or tests.
- Make sure that same time and terminal cleaning of isolation room and equipment is per housekeeping procedures.
- Handle/discard contaminated objects as per Standard Precautions.
- Request Infectious Diseases consultation as needed.
- Discharge patient if medical condition allows.
- Discontinue isolation after prior consultation with the ICP
- Review implementation of HAIs bundles (Surveillance MOH GDIPC Guideline).

**6. Enhanced environmental measures:**

- Start patient-dedicated or single use disposable non-critical equipment (e.g. blood pressure cuff, stethoscope), instruments, and devices.
- Monitor compliance to environmental cleaning policies.
- Monitor cleaning performance to make sure of consistent cleaning and disinfection of surfaces in close proximity to the patient.
- Obtain environmental cultures when there is epidemiological evidence than an environmental source is associated with on-going transmission of the targeted MDROs.
- Empty units for environmental intensive cleaning when previous efforts have failed.
- Clean patient's room.

- ✓ Clean rooms everyday by the designated personnel with disposable or dedicated equipment.
- ✓ Change mop water after each isolation patient's room is completed.
- ✓ Wipe mop handles with disinfectant and the mop head will be bagged and sent to the laundry.
- ✓ Clean all equipment with hospital approved disinfectant after each use.
- ✓ Do terminal cleaning of the room: This includes changing the curtains and wet disinfectant/mopping of floors, walls, bed, bedside table, telephone, and IV poles, etc. curtains, sheets, and other durable items will be bagged and sent to the laundry.
- ✓ Use single-use or disposable equipment for the care of patients with MDROs-whenever possible.
- ✓ Clean when durable equipment is used, including but not limited to portable x-ray machines, ABG machines, dialysis machines, etc., the equipment with hospital approved disinfectant and/or according to manufacturer's recommendations before the equipment is used to care for another patient.
- ✓ Keep all medical items such as dressings, syringes, IV fluids, etc. to minimal in the patient room; if these items found in the patient room after diagnosis with MDROs - all should be discarded.
- ✓ Keep linen in water-soluble bag and send to laundry as per hospital policy.
- ✓ For intensified interventions to prevent MDROs Transmission, see Appendix-3

# Epidemiology of specific MDRO outbreaks in hospitals

| MRSA | |
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| Pathogen | • Methicillin-resistant Staphylococcus aureus (MRSA): Includes S. aureus cultured from any specimen that tests oxacillin-resistant, cefoxitin-resistant, or methicillin-resistant by standard susceptibility testing methods<br>• Methicillin-sensitive Staphylococcus aureus (MSSA): S. aureus cultured from any specimen testing intermediate or susceptible to oxacillin, cefoxitin, or methicillin by standard susceptibility testing methods |
| Burden | • Approximately 5% of patients in U.S. hospitals carry MRSA in their nose or on their skin.<br>• Approximately 4% to 9% of all HAI are caused by MRSA<br>• Approximately 25-50% of staphylococcus aureus causing HAI are MRSA |
| Risk factors | • Risk factors in hospital setting<br>✓ Frequent/prolonged hospitalization<br>✓ People with indwelling central line, urinary catheters, implants, prostheses, and drains<br>✓ Immunocompromised patients (HIV/AIDS, lupus, or cancer sufferers; transplant recipients; severe asthmatics; etc.)<br>✓ Surgical and non-surgical wound<br>✓ Diabetics<br>✓ Users of quinolone antibiotics<br>✓ Elderly people<br>✓ Nursing home and long term care<br>• Risk factors in community setting<br>✓ People who are frequently in crowded places, especially with shared equipment and skin-to-skin contact<br>✓ Participating in contact sports. MRSA can spread easily through cuts, scrapes, and skin-to-skin contact.<br>✓ Intravenous drug users and homosexual |

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| | ✓ Prison inmates and military personnel |
| Hospital outbreak | • Common cause of hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a MRSA infection depend on the part of the body that is infected. For example, bloodstream infection is manifested as fever, shivering, and low blood pressure.<br>• Staph skin infections cause swelling, warmth, redness, and pain, which may become abscess<br>• It can cause severe infections including<br>✓ Bloodstream infections<br>✓ Pneumonia<br>✓ Surgical site infections<br>✓ Sepsis<br>✓ Death |
| Diagnosis | • Positive culture for MRSA. Normally, a bacterium must be cultured from blood, urine, sputum, or other body-fluid samples<br>• PCR<br>• Rapid latex agglutination test |
| Mode of Transmission | • Direct contact with contaminated hands (usually HCWs) or infected patients<br>• Direct contact with colonized patients<br>• Indirect contact with contaminated surfaces and objects |
| Screening | • In health-care settings, isolating those with MRSA from those without the infection is one method to prevent transmission.<br>• Rapid culture and sensitivity testing and molecular testing identifies carriers and reduces infection rates<br>• Swabbing sites: nares, axilla, and groins<br>• Screen the following patients:<br>✓ Patients transferred from another hospital<br>✓ Patients with history of hospitalization one month before admission<br>✓ Patients who are previously infected or colonized with MRSA<br>✓ Before admission to ICU and oncology unit |

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| | ✓ Scheduled for Cardiac Surgery, Orthopedic surgery, Neurosurgery and surgery with an implant.<br>✓ Patients on continuous ambulatory peritoneal dialysis<br>✓ Roommates of positive patients not on precautions for more than 72 hours<br>• Screening of HCWs is not recommended, unless they are epidemiologically linked to new acquisitions of MRSA |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment.<br>• Use dedicated patient-care equipment (e.g. blood pressure cuffs, stethoscopes), and single use disposable items (e.g. single patient digital thermometer) whenever possible<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging.<br>• Provide education on management of MRSA patients to HCWs.<br>**Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing CLABSI<br>• Implement strategies for preventing SSI<br>• Implement strategies for preventing bacteremia in dialysis patients<br>**Implement supplemental prevention strategies:**<br>• Performance of active surveillance testing before admission to ICU and oncology unit<br>• Decolonization and chlorhexidine bath |
| Decolonization | • Decolonization for MRSA carriers who were implicated in an outbreak (intranasal mupirocin twice a day to each nare for 5 days).<br>• For more details, see Appendix 4 |

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| Discontinue Contact isolation | • Discontinue contact isolation after three consecutive negative cultures (taken 3 days apart) from a previously positive patient (in the absence of antibiotic therapy for at least three days)<br>• Consult IC / RHD outbreak coordinators and treating physician |

| VRE | |
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| Pathogen | • Vancomycin-resistant Enterococci (VRE): Enterococcus faecalis, Enterococcus faecium, or Enterococcus species unspecified that is resistant to vancomycin, by standard susceptibility testing methods<br>• Enterococci are bacteria normally present in the human intestines and in the female genital tract, and are often found in the environment, like in soil and water. |
| Burden | • Approximately 3% of all HAI are caused by VRE<br>• Approximately 10-20% of enterococci causing HAI are VRE |
| Risk factors | • Risk factors in hospital setting<br>✓ Frequent/prolonged hospitalization<br>✓ People with indwelling central line, urinary catheters, implants, prostheses, and drains<br>✓ Immunocompromised patients (cancer, transplant recipients, neutropenia, or renal dysfunction)<br>✓ Diabetes mellitus<br>✓ Patients undergoing surgical procedures<br>✓ Patients who have been previously treated with antibiotics, including vancomycin, for long periods of time |
| Hospital outbreak | • Common cause of hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a VRE infection depend on the part of the body that is infected. For example, bloodstream infection is manifested as fever, shivering, and low blood pressure.<br>• It can cause severe infections including<br>✓ Bloodstream infections<br>✓ Urinary tract infection<br>✓ Surgical site infections<br>✓ Dialysis bacteremia |
| Diagnosis | • Positive culture for VRE. Normally, a bacterium must be cultured from infected wound, blood, urine, or stool |

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| Mode of Transmission | • Indirect contact with contaminated surfaces and objects. Items such as bedrails, stethoscopes, blood pressure cuffs are reservoirs for VRE<br>• Direct contact with contaminated hands (usually HCWs) or infected patients<br>• Direct contact with colonized patients<br>• It is not spread through the air by coughing or sneezing |
| Screening | • Screening for VRE:<br>✓ Patients who were previously VRE positive within the past 6-12 months.<br>✓ Roommates exposed to VRE-positive patients.<br>• Screening of HCWs is not recommended, unless they are epidemiologically linked to new acquisitions of VRE<br>• Sites to screen:<br>✓ Rectal swab or<br>✓ Perianal swab |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene. Patients and their caregivers should wash their hands with soap and water or use alcohol-based hand sanitizer, particularly:<br>✓ After using the bathroom<br>✓ Before and after handling medical devices or caring for wounds<br>✓ Before preparing food<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment.<br>• Use dedicated patient-care equipment (e.g. blood pressure cuffs, stethoscopes), and single use disposable items (e.g. single patient digital thermometer) whenever possible<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging.<br>• Provide education on management of VRE patients to HCWs. |

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| | **Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing CLABSI<br>• Implement strategies for preventing CAUTI<br>• Implement strategies for preventing SSI<br>• Implement strategies for preventing bacteremia in dialysis patients |
| Decolonization | • None |
| Discontinue Contact isolation | • Discontinue contact isolation after three consecutive negative cultures (taken 3 days apart) from a previously positive patient (in the absence of antibiotic therapy for at least three days)<br>• Consult IC / RHD outbreak coordinators and treating physician |

| CRE | |
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| Pathogen | • Carbapenem-resistant Enterobacteriaceae (CRE): Any Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, or Enterobacter spp. testing resistant to imipenem, meropenem, doripenem, or ertapenem by standard susceptibility testing methods OR by production of a carbapenemase demonstrated using a recognized test (e.g., PCR or modified-Hodge test)<br>• Enterobacteriaceae are a large family of Gram-negative bacteria that includes a number of pathogens such as Klebsiella, Escherichia coli, Enterobacter, Citrobacter, Salmonella, Shigella, Proteus, Serratia and other species.<br>• These pathogens are present in the human intestinal tract and are a normal part of the gut flora. |
| Burden | • CRE is endemic in many parts of the world<br>• Approximately 5% of Enterobacteriaceae causing HAI are CRE<br>• Approximately 30% of CRE produce carbapenemases, enzymes that break down carbapenems<br>• Why are CRE considered epidemiologically important?<br>✓ CRE organisms are often resistant to multiple classes of antibiotics, substantially limiting treatment options.<br>✓ Infections caused by these organisms are associated with high mortality rates among hospitalized patients, up to 50% in some studies.<br>✓ Many CRE produce carbapenemases, which can be transmitted from Enterobacterales to other germs, facilitating spread of resistance.<br>✓ Although CRE is currently primarily associated with inpatient healthcare settings, it has the potential to spread to community settings. |
| Risk factors | • Risk factors in hospital setting<br>✓ Frequent/prolonged hospitalization<br>✓ People with indwelling central line, urinary catheters, and |

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| | ventilator<br>✓ Patients who have been previously treated with antibiotics, including carbapenems, cephalosporins, fluoroquinolones, and vancomycin, for long periods of time<br>✓ Immunocompromised patients (cancer, transplant recipients, neutropenia, or renal dysfunction)<br>✓ Advanced age |
| Hospital outbreak | • Common cause of hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a CRE infection depend on the part of the body that is infected.<br>• CRE can cause infections in almost any body part, including<br>✓ Urinary tract infection<br>✓ Bloodstream infections<br>✓ Ventilator-associated pneumonia<br>✓ Intra-abdominal abscesses<br>✓ Surgical site infections<br>✓ Dialysis bacteremia |
| Diagnosis | • Positive culture for CRE.<br>✓ Phenotypic diagnosis requires bacterial culture and identification.<br>✓ Disk diffusion or automated susceptibility testing is done to identify the carbapenem resistance phenotype.<br>• Molecular identification is much faster (hours instead of days) and can quickly determine the type of resistance mechanism involved. The five carbapenemases most frequently identified in CRE: KPC, NDM, VIM, OXA-48-type, and IMP. However, this method simply indicates the presence of a resistance gene and may not determine the efficacy of specific antibiotics. |
| Mode of Transmission | • Indirect contact with contaminated surfaces and objects. Sink drains and toilets are increasingly recognized as an environmental reservoir and CRE transmission source.<br>• Direct contact with contaminated hands (usually HCWs) or infected |

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| | patients |
| Screening | • Screening certain high-risk patients for CRE colonization is a recommended intervention. However, screening are generally reserved for carbapenemase producing-CRE, which have greater potential for spread.<br>✓ Roommates exposed to CRE-positive patients<br>✓ Active surveillance culture before admission in specific units<br>• Screening of HCWs is not recommended, unless they are epidemiologically linked to new acquisitions of CRE<br>• Specimens:<br>✓ Stool sample or<br>✓ Rectal swab<br>AND, if indicated<br>✓ Urine (in the presence of a urinary catheter)<br>✓ Stoma swab (patient with colostomy or ileostomy)<br>✓ Wounds<br>✓ Catheter exit sites |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene. Patients and their caregivers should wash their hands with soap and water or use alcohol-based hand sanitizer, particularly:<br>✓ After using the bathroom<br>✓ Before and after handling medical devices or caring for wounds<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment.<br>• Whenever possible, place patients currently or previously colonized or infected with CRE in a private room with a bathroom and dedicate noncritical equipment (e.g., stethoscope, blood pressure cuff) to CRE patients.<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and |

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| | flagging<br>• Provide education on management of CRE patients to HCWs.<br>✓ Prescribe and use antibiotics appropriately.<br>✓ Discontinue devices like urinary catheters as soon as no longer necessary.<br>**Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing CAUTI<br>• Implement strategies for preventing CLABSI<br>• Implement strategies for preventing VAP<br>• Implement strategies for preventing bacteremia in dialysis patients<br>• Implement strategies for preventing SSI |
| Decolonization | • None |
| Discontinue contact isolation | • Contact isolation should continue for duration of acute care hospitalization<br>• Only discontinue after consultation with IPC<br>• Consult IC / RHD outbreak coordinators and treating physician |

| ESBL | |
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| Pathogen | • ESBLs are enzymes that confer resistance to most beta-lactam antibiotics, including penicillins, cephalosporins, and the monobactam aztreonam<br>• They are present in Enterobacteriaceae (such as Escherichia coli and Klebsiella) and other gram negatives (such as Pseudomonas aeruginosa) |
| Burden | • Approximately 15-30% of Enterobacteriaceae causing HAI are ESBL |
| Risk factors | • Anyone can get an ESBL producing bacteria.<br>• Risk factors in hospital setting<br>✓ Patients who have been previously treated with broad spectrum antibiotics, particularly third-generation cephalosporins, fluoroquinolones, vancomycin, and quinolones<br>✓ Frequent/prolonged hospitalization<br>✓ ICU admission<br>✓ People with indwelling central line, urinary catheters, and ventilator<br>✓ Open wound or drain<br>✓ Multiple comorbidity<br>✓ Advanced age<br>• Risk factors in community setting<br>✓ History of repeated UTIs<br>✓ Prior antibiotic exposure |
| Hospital outbreak | • Can cause hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a ESBL infection depend on the part of the body that is infected.<br>• ESBL can cause infections, including<br>✓ Urinary tract infection (most common)<br>✓ Abdominal infection and diarrhea<br>✓ Wound infection<br>✓ Bloodstream infections<br>✓ Ventilator-associated pneumonia |

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| Diagnosis | • Positive culture<br>✓ Phenotypic diagnosis requires bacterial culture and identification.<br>✓ Disk diffusion or automated susceptibility testing is done to identify resistance or decreased sensitivity to ceftazidime, cefotaxime, ceftriaxone and aztreonam<br>• A second confirmatory test, based on the synergy between a cephalosporin (cefotaxime or ceftazidime) and a ß-lactamase inhibitor (clavulanic acid), should then be carried out. This test could be a double disk test, combination disk method or ESBL Etest |
| Mode of Transmission | • Indirect contact with contaminated surfaces and objects.<br>• Direct contact with contaminated hands (usually HCWs) or infected patients |
| Screening | • Screening certain high-risk patients for ESBL<br>✓ Roommates exposed to ESBL-positive patients<br>✓ Active surveillance culture for specific at-risk units such as intensive care, burn, oncology-hematology, hemodialysis and organ transplant units<br>• Screening of HCWs is not recommended, unless they are epidemiologically linked to new acquisitions of ESBL<br>• Specimens:<br>✓ Stool sample or<br>✓ Rectal swab<br>AND, if indicated<br>✓ Urine (in the presence of a urinary catheter) |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene. Patients and their caregivers should wash their hands with soap and water or use alcohol-based hand sanitizer, particularly:<br>✓ After using the bathroom<br>✓ Before and after handling medical devices or caring for wounds<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's |

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| | environment.<br>• Whenever possible, place patients currently or previously colonized or infected with ESBL in a private room with a bathroom and dedicate noncritical equipment (e.g., stethoscope, blood pressure cuff) to ESBL patients.<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging<br>• Provide education on management of ESBL patients to HCWs.<br>✓ Prescribe and use antibiotics appropriately.<br>✓ Discontinue devices like urinary catheters as soon as no longer necessary.<br>**Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing CAUTI<br>• Implement strategies for preventing SSI<br>• Implement strategies for preventing CLABSI<br>• Implement strategies for preventing VAP |
| Decolonization | • None |
| Discontinue contact isolation | • Contact isolation should continue for duration of acute care hospitalization<br>• Only discontinue after consultation with IPC<br>• Consult IC / RHD outbreak coordinators and treating physician |

| MDR Pseudomonas aeruginosa | |
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| Pathogen | • Pseudomonas aeruginosa is a leading nosocomial pathogen<br>• Pseudomonas aeruginosa lives in the environment and can be spread to people in healthcare settings when they are exposed to contaminated water or soil<br>• MDR pseudomonas: non-susceptible (resistant or intermediate) to at least one agent in at least 3 out of 5 antimicrobial classes (penicillins, aminoglycosides, cephalosporins, fluoroquinolones, and carbapenems) |
| Burden | • Approximately 5-20% of Pseudomonas aeruginosa causing HAI are meeting the definition of MDRO |
| Risk factors | • Risk factors in hospital setting<br>✓ Frequent/prolonged hospitalization<br>✓ ICU admission<br>✓ People with indwelling device such as ventilator, central line, and urinary catheters<br>✓ Open wound or drain<br>✓ Immunocompromised patients<br>✓ Multiple comorbidity<br>✓ Previous use of broad-spectrum antimicrobials (both antipseudomonal and non-antipseudomonal) |
| Hospital outbreak | • Can cause hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a MDR pseudomonas infection depend on the part of the body that is infected.<br>• MDR pseudomonas can cause infections, including<br>✓ Ventilator-associated pneumonia<br>✓ Bloodstream infections<br>✓ Surgical site infection<br>✓ Urinary tract infection<br>✓ Abdominal infection |
| Diagnosis | • Positive culture. |

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| | ✓ Phenotypic diagnosis requires bacterial culture and identification.<br>✓ Disk diffusion or automated susceptibility testing is done to identify resistance phenotype of MDR pseudomonas. |
| Mode of Transmission | • Indirect contact with contaminated surfaces and objects.<br>• Direct contact with contaminated hands (usually HCWs) or infected patients<br>• Can cause waterborne outbreaks due to exposure to contaminated water |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene, particularly before and after caring for wounds or touching a medical device<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment.<br>• Whenever possible, place patients currently or previously colonized or infected with MDR pseudomonas in a private room with a bathroom and dedicate noncritical equipment (e.g., stethoscope, blood pressure cuff) to MDR pseudomonas patients.<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging<br>• Provide education on management to HCWs.<br>**Precautions to prevent waterborne transmission**<br>• Water disinfection<br>• Periodic cleaning and maintenance of showers, baths and sinks<br>• Installing disinfection systems and filters<br>• Avoiding the installation of other potential sources of infection such as decorative pools and fountains.<br>**Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing VAP |

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| | • Implement strategies for preventing CLABSI<br>• Implement strategies for preventing CAUTI<br>• Implement strategies for preventing SSI |
| Discontinue Contact isolation | • The patient has two consecutive negative rectal swab at least 7 days apart<br>• Consult IC / RHD outbreak coordinators and treating physician |

| MDR Acinetobacter | |
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| Pathogen | • Acinetobacter baumannii is a leading nosocomial pathogen<br>• Acinetobacter lives in the environment and can be spread to people in healthcare settings when they are exposed to contaminated water or soil<br>• MDR Acinetobacter: non-susceptible (resistant or intermediate) to at least one agent in at least 3 out of 6 antimicrobial classes (penicillins, aminoglycosides, cephalosporins, fluoroquinolones, carbapenems, and sulbactam) |
| Burden | • Approximately 40-65% of Acinetobacter causing HAI are meeting the definition of MDRO |
| Risk factors | • Risk factors in hospital setting<br>✓ Frequent/prolonged hospitalization<br>✓ ICU admission<br>✓ People with indwelling device such as ventilator, central line, and urinary catheters<br>✓ Open wound or drain<br>✓ Immunocompromised patients<br>✓ Multiple comorbidity<br>✓ Previous use of broad-spectrum antimicrobials such as carbapenems and piperacillin/tazobactam |
| Hospital outbreak | • Can cause hospital outbreaks |
| Symptoms & clinical picture | • The symptoms of a MDR Acinetobacter infection depend on the part of the body that is infected.<br>• MDR Acinetobacter can cause infections, including<br>✓ Ventilator-associated pneumonia<br>✓ Bloodstream infections<br>✓ Surgical site infection<br>✓ Urinary tract infection |
| Diagnosis | • Positive culture.<br>✓ Phenotypic diagnosis requires bacterial culture and identification. |

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| | ✓ Disk diffusion or automated susceptibility testing is done to identify resistance phenotype of MDR Acinetobacter. |
| Mode of Transmission | • Indirect contact with contaminated surfaces and objects.<br>• Direct contact with contaminated hands (usually HCWs) or infected patients |
| Prevention and control | **Implement core prevention strategies**<br>• Promote hand hygiene, particularly before and after caring for wounds or touching a medical device<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment.<br>• Whenever possible, place patients currently or previously colonized or infected with MDR Acinetobacter in a private room with a bathroom and dedicate noncritical equipment (e.g., stethoscope, blood pressure cuff) to MDR Acinetobacter patients.<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging<br>• Provide education on management to HCWs.<br>**Implement interventions to reduce device-associated and procedure-associated HAIs**<br>• Implement strategies for preventing VAP<br>• Implement strategies for preventing CLABSI<br>• Implement strategies for preventing CAUTI<br>• Implement strategies for preventing SSI |
| Discontinue Contact isolation | • The patient has two consecutive negative rectal swab at least 7 days apart<br>• Consult IC / RHD outbreak coordinators and treating physician |

| Clostridium difficile | |
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| Pathogen | • Anaerobic, spore-forming Gram-positive bacilli<br>• Present in soil and environment<br>• Hospitals are major reservoirs<br>✓ Hospital toilets<br>✓ Metal bedpans<br>✓ Commodes<br>✓ Thermometers<br>✓ Floors<br>• Spores can persist in rooms up to 40 days after infected patient is discharged; usually < 10 colonies<br>• Resistant to many commonly used cleaning agents.<br>• Detergent-based agents do not eliminate C. difficile spores |
| Burden | • Normal flora in ~2-3% of healthy adults<br>• The overall rate is 2-3 per 1000 admissions/year<br>• Recurrence occurs in 15-20% of patients after discontinuation of treatment. |
| Risk factors | • Risk factors in hospital setting<br>✓ Older age<br>✓ Prolonged or multiple antimicrobial therapy<br>✓ Use of acid-reducing drugs (proton-pump inhibitors or H2 blockers)<br>✓ Infected roommate<br>✓ Recent or prolonged hospitalization<br>✓ ICU stay<br>✓ Multiple, severe underlying conditions<br>✓ Immunocompromised patients<br>✓ Surgery of the gastrointestinal (GI) tract<br>✓ Colon disease e.g. inflammatory bowel disease or colorectal cancer<br>✓ Tubal feeding<br>✓ Previous C. diff infection<br>• High risk antimicrobials<br>✓ 2nd generation cephalosporins |

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| | ✓ 3rd generation cephalosporins<br>✓ Clindamycin<br>✓ Fluoroquinolones<br>✓ Low risk<br>• Low risk antimicrobials<br>✓ Aminoglycosides<br>✓ Beta-lactam/beta-lactamase inhibitors |
| Hospital outbreak | • Can cause hospital outbreak |
| Symptoms & clinical picture | • A spectrum of C. difficile infections (CDI), including<br>✓ Asymptomatic colonization<br>✓ Diarrhea (mild to severe) and abdominal pain<br>✓ Fever, loss of appetite, and nausea<br>✓ Colitis +/- pseudomembranes<br>✓ Toxic megacolon<br>✓ Colonic perforation/peritonitis<br>✓ Sepsis & acute abdomen without diarrhea |
| Diagnosis | • A positive laboratory test result for C. difficile toxin A and/or B, (includes molecular assays [PCR] and/or toxin assays) tested on an unformed stool specimen (must conform to the container) OR<br>• A toxin-producing C. difficile organism detected by culture or other methods performed on an unformed stool sample (must conform to the container) |
| Categorization | **CDI event categorization by prior positivity:**<br>• Incident CDI: Positive specimen obtained >8 weeks from most recent (previous) positive stool sample or first time<br>• Recurrent CDI: Positive specimen obtained > 2 weeks but ≤8 weeks from most recent (previous) positive stool sample<br>• Duplicate CDI: Positive specimen obtained ≤2 weeks from most recent (previous) positive stool sample (do not report)<br>**CDI event categorization by source:** |

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| | • Community-onset: Specimen collection (event) date is in the first 3 days of admission<br>• Healthcare-onset: Specimen collection (event) date is after the first 3 days of admission<br>• Community-onset healthcare -associated: Specimen collection (event) date is in the first 3 days of admission BUT within 4 weeks from last discharge |
| Mode of Transmission | • Indirect contact with contaminated surfaces and objects. C. diff is shed in feces. Any surface, device, or material (such as commodes, bathtubs, and electronic rectal thermometers) that becomes contaminated with feces could serve as a reservoir for the C. diff spores.<br>• C. diff spores can also be transferred to patients via the hands of HCWs who have touched a contaminated surface or item. |
| Prevention and control | • Promote hand hygiene, particularly After using the bathroom, before preparing food or eating, and after diapering a child or caring for an ill person.<br>• Implement contact precautions. Wear a gown and gloves for all interactions that may involve contact with the patient or the patient's environment<br>• Ensure adequate cleaning and disinfection of surfaces such as countertops, sinks, faucets, bathroom doorknobs, and toilets regularly using warm/hot water (see below)<br>• Whenever possible, place patients currently or previously colonized or infected with C. diff in a private room with a bathroom and dedicate noncritical equipment (e.g., stethoscope, blood pressure cuff) to C. diff patients.<br>• If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient<br>• Recognize previously colonized patients through screening and flagging<br>• Provide education on management to HCWs. |

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| | • C diff spores are resistant to extreme environmental conditions<br>• Elimination needs physical cleaning and disinfection<br>• Disinfectant of choice for environmental cleaning is household bleach (5% sodium hypochlorite solution) in 1:5 dilution (250/L) or 10,000 ppm (1%)<br>• Some disinfectants (e.g., glutaraldehyde) normally used to reprocess gastrointestinal endoscopes need prolonged contact times to kill clostridium difficile spores |
| Discontinue contact isolation | • When the patient returns to his/her normal stooling pattern for minimum of 48 hours<br>• Because C diff patients continue to shed the organism for a number of days following cessation of diarrhea, some institutions routinely continue isolation until discharge<br>• Consult IC / RHD outbreak coordinators and treating physician |

# Epidemiology of specific bacterial outbreaks in hospitals

- Mycobacterium Tuberculosis
- Legionella Pneumophila
- Burkholderia Cepacia
- Salmonella Species
- Shigella Species
- S. Pyogenes (Group A Streptococcus)

| Tuberculosis (TB) | |
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| Pathogen | • Mycobacterium Tuberculosis |
| Epidemiology | • Globally, tuberculosis is a leading cause of death from a single infectious agent, with 1.4 million deaths every year<br>• Tuberculosis affects approximately 10 million new patients every year<br>• Globally, tuberculosis incidence is falling at about 2% per year<br>• High-risk population groups, including household contacts of tuberculosis affected individuals, persons living with human immunodeficiency virus (HIV), persons with medical conditions that weaken the immune system, and HCWs<br>• HCWs are at increased risk of hospital-acquired tuberculosis infection due to persistent exposure to Mycobacterium tuberculosis in healthcare settings.<br>• Multidrug-resistant tuberculosis (MDR-TB) remains a public health crisis and a health security threat |
| Hospital outbreak | • Tuberculosis is a common cause of hospital outbreaks among HCWs and patients across the world |
| Symptoms & clinical picture | • Pulmonary tuberculosis: Continuous cough (lasting for 3 weeks or more), hemoptysis, chest pain during breathing or coughing, anorexia, fatigue, fever, night sweats and chills.<br>• Extra pulmonary tuberculosis: site swelling, abscess, hematuria. |
| Diagnosis | • Positive culture for M. tuberculosis complex<br>• Positive microscopic examination for acid-fast bacilli when a culture has not been or cannot be obtained<br>• Demonstration of M. tuberculosis complex nucleic acid directly from specimens<br>• Histology strongly suggestive of tuberculosis when there is a strong clinical probability. |
| Mode of Transmission | • Transmission is by inhalation of airborne droplets produced by people with pulmonary or laryngeal tuberculosis, especially during coughing or sneezing. |

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| | • People with extrapulmonary tuberculosis alone cannot transmit the infection to others.<br>• People with latent tuberculosis infection are not infectious.<br>• Bovine tuberculosis may also be transmitted from infected cattle to humans by ingestion of contaminated unpasteurized milk or milk products or by airborne droplet spread to people who work closely with cattle. |
| Incubation Period | • The period from infection to demonstrable primary lesion or significant tuberculin (Mantoux) reaction is between 2 and 10 weeks |
| Period of Infectivity | • Untreated adults and adolescents with pulmonary TB may be intermittently infectious for years.<br>• Children under the age of 12 years are rarely infectious.<br>• Once a person with pulmonary TB has been commenced on effective treatment, the risk of transmission declines over 2–4 weeks to negligible levels in most cases |
| Prevention and control | • The WHO multimodal IPC strategy consists of a combination of interventions designed to minimize and prevent the risk of tuberculosis transmission in healthcare settings.<br>1. Administrative controls<br>o Triage and isolation of people (with presumed or confirmed tuberculosis infection). Isolation and airborne precautions are indicated for cases with active pulmonary or laryngeal tuberculosis<br>o Prompt initiation of effective treatment<br>o Respiratory hygiene (practice of covering of the mouth and nose during coughing and sneezing)<br>o Management of HCWs (including education and training)<br>2. Environmental controls<br>o Ventilation systems; natural, mechanical, mixed-mode, and recirculated air through HEPA filters<br>o Germicidal ultraviolet systems<br>3. Personal respiratory protection<br>o Particulate respirators (N95 or FFP2) |

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| | ○ Respirator fit testing |
| Vaccines | • The BCG is a live attenuated Mycobacterium bovis vaccine that protects against tuberculosis<br>• The overall protective efficacy of 50% with 56% protection against TB meningitis.<br>• It is given as part of childhood immunization and high risk HCWs<br>• However, BCG is not generally recommended for use in many low risk countries such as USA and UK |

| Legionella | |
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| Pathogen | • Legionella Pneumophila is a Gram-negative bacterium<br>• Legionella lives and grows in water systems at temperatures of 20 to 50 degrees Celsius (optimal 35 degrees Celsius).<br>• Legionella can survive and grow as parasites within free-living protozoa and within biofilms which develop in water systems. |
| Epidemiology | • Legionnaires' disease is a severe type of pneumonia.<br>• It is typically acquired by inhalation of contaminated water containing the Legionella pneumophila<br>• Hospital-acquired Legionnaires' disease usually originates in hospital water systems<br>• The overall death rate is usually within the range of 5–10%.<br>• The death rate may be as high as 40–80% in untreated immuno-suppressed patients |
| Hospital outbreak | • Legionella one of the most common cause of waterborne outbreaks in hospitals |
| Symptoms & clinical picture | • The severe pneumonia occurs most frequently in susceptible patients<br>  ○ People 50 years or older<br>  ○ Current or former smokers<br>  ○ People with a chronic lung disease<br>  ○ People with weak immune systems, cancer, and organ failure<br>• **Pneumonic form,**<br>  ○ Incubation period of 2 to 16 days<br>  ○ Initially, symptoms are fever, loss of appetite, headache, malaise and lethargy.<br>  ○ Later symptoms are cough and may be hemoptysis<br>  ○ The severity of disease ranges from a mild cough to a rapidly fatal pneumonia.<br>  ○ Death occurs through progressive pneumonia with respiratory failure and/or shock and multi-organ failure.<br>• **Non-pneumonic form (Pontiac disease)** |

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| | ○ It is an acute, self-limiting influenza-like illness usually lasting 2–5 days.<br>○ The incubation period is from a few and up to 48 hours.<br>○ The main symptoms are fever, chills, headache, malaise and muscle pain (myalgia).<br>○ No deaths are associated with this type of infection. |
| Diagnosis | • PCR testing<br>• Positive Legionella culture<br>• Legionella urinary antigen test |
| Mode of Transmission | • Inhalation of contaminated water aerosols from shower heads, some medical equipment (i.e., respiratory devices), air conditioning cooling towers, hot tubs, hot water tanks and heaters, complex plumbing systems, hydrotherapy equipment's and/or decorative water fountains<br>• Less commonly, people can get sick by aspiration of drinking water containing Legionella.<br>• Rarely person to person transmission |
| Incubation Period | • The average is 5 to 6 days from the time of exposure to symptom onset, (range 2 to 16 days) |
| Period of Infectivity | • As long as the contamination source is available |
| Prevention and control | • Minimizing Legionella growth in complex hospital water systems and devices is key to preventing infection.<br>• Water disinfection is generally insufficient to control the risk of infection, as the biofilm contamination can be extensive and very difficult to remove.<br>• Education of all direct care providers and family members to minimize patient exposure to tap water<br>• Provision of sterile water to immunocompromised patients<br>• Organizing a program of periodic cleaning and maintenance of showers, baths and sinks<br>• Installing disinfection systems and/or point-of-use filters on taps and shower heads in those settings |

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| | • Shock treatment: heating, flushing, and shock chlorination<br>• Avoiding the installation of other potential sources of infection such as decorative pools and fountains. |
| Vaccines | • None |

| Burkholderia | |
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| Pathogen | • Burkholderia cepacia is Gram-negative bacteria found in soil and water |
| Epidemiology | • Burkholderia has been linked to multiple healthcare-associated outbreaks.<br>• Medical products, antiseptics, and disinfectants are the most frequent source.<br>• In outbreak investigations, HCWs should look for contaminated object to withdraw. This would be the critical point to immediately stop new cases due to contamination. |
| Hospital outbreak | • Multiple outbreaks have been reported in relation to use of contaminated medical products, antiseptics, and disinfectants, mainly in immunocompromised patients |
| Symptoms & clinical picture | • The signs and symptoms will depend on the cause<br>• It can produce severe lung infections in young people with cystic fibrosis, often late in the course of the disease.<br>• If contaminated saline is administered to flush into a vein through an IV, bloodstream infections can happen:<br>o Fever<br>o Chills or shivering<br>o Clammy or sweaty skin<br>o Confusion or disorientation<br>o Shortness of breath<br>o Increased heart rate<br>• If contaminated chlorhexidine is administered for oral care of ventilated patients, ventilator associated pneumonia can happens:<br>o Fever<br>o Purulent tracheobronchial secretions<br>o New or progressive infiltrate on chest radiograph,<br>o leukocytosis |
| Diagnosis | • Culture of clinical and environmental specimens<br>• PCR testing |

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| Mode of Transmission | • Use of contaminated medical products, antiseptics, and disinfectants.<br>• Person-to-person through droplet and direct/indirect contact |
| Incubation Period | • The average is 9 days (range between 1 and 21 days) |
| Period of Infectivity | • Unclear, probably during the period of the disease |
| Prevention and control | • Stop using any remaining contaminated products.<br>• Immediately destroy any unused product from pharmacies, medication carts, medication preparation areas, and patient care areas.<br>• Notify local or state health authorities of any cases and implicated products to stop the spread in other hospitals<br>• Other measures based on disease; droplet precautions for ventilator associated pneumonia and contact precautions and hand hygiene for bloodstream infection |
| Vaccines | • None |

# Epidemiology of specific viral outbreaks in hospitals

- **Respiratory viruses**
  - SARS
  - SARS-CoV- 2 or **(Covid-19)**
  - MERS-CoV
  - Influenza Viruses A and B
  - Varicella Zoster
  - Measles
  - Respiratory Syncytial Virus
- **Blood-borne**
  - Hepatitis B Virus
  - Hepatitis C Virus
  - Human Immunodeficiency Virus
- **Contact viruses**
  - Varicella Zoster virus
  - Herpes Simplex virus
  - Cytomegalovirus
  - Epstein Barr virus
- **GIT viruses**
  - Rotavirus
  - Hepatitis A Virus

| SARS | |
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| Pathogen | • Coronavirus causing severe acute respiratory syndrome (SARS) |
| Epidemiology | • SARS was first reported in Asia in February 2003. The illness spread to more than two dozen countries in North America, South America, Europe, and Asia before the SARS global outbreak of 2003 was contained.<br>• According to the WHO, a total of 8098 people worldwide became sick with SARS during the 2003 outbreak. Of these, 774 died.<br>• Currently, there is no known SARS transmission anywhere in the world |
| Hospital outbreak | • Multiple hospital outbreaks have been reported in China and other countries among HCWs, their family and friends, hospital visitors, and in inpatients |
| Symptoms & clinical picture | • Relatively insidious onset with fever, myalgia, malaise and headache, followed a few days to 1 week later by dry cough and dyspnea.<br>• About 10-20% of cases have diarrhea.<br>• Symptoms of upper respiratory tract infection (rhinorrhea and sore throat) are uncommon.<br>• About 10-20% of cases develop severe pulmonary disease that may lead to death from respiratory failure. |
| Diagnosis | • Symptoms & clinical picture, especially with epidemiologic link<br>• Chest X-rays typically show scattered peripheral and lower zone opacification.<br>• Laboratory confirmation requires at least one of the following<br>  ○ Detection of diagnostic levels of serum antibody to SARS-CoV<br>  ○ Isolation (for example, in cell culture) of SARS-CoV<br>  ○ Detection of SARS-CoV nucleic acid |
| Mode of Transmission | • Person to person, by droplet transmission, direct contact with respiratory tract secretions and possibly fomites.<br>• Airborne transmission of SARS can occur during aerosol generating procedures, such as intubation or nebulization |

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| Incubation Period | • The average is 2-7 days but may be as long as 10 days |
| Period of Infectivity | • From onset of symptoms until 10 days after resolution of fever |
| Prevention and control | • In hospital, place cases under airborne and contact precautions throughout the period of communicability.<br>• Staff should also wear eye protection and footwear that can be decontaminated or disposed of and use disposable equipment for the case wherever possible.<br>• Clean and disinfect surfaces and articles soiled with respiratory secretions or feces, using a product with antiviral activity.<br>• Prompt detection of cases through good surveillance and contact tracing<br>• Quarantine of suspected contacts for 10 days<br>• Outside hospital, cases should be isolated at home or in some other suitable facility throughout the period of communicability. |
| Vaccines | • None |

| SARS-CoV-2 (COVID-19) | |
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| Pathogen | • The virus is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)<br>• The disease is called coronavirus disease of 2019 (COVID-19) |
| Epidemiology | • At the end of 2019, a novel coronavirus was identified as the cause of a cluster of pneumonia cases in Wuhan<br>• It rapidly spread, resulting in an epidemic throughout China, followed by a global pandemic.<br>• It caused the largest pandemic in human history |
| Hospital outbreak | • Multiple hospital outbreaks across the globe have been reported among patients and HCWs<br>• According to MOH Regulation |
| Symptoms & clinical picture | • Most common symptoms: fever, cough, tiredness, and loss of taste or smell<br>• Less common symptoms: sore throat, headache, aches and pains, diarrhea, a rash on skin, discoloration of fingers or toes, red or irritated eyes<br>• Serious symptoms: difficulty breathing or shortness of breath, loss of speech or mobility, confusion, and chest pain |
| Diagnosis | • **Suspected case:** One of the following<br>o Sudden onset of at least one of the following: fever, cough, or shortness of breath<br>o Patient with sudden onset of at least one of the following: headache, sore throat, rhinorrhea, nausea, diarrhea or loss of smell or taste. In addition (in the 14 days prior to symptom onset), had contact with a confirmed COVID-19 case OR working in or attended a healthcare facility<br>o Any admitted adult patient with unexplained sever acute respiratory infection (SARI), either Community Acquired Pneumonia (CAP) or Hospital Acquired Pneumonia (HAP). |

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| | • **Confirmed Cases**<br>  o A person who meets the suspected case definition with laboratory confirmation of COVID 19 infection (PCR) |
| Mode of Transmission | • Person to person, by droplet transmission, direct contact with with infected people through infected secretions such as saliva and respiratory secretions or their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks or sings<br>• Airborne transmission of SARS-CoV-2 can occur during aerosol generating procedures |
| Incubation Period | • The average is 5-6 days (range 2 to 14 days) |
| Period of Infectivity | • Up to 10 days after symptom onset or 24 hours after resolution of fever<br>• Up to10 days after the first positive test in asymptomatic patients<br>• Up to 20 days after symptom onset in severely ill patients (i.e., those requiring hospitalization, intensive care, or ventilation support) or severely immunocompromised patients |
| Prevention and control | • **Early recognition and source control**<br>  o Encourage HCWs to have a high level of clinical suspicion.<br>  o Activation of respiratory triage<br>  o Post signage reminding symptomatic patients to alert HCWs.<br>  o Promotion of respiratory hygiene is an important preventative measure.<br>  o Suspected COVID-19 patients should be placed in an area separate from other patients, and additional Infection Prevention and Control IPC (droplet and contact) precautions promptly implemented<br>• **Application of Standard Precautions for all patients**<br>  o Universal masking of all HCWs, patients and visitors<br>  o Correct and consistent use of available PPE and appropriate hand hygiene.<br>  o Perform hand hygiene after contact with respiratory secretions. |

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| | ○ Ensure that environmental cleaning and disinfection procedures are followed consistently and correctly.<br>• **Contact and droplet precautions for suspected COVID-19**<br>○ Place patients in adequately ventilated single rooms<br>○ In cases of severe shortage of single rooms, it is possible to cohort suspected COVID-19 patients<br>• **Airborne precautions**<br>○ For aerosol-generating procedures for suspected COVID-19<br>• **Management of exposure**<br>○ Patients sharing the same room (any setting e.g. Ward with shared beds, open ICU, open emergency unit etc.) with a confirmed case of COVID-19 for at least 15 minutes should be monitored and tested<br>• **Precautions during transportation of patients**<br>○ There should be arrangement between the transporting facility and the receiving facility for transportation timing, personal and clinical information.<br>○ The patient should be masked with surgical mask during transportation.<br>○ The patient must be health educated about respiratory etiquette.<br>○ The driver should wear surgical mask during transportation.<br>○ Never transport suspected with confirmed COVID-19 in one vehicle.<br>○ The used vehicle should be disinfected using MOH approved disinfectant (quaternary ammonium chloride wipes or spray / freshly prepared sodium hypochlorite solution 1000 ppm).<br>• **Administrative controls**<br>○ Establishment of sustainable IPC infrastructures and activities.<br>○ Adequate staff training and specifically appropriate human behavior, and patients' care givers education.<br>○ Policies on early recognition of acute respiratory infection potentially due to COVID-19. |

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| | ○ Access to prompt laboratory testing for identification of the etiologic agent.<br>○ Prevention of overcrowding especially in the emergency department.<br>○ Provision of dedicated waiting areas with clear signage of "Respiratory Waiting Area" for symptomatic patients and appropriate placement of hospitalized patients promoting an adequate patient-to-staff ratio.<br>○ Provision and use of regular supplies.<br>○ IPC policies and procedures for all facets of healthcare provisions with emphasis on surveillance of acute respiratory infection potentially due to COVID-19 among HCWs and the importance of seeking medical care.<br>○ Monitoring of HCW compliance with standard precautions, along with mechanisms for improvement as needed.<br>• **Environmental and engineering controls**<br>○ Basic health-care facility infrastructures.<br>○ Ensuring adequate environmental ventilation.<br>○ Adequate environmental cleaning in all areas within the health-care facility.<br>○ Terminal room cleaning at the time of discharge or transfer of patients.<br>○ Physical separation of at least 1.5-2-meter distance should be maintained between each suspect patient and others.<br>• **Precautions during collection and handling of laboratory specimen**<br>○ All samples collected for laboratory investigations should be regarded as potentially infectious.<br>○ HCWs who collect or transport clinical specimens should adhere rigorously to Standard Precautions to minimize the possibility of exposure to pathogens.<br>○ Ensure that HCWs who collect specimens use appropriate PPE (eye protection, surgical mask, long-sleeved gown, gloves). |

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| | ○ The respiratory specimen should be collected under aerosol generating procedure, personnel should wear a particulate certified N95 respirator.<br>○ Ensure that all personnel who transport specimens are trained in safe handling practices and spill decontamination procedures.<br>○ Place specimens for transport in leak-proof specimen bags (secondary container) that have a separate sealable pocket for the specimen (i.e. a plastic biohazard specimen bag), with the patient's name label on the specimen container (primary container), and a clearly written laboratory request form.<br>○ Ensure that health-care facility laboratories adhere to appropriate biosafety practices and transport requirements according to the type of organism being handled.<br>○ Deliver all specimens by hand whenever possible.<br>○ DO NOT use pneumatic-tube systems to transport specimens.<br>○ HESN Printed lab requisitions must be sent with samples and national lab reception report and result values must be updated on HESN on their corresponding<br>• **Environmental cleaning and disinfection after a COVID-19**<br>○ In-patient rooms (housing COVID-19 patients) should be cleaned and disinfected at least daily and at the time of patient transfer or discharge<br>○ More frequent cleaning and disinfection may be indicated for high-touch surfaces and following aerosol producing procedures (e.g. tables, hard-backed chairs, doorknobs, light switches, remotes, handles, desks, toilets, sinks)<br>○ Cleaning staff should wear disposable gloves, surgical mask and isolation gowns for all tasks in the cleaning process, including handling of waste.<br>○ Cleaning and disinfection of the environmental surfaces should be with approved MOH disinfectant e.g. Hydrogen peroxide, quaternary ammonium chloride 4th generation, freshly prepared sodium hypochlorite solution 1000 ppm with consideration to the |

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| | contact time in accordance with manufacturer's instructions for environmental surface disinfection.<br>o After patient transfer, terminal cleaning should be done using manual method and /or ultraviolet germicidal irradiation or hydrogen peroxide dry mist or vapor |
| Discontinuing Isolation | • According to the last update PUBLIC HEALH AUTHORITY "Management of Healthcare Workers Exposed to COVID-19" guide |
| Vaccines | • Messenger RNA (mRNA) vaccine such as Pfizer-BioN Tech and the Moderna vaccines<br>• Vector vaccine such as AstraZeneca and Johnson & Johnson COVID-19 vaccines<br>• Protein subunit vaccine such as Novavax |

| MERS-CoV | |
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| Pathogen | • Middle Eastern Respiratory Corona Virus (MERS CoV) |
| Epidemiology | • It was first isolated in Saudi Arabia in 2012<br>• Currently present more than 27 countries including the KSA, UAE, Qatar, Austria, Bangladesh, Thailand, Indonesia, UK and USA.<br>• Around 2500 cases of MERS-CoV have been reported till now with approximately 80% of reported cases have been linked to exposure in Saudi Arabia<br>• The disease had approximately 35% fatality rate |
| Hospital Outbreak | • According to last update of National guideline of MERS CoV ( MERS-CoV Outbreak evidence of secondary transmission within a healthcare facilities of one or more secondary cases) |
| Symptoms & clinical picture | • Most people with this illness present with: Fever greater than 38 C, cough, shortness of breath and breathing difficulties, body aches, runny nose, sore throat.<br>• More severe disease in people with weakened immune systems, older people, and those with such chronic diseases as diabetes, cancer and chronic lung disease<br>• Suspect MERS CoV in any of the followings:<br>o Severe pneumonia (severity score ≥3 points) or ARDS (based on clinical or radiological evidence)<br>o Unexplained deterioration of a chronic condition of patients with congestive heart failure or chronic kidney disease on hemodialysis<br>o Acute febrile illness (T ≥380 C) with/without respiratory symptoms<br>o Gastrointestinal symptoms (diarrhea or vomiting), AND leukopenia (WBC≤3.5x109 /L) or thrombocytopenia (platelets < 150x109/L) |
| Diagnosis | • **Suspected case:**<br>o A person with any of the above mentioned signs and symptoms and has been in contact with a confirmed MERS CoV confirmed |

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| | case or is a resident of or has visited any of the MERS CoV endemic countries.<br>• **Confirmed Cases**<br>  ○ A clinically compatible illness that is laboratory confirmed (positive PCR) |
| Mode of Transmission | • Human to human: The virus does not pass easily from person to person unless there is close contact with an ill patient suffering from an acute respiratory illness in the community or healthcare setting in the 14 days before the onset of illness<br>• Non-Human to human: History of contact with camels or camel's products in the 14 days before the onset of illness |
| Incubation Period | • (Range 2 to 14 days) |
| Period of Infectivity | • Unknown but is likely to extend from the onset of fever until 10 days after fever resolves |
| Prevention and control | • Suspected and confirmed cases who are not critically ill should be placed in single rooms under standard, contact and droplet precautions.<br>• Those who are critically ill should be placed in Airborne Infection isolation rooms (negative pressure rooms) or, if unavailable, adequately ventilated single rooms with HEPA filter placed to the side of the bed.<br>• Staff should also wear PPE that includes gowns, surgical mask, eye protection and gloves. Those who are entering an airborne isolation room should wear fit-tested seal-checked N95 mask.<br>• Symptomatic contacts should be managed as suspected cases |
| Vaccines | • None |

| Influenza Viruses A and B | |
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| Pathogen | • Influenza A and subtyping (such as H1N1, H3N2, H7N9)<br>• Influenza B and subtyping (such as B/Washington, B/Phuket, and B-Yamagata) |
| Epidemiology | • Seasonal influenza affects 5–10% of the world's population<br>• It can cause hospital outbreaks and sometimes large pandemics |
| Hospital outbreak | • Influenza outbreaks are frequent, with attack rates from 12% to 60%<br>• The transmission of influenza from HCWs to patients is well described<br>• The diagnosis is commonly missed because of substantial proportions of asymptomatic cases |
| Symptoms & clinical picture | • Symptoms can be mild to severe<br>• The most common symptoms include: a high fever, runny nose, sore throat, muscle pains, headache, coughing, and feeling tired.<br>• These symptoms typically begin two days after exposure to the virus and most last less than a week.<br>• Gastrointestinal symptoms, more common in in children than adults.<br>• Complications: viral pneumonia, secondary bacterial pneumonia, sinus infections, and worsening of previous health problems such as asthma or heart failure |
| Diagnosis | • Symptoms & signs<br>• Confirmation using PCR or other diagnostic tests using nasopharyngeal specimens |
| Mode of Transmission | • Human to human: from person to person by inhalation or ingestion of droplets containing virus from people sneezing or coughing<br>• Non-human to human: from infected animals such as Pork or birds (usually in the community) |
| Incubation Period | • The average is 2 days (range 1 to 7 days) |
| Period of Infectivity | • The infected patient is contagious one day before onset of symptoms to about a week after symptoms<br>• In severely ill patients and in some children, some contagious viruses |

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| | may be shed for a few weeks. |
| Prevention and control | • Vaccination, especially among HCWs<br>• Respiratory hygiene/cough etiquette<br>• Clinical triage and cohorting<br>• Management of patient flow, beds and care organization<br>• Droplet precautions and extra caution when performing aerosol-generating procedures<br>• Proper environmental hygiene<br>• Restrict visitor access and movement within the facility<br>• Training and education (hand hygiene, droplet precautions, etc.)<br>• Surveillance of nosocomial influenza and early warning |
| Vaccines | • It contains 4 strains; two influenza A (H1N1and H3N2) and two influenza B viruses.<br>• It should be given annually to:<br>o HCWs<br>o Age <5 years and >65 years<br>o Pregnancy<br>o Chronic lung disease as asthma and COPD<br>o Other chronic disease as CVD, cancer, neuro,..etc<br>o Residents of nursing homes and other long-term care facilities<br>• Reduce symptoms by 40% and 60%<br>• Reduce ICU admission and death by 30% to 60% |

| Varicella | |
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| Pathogen | • Varicella Zoster Virus, a member of the herpesvirus group |
| Epidemiology | • Chickenpox (varicella) is a highly contagious rash illness with secondary attack rates is approximately 80%<br>• It is transmitted from patients with either varicella or herpes zoster by direct contact or airborne spread<br>• Once chickenpox has resolved, the virus may remain inactive in nerve cells. In about 10–20% of cases, the virus reactivates later in life, producing a disease known as shingles or herpes zoster |
| Hospital outbreak | • Hospital outbreaks are common among HCWs and sometimes in patients<br>• Adult and immunocompromised patients suffering from varicella (chicken pox) are potential source of infection to HCWs. |
| Symptoms & clinical picture | • Chickenpox (varicella)<br>○ The classic symptom of chickenpox is a pruritic rash, which progresses rapidly from macules to papules to vesicular lesions before crusting<br>○ Other typical symptoms that may begin to appear 1-2 days before rash include fever, malaise, loss of appetite and headache.<br>○ Some people who have been vaccinated against chickenpox can still get the disease. However, the symptoms are usually milder.<br>• Shingles<br>○ Painful skin rash with blisters in a localized area that follows a dermatome<br>○ Can disseminate in immunocompromised patients |
| Diagnosis | • Symptoms & signs<br>• Confirmation using PCR to detect VZV in skin lesions or positive IgG ELISA result indicates that a person has antibodies to VZV either from past varicella disease history or vaccination. |
| Mode of Transmission | • Varicella is highly contagious.<br>• The virus can be spread from person to person by direct contact, inhalation of aerosols from vesicular fluid of skin lesions of acute |

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| | varicella or zoster and possibly through infected respiratory secretions that also may be aerosolized |
| Incubation Period | • The average is 14–16 days (range, 10–21 days). |
| Period of Infectivity | • Patient is infectious from 1 to 2 days before the rash appears and until all lesions are crusted over (average range, 4–7 days after rash onset) |
| Prevention and control | • Vaccination of children and high risk groups<br>• Pre-employment screening of HCWs and vaccination if needed<br>• Patients with uncomplicated chickenpox or shingles should, if possible, be nursed at home.<br>• Chickenpox cases should be placed in isolation: Follow standard precautions plus airborne precautions, and contact precautions until lesions are dry and crusted<br>• Contact precautions with shingles and isolation is preferable but most of the time not necessary<br>• Post-exposure screening and vaccination<br>• Sick leave for affected HCWs |
| Vaccines | • Live-attenuated vaccine given in 2 doses children 12 to 18 months of age<br>• Varicella vaccine is 70% to 90% effective for preventing varicella and more than 95% effective for preventing severe varicella<br>• Anyone who is not fully vaccinated, and never had chickenpox, should receive one or two doses of chickenpox vaccine<br>• Not given during pregnancy or immunosuppression<br>• Herpes zoster vaccine contains the same strain used in the varicella vaccine, but 14x more potent<br>• Herpes zoster vaccine gives 50-60% protection for at least 3-4 years<br>• VZIG (varicella immunoglobulin): for immunocompromised or pregnant within 96 hours of exposure |

| Measles | |
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| Pathogen | • Measles morbillivirus |
| Epidemiology | • Measles is a highly contagious serious disease.<br>• Before widespread vaccination, major epidemics occurred approximately every 2–3 years, with 2.6 million deaths each year.<br>• Even though a safe and cost-effective vaccine is available, in 2018, there were more than 140 000 measles deaths globally, mostly among children under the age of five.<br>• Measles vaccination resulted in a 73% drop in measles deaths between 2000 and 2018 worldwide |
| Hospital outbreak | • Hospital outbreaks are common among HCWs and sometimes in patients |
| Symptoms & clinical picture | • Generalized maculopapular rash, starting on the head and neck.<br>• Fever (at least 38ºC if measured) present at the time of rash onset.<br>• Cough, coryza, conjunctivitis or Koplik's spots present at the time of rash onset.<br>• Serious complications are more common in children under the age of 5, and adults over the age of 30.<br>• The most serious complications include blindness, encephalitis (an infection that causes brain swelling), severe diarrhea and related dehydration, ear infections, or severe respiratory infections such as pneumonia. |
| Diagnosis | • Detection of IgM antibody specific to the virus.<br>• IgG seroconversion or a significant rise (four-fold or greater) in antibody level for the virus between paired sera tested in parallel where the convalescent serum was collected 10 to 14 days after the acute serum.<br>• Isolation of measles virus by culture.<br>• Detection of measles virus nucleic acid. |
| Mode of Transmission | • Measles is one of the world's most contagious diseases.<br>• Transmitted by airborne spread and by direct contact<br>• It is spread by coughing and sneezing, close personal contact or direct |

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| | contact with infected nasal or throat secretions.<br>• The virus remains active and contagious in the air or on infected surfaces for up to 2 hours |
| Incubation Period | • The average is 10 days (range, 7-18 days). |
| Period of Infectivity | • For public health purposes, this can usually be considered from 5 days before to 5 days after rash onset, counting the day of rash onset as day 1. |
| Prevention and control | • MMR vaccination of children and high-risk groups<br>• Pre-employment screening of HCWs and vaccination if needed<br>• Patients with uncomplicated measles, if possible, be nursed at home.<br>• Measles cases should be placed in isolation: Follow standard precautions plus airborne and contact precautions<br>• Post-exposure screening and vaccination<br>• Exclude HCWs without evidence of immunity from duty from day 5 after first exposure to day 21 after last exposure, regardless of the post-exposure prophylaxis given. |
| Vaccines | • MMR is live-attenuated vaccine against measles, mumps, and rubella (German measles).<br>• The first dose is generally given to children around 9 months to 15 months of age, with a second dose at 15 months to 6 years of age, with at least 4 weeks between the doses.<br>• After two doses, 97% of people are protected against measles,<br>• The vaccine is also recommended for those who do not have evidence of immunity, those with well-controlled HIV/AIDS, and within 72 hours of exposure to measles<br>• Measles immunoglobulin within 6 days of exposure in health care facility with work restriction |

| Respiratory Syncytial Virus | |
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| Pathogen | • Respiratory Syncytial Virus (RSV) |
| Epidemiology | • RSV infections can be dangerous for certain pediatric patients<br>  ○ Premature infants<br>  ○ Very young infants, especially those 6 months and younger<br>  ○ Children younger than 2 years old with chronic lung disease or congenital heart disease<br>  ○ Children with suppressed immune systems<br>• RSV infections can be dangerous for certain adult patients<br>  ○ Older adults, especially those 65 years and older<br>  ○ Adults with chronic heart or lung disease<br>  ○ Adults with weakened immune systems |
| Hospital outbreak | • Hospital outbreaks have been reported specially in pediatric and neonatal ICUs. Also in adult hematology and bone marrow transplant |
| Symptoms & clinical picture | • Mild symptoms: cold-like symptoms including runny nose, sore throat, cough, and headache<br>• Severe symptoms viral pneumonia, secondary bacterial pneumonia, sinus infections, and worsening of previous health problems such as asthma or heart failure |
| Diagnosis | • Symptoms & signs<br>• Confirmation using PCR or antigen testing |
| Mode of Transmission | • Respiratory (droplet) route: Contact with large droplets that form when a child talks, coughs, or sneezes.<br>• Contact with the respiratory secretions from or contaminated objects. The virus can live on surfaces for many hours and 30 minutes or more on hands. |
| Incubation Period | • The average is 4 to 6 days (range 2 to 8 days) |
| Period of Infectivity | • The patient is infectious for 3 to 8 days after symptoms<br>• In severely ill patients and in some children, some contagious viruses may be shed for a few weeks. |

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| Prevention and control | • Respiratory hygiene/cough etiquette<br>• Hand hygiene<br>• Droplet precautions<br>• Proper environmental cleaning<br>• Restrict visitor access and movement within the facility |
| Vaccines | • Not yet |

| Hepatitis B virus | |
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| Pathogen | • Hepatitis B virus |
| Epidemiology | • Hepatitis B is a viral infection that attacks the liver and can cause both acute and chronic disease.<br>• WHO estimates that 296 million people were living with chronic hepatitis B infection in 2019, with 1.5 million new infections each year?<br>• In 2019, hepatitis B resulted in an estimated 820 000 deaths, mostly from cirrhosis and hepatocellular carcinoma (primary liver cancer). |
| Hospital outbreak | • Hospital outbreaks are still detected in patients in long-term care facilities, dialysis units, dental clinics, and pain management clinic |
| Symptoms & clinical picture | • The onset is usually insidious with anorexia, abdominal discomfort, nausea, vomiting, lethargy and occasional rash and arthralgia.<br>• It often progresses to dark urine and jaundice.<br>• At least 50% of infections asymptomatic<br>• Some cases present with fulminating extensive acute hepatic necrosis<br>• Hepatitis B infection acquired in adulthood leads to chronic hepatitis in less than 5% of cases, whereas infection in infancy and early childhood leads to chronic hepatitis in about 95% of cases. |
| Diagnosis | • At least one of the following:<br>o HBsAg positive.<br>o Change from HBsAg negative to HBsAg positive within a 12-month period<br>o Anti-HB core IgM reactive (unless HBsAg positive more than 6 months ago and the history is readily available in laboratory information systems)<br>o Detection of hepatitis B virus (HBV) DNA. |
| Mode of Transmission | • Many body substances and tissues (such as blood, semen and vaginal fluids) are capable of transmitting hepatitis B, via percutaneous (intravenous, intramuscular, subcutaneous or across broken skin) or permucosal exposure. This includes transmission through sexual contact, body piercing and tattooing. |

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| | • Perinatal mother-to-infant transmission and transmission through occupational exposure to infected blood is possible. |
| Incubation Period | • The average is 60–90 days (range 30 to 180 days) |
| Period of Infectivity | • The case is potentially infective 2–3 weeks before the onset of symptoms, during the clinical disease and usually for 2–3 months after acute infection or as long as HBsAg continues to be present in blood. |
| Prevention and control | • Vaccination of children and high risk groups<br>• Screening of HCWs and vaccination if needed<br>• Ensure that all blood and blood products are screened and not derived from donors at risk of infection<br>• Adopt universal procedures for the prevention of blood-borne virus transmission in hospitals, laboratory, barber shops, acupuncture clinics, tattoo shops.<br>• Clean equipment and surfaces potentially contaminated with blood or body fluids.<br>• Double-gloving during exposure-prone procedure<br>• Disposable syringes and other instruments<br>• Consider referral to needle-stick management.<br>• Promote condom use and safe sex practices |
| Vaccines | • Composition: Recombinant HBsAg<br>• Efficacy: 95% (Range, 80%-100%)<br>• Duration of Immunity: 20 years or more<br>• Schedule: 3 Doses<br>• Booster doses not routinely recommended<br>• Given to infants and high risk groups |

| Hepatitis C virus | |
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| Pathogen | • Hepatitis C virus |
| Epidemiology | • The virus can cause both acute and chronic hepatitis, ranging in severity from a mild illness to a serious, lifelong illness including liver cirrhosis and cancer.<br>• Globally, an estimated 58 million people have chronic hepatitis C virus infection, with about 1.5 million new infections occurring per year.<br>• WHO estimated that in 2019, approximately 290 000 people died from hepatitis C, mostly from cirrhosis and hepatocellular carcinoma (primary liver cancer).<br>• Antiviral medicines can cure more than 95% of persons with hepatitis C infection, but access to diagnosis and treatment is low. |
| Hospital outbreak | • Hospital outbreaks are still detected in patients in long-term care facilities, dialysis units, dental clinics, and pain management clinic |
| Symptoms & clinical picture | • Acute HCV infections are usually asymptomatic and most do not lead to a life-threatening disease.<br>• Around 30% (15–45%) of infected persons spontaneously clear the virus within 6 months of infection without any treatment.<br>• The remaining 70% (55–85%) of persons will develop chronic HCV infection.<br>• Of those with chronic HCV infection, the risk of cirrhosis ranges from 15% to 30% within 20 years. |
| Diagnosis | • HCV infection is diagnosed in 2 steps:<br>o Testing for anti-HCV antibodies with a serological test identifies people who have been infected with the virus.<br>o If the test is positive for anti-HCV antibodies, a nucleic acid test for HCV ribonucleic acid (RNA) is needed to confirm chronic infection |
| Mode of Transmission | • Reuse or inadequate sterilization of medical equipment, especially syringes and needles in healthcare settings<br>• Transfusion of unscreened blood and blood products |

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| | • Injecting drug use through the sharing of injection equipment. |
| Incubation Period | • The average is 40-60 days (range 15 to 180 days) |
| Period of Infectivity | • From 1 week before onset of first symptoms.<br>• Infection usually persists indefinitely without treatment. Infectivity correlates with serum HCV RNA levels |
| Prevention and control | • In almost all cases, there are no restrictions on work, attendance at early childhood services or school or other community activities.<br>• Ensure that all blood and blood products are screened and not derived from donors at risk of infection<br>• Adopt universal procedures for the prevention of blood-borne virus transmission in hospitals, laboratory, barber shops, acupuncture clinics, tattoo shops.<br>• Clean equipment and surfaces potentially contaminated with blood or body fluids.<br>• Double-gloving during exposure-prone procedure<br>• Disposable syringes and other instruments<br>• Consider referral to needle-stick management. |
| Vaccines | • None |

| Hepatitis A Virus | |
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| Pathogen | • Hepatitis A virus |
| Epidemiology | • Hepatitis A is an inflammation of the liver that can cause mild to severe illness.<br>• Almost everyone recovers fully from hepatitis A with a lifelong immunity. However, a very small proportion of people infected with hepatitis A could die from fulminant hepatitis.<br>• The risk of hepatitis A infection is associated with a lack of safe water and poor sanitation and hygiene (such as contaminated and dirty hands). |
| Hospital outbreak | • A hepatitis A outbreak infrequently happened among hospital patients and HCWs, resulting from exposure to a single patient with undiagnosed HAV infection. |
| Symptoms & clinical picture | • Following a prodrome of fever, malaise, anorexia, nausea or abdominal discomfort, there is jaundice, elevated serum aminotransferase levels and sometimes an enlarged tender liver.<br>• Cases are often asymptomatic<br>• Unlike hepatitis B and C, hepatitis A does not cause chronic liver disease but it can cause debilitating symptoms and rarely fulminant hepatitis (in 0.5% of cases), which is often fatal. |
| Diagnosis | • Positive hepatitis A-specific IgM in serum (in the absence of recent vaccination). |
| Mode of Transmission | • Ingestion of contaminated food and water or through direct contact with an infectious person.<br>• Foodborne outbreaks have been linked to an infected food handler, raw or undercooked shellfish harvested from contaminated water, and contaminated produce such as lettuce or berries. |
| Incubation Period | • The average is 28 days (range 15–50 days) |
| Period of Infectivity | • Maximum infectivity is during the 1–2 weeks before and the first few days after the onset of jaundice.<br>• Prolonged viral excretion (up to 6 months) has been documented in |

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| | infants and children. |
| Prevention and control | • Vaccination of children and high risk groups<br>• Patients should stay away from work or school for at least 1 week from onset of jaundice or symptoms<br>• The likelihood of nosocomial transmission can be reduced with proper hand hygiene, standard precautions, and routine disinfection.<br>• In case of food hander, educate about hand hygiene and advise not to prepare or handle food for others until no longer considered infectious<br>• The spread of hepatitis A in the community can be reduced by:<br>o Adequate supplies of safe drinking water<br>o Proper disposal of sewage within communities<br>o Personal hygiene practices such as regular handwashing before meals and after going to the bathroom |
| Vaccines | • It is given as two shots, 6 months apart, and both shots are needed for long-term protection against hepatitis A.<br>• The following people should be vaccinated against hepatitis A:<br>o All children aged 12–23 months<br>o All children and adolescents 2–18 years of age who have not previously received hepatitis A vaccine (catch up vaccination)<br>o People at increased risk for hepatitis A<br>✓ International travelers<br>✓ Those who use illegal drugs<br>✓ People with occupational risk for exposure<br>✓ People experiencing homelessness |

| Rotavirus | |
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| Pathogen | • Rota virus |
| Epidemiology | • Rotavirus constitutes the principal causal agent of intra-hospital diarrhea in children<br>• Incidence of intra-hospital gastroenteritis is 2 to 7% of hospitalized children primarily between 6 and 23 months old<br>• Responsible for an estimated 20-50% of all hospitalizations for diarrhea among infants and children under 5 years |
| Hospital outbreak | • Hospital outbreak have been reported mainly in pediatric wards<br>• Outbreaks were also seen in adult wards treating immunosuppressed patients (hematology/oncology) |
| Symptoms & clinical picture | • Fever, abdominal pain, and vomiting, followed by watery diarrhea that lasts for 4 to 7 days<br>• Gastroenteritis in immunocompromised and elderly patients and may be outbreaks |
| Diagnosis | • Rapid detection of rotavirus antigen in stool specimens |
| Mode of Transmission | • The transmission is from person to person and indirectly<br>• Rotavirus can be spread by contaminated hands, objects (toys, surfaces), food, or water<br>• The virus survives on the hands of health workers for four hours and in inanimate objects it could survive for several days. |
| Incubation Period | • It is usually short (1 to 2 days) |
| Period of Infectivity | • Infected persons shed large quantities of virus in their stool beginning 2 days before the onset of diarrhea and for up to 10 days after onset of symptoms. |
| Prevention and control | • Vaccination<br>• Hand hygiene and environmental cleaning<br>• Contact precautions<br>• Single room or cohort isolation<br>• In early childhood services or other institutional situations, ensure satisfactory facilities and practices regarding hand cleaning; nappy |

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| | changing; toilet use and toilet training; preparation and handling of food; and cleaning of sleeping areas, toys and other surfaces.<br>• Community: sanitation-based strategies and breastfeeding |
| Vaccines | • Live-attenuated vaccine<br>• Given to children in 2-3 doses<br>• Provide 74% to 87% protection against rotavirus illness of any severity<br>• Provide 85% to 98% protection against severe rotavirus illness<br>• Provide 40-90% reduction of rotavirus hospitalizations and 60-70% reduction of Rota-caused deaths |

# Epidemiology of specific fungal outbreaks in hospitals

- Candida
- Candida Auris
- Aspergillus Species

| Candida Auris | |
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| Pathogen | • Candida Auris |
| Epidemiology | • Candida auris is an emerging fungus that presents a serious global health threat due to several reasons:<br>  ○ It is becoming more common<br>  ○ It is often multidrug-resistant<br>  ○ It is difficult to identify with standard laboratory methods<br>  ○ It has caused outbreaks in healthcare settings<br>• Only three classes of antifungal drugs are available to treat severe Candida infections: azoles, echinocandins, and amphotericin B.<br>• It can cause severe illness among patients with immunocompromising conditions or those receiving high acuity care<br>• These risk factors include<br>  ✓ Device insertion including feeding tube, central line, and ventilator<br>  ✓ Immunosuppression<br>  ✓ Recent surgery<br>  ✓ Diabetes<br>  ✓ Prolonged hospitalization and ICU stay<br>  ✓ Broad-spectrum antibiotic<br>  ✓ Antifungal use. |
| Hospital outbreak | • Hospital outbreak have been reported in admitted patients in different units |
| Symptoms & clinical picture | • Infections have been found in patients of all ages, from preterm infants to the elderly<br>• Candida auris has caused bloodstream infections, wound infections, and ear infections.<br>• It also has been isolated from respiratory and urine specimens, but it is unclear if it causes infections in the lung or bladder.<br>• Suspected case: A person with presumptive laboratory evidence from a clinical specimen with no evidence of epidemiologic linkage |

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| | • Probable case: A person with presumptive laboratory evidence from a clinical specimen and evidence of epidemiologic linkage.<br>✓ Sharing the same healthcare facility<br>✓ Household<br>• Confirmed case: A person with confirmatory laboratory evidence from a clinical specimen |
| Diagnosis | • Confirmatory laboratory evidence:<br>✓ Culture of blood or other body fluids<br>✓ Candida auris PCR<br>• Presumptive laboratory evidence<br>✓ Detection of C. haemulonii from any body site using a yeast identification method that is not able to detect C. auris |
| Mode of Transmission | • Typically, Candida auris spreads in hospitals and other care facilities through contact with contaminated surfaces or equipment.<br>• However, it can also spread from person to person. People with Candida may shed the fungus through their skin cells. |
| Incubation Period | • Scientists do not know how long it takes for symptoms to appear.<br>• It probably varies from patient to patient. |
| Period of Infectivity | • Patients and residents in healthcare facilities often remain colonized with Candida auris for many months, perhaps indefinitely, even after acute infection (if present) has been treated and resolves |
| Screening | • Screening can be done for exposed HCWs and roommates<br>• Screen HCWs who had a direct and prolonged interaction (e.g. bedside care, medical examination, physiotherapy) with the positive case before identification. Review list of exposed HCWs for the last four weeks.<br>• Screen roommate(s) going back 4 weeks from the date of positive culture<br>• Screen all patients in the unit if the patient was housed for more than 3 days undiagnosed.<br>• At risk patients should ideally be screened whilst off antifungal medications for 7 days and not within 48 hours of using antiseptic |

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| | body washes as these treatments may result in falsely negative screens.<br>• Specimens type:<br>✓ HCWs: (1) composite swab for axilla and groin (2) nares<br>✓ Roommates: (1) composite swab for axilla and groin (2) nares (3) stool<br>• Defer transfer to other areas/wards until the results of the initial screening has been found to be negative. |
| Prevention and control | • Screening patients to identify risk and colonization<br>• Emphasize adherence to hand hygiene<br>• Limiting the number of people who work with patients who have Candida auris<br>• Contact Precautions:<br>o Keep patients in single rooms<br>o In case of limited single rooms may be cohorting with other patients with Candida auris (but other MDRO)<br>o HCWs wear gowns and gloves during patient care.<br>o Practicing regular hand hygiene<br>• Cleaning and disinfecting the patient care environment (daily and terminal cleaning) and reusable equipment with recommended products.<br>• Communicating with other care facilities the patient attends to follow up on the person's status |
| Decolonization | ✓ Decolonization Protocol for 5 days<br>✓ Use 2% Chlorhexidine gluconate (CHG) wipes or bath using 4% CHG soap twice a day to reduce or inhibit skin colonization.<br>✓ Use 0.2 % Chlorhexidine mouthwash for patients on ventilator<br>• Repeat screening within 1 week after decolonization is completed<br>• Oral nystatin if oropharyngeal is colonized |
| Discontinue Contact isolation | • Discontinue Contact isolation after obtaining two negative cultures from the previous positive site one week apart.<br>• If a patient's swab is positive, there is no need to repeat sampling for |

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| | at least another month for patients and every two weeks for HCWs. |
| Environmental Cleaning | • Candida auris can persist on surfaces in healthcare environments.<br>• Quaternary ammonia products that are routinely used for disinfection are not effective against Candida auris<br>• Educate environmental cleaning staff and implement supervised cleaning.<br>• If to use hands-free disinfection methods, like UV light it would require longer cycle times when used for Candida auris<br>• We recommend use of a hospital-approved disinfectant effective against<br>• Clostridium difficile spores.<br>• If not available a solution of 1:50 household bleach for daily general cleaning and a solution of 1:10 for terminal cleaning can be used.<br>• Use the 1:50 household bleach chlorine disinfectants solution for cleaning and disinfection of areas outside of their rooms where they receive care (e.g., radiology, physical therapy).<br>• Follow recommendation for contact time of ten (10) minutes.<br>• Housekeepers performing environmental cleaning should wear the recommended PPEs described above.<br>• Use designated cleaning equipment (e.g., mop, buckets, etc.) and disposable cleaning materials in the isolation room/unit.<br>• Clean and disinfect equipment and furniture upon patient discharge.<br>• The need for environmental screening would be performed after consultation with the IP&C department. |
| Vaccines | • None |

| Aspergillosis | |
|---|---|
| Pathogen | • Aspergillus Species<br>• Most commonly, Aspergillus fumigatus and A. flavus. Less common species include A. terreus, A. nidulans, A. niger, and A. versicolor. |
| Epidemiology | • Nosocomial aspergillosis represents a serious threat for severely immunocompromised patients<br>• High-risk groups include individuals undergoing hematopoietic stem cell transplantation, solid organ transplantation, major surgery (especially gastrointestinal surgery), or severe burns; those with neutropenia, AIDS, neoplastic disease, immunosuppressive therapy, or advanced age; and premature babies |
| Hospital outbreak | • Multiple hospital outbreaks have been reported in admitted immunocompromised patients in different units such as<br>  ○ Oncology/hematology unit<br>  ○ Hematopoietic stem cell transplantation<br>  ○ Solid organ transplantation<br>  ○ Neonatal ICU<br>  ○ Burns ICU<br>• Sources of Aspergillus Species in hospital are; construction work, renovation activities, and contaminated or defective air supply system |
| Symptoms & clinical picture | • Allergic bronchopulmonary aspergillosis in people who have cystic fibrosis or asthma; coughing, shortness of breath, and wheezing<br>• Allergic Aspergillus sinusitis; stuffiness, runny nose, headache, and reduced ability to smell<br>• Chronic pulmonary aspergillosis in patients with other chronic lung disease; weight loss, cough, coughing up blood, fatigue, and shortness of breath<br>• Invasive aspergillosis in immunocompromised patients: most commonly affects the lungs, but it can also spread to other parts of the body; fever, chest pain, cough, hemoptysis, and shortness of breath<br>• Cutaneous aspergillosis can also occur if invasive aspergillosis spreads to the skin from somewhere else in the body |

| | |
|---|---|
| Diagnosis | • Microscopy: Evaluation of respiratory specimens after the application of special stains can allow for visualization of Aspergillus elements.<br>• Galactomannan antigen detected in plasma, serum, bronchoalveolar Lavage (BAL), or cerebrospinal fluid (CSF)<br>• Aspergillus PCR<br>• Aspergillus species recovered by culture from sputum, BAL, bronchial brush, or aspirate |
| Mode of Transmission | • Inhalation of Aspergillus spores<br>• Aspergillosis can't spread from person to person |
| Incubation Period | • Unclear<br>• Incubation Period of invasive aspergillosis is estimated at 15 days |
| Period of Infectivity | • As long as the source of Aspergillus spores is available<br>• Aspergillosis can't spread from person to person |
| Prevention and control | • Protect patients specially high risk ones from the sources of Aspergillus spores<br>o Seal off patient care areas with adequate and impermeable barriers, and keep doors and windows closed<br>o Avoid non-emergent admissions during heavy construction periods<br>o If possible, locate high-risk patients as far as possible from areas of demolition or construction<br>o Verify that HEPA air filtration is sufficient and proper air exchange rates are maintained.<br>o Provide treatment in the patient's room if possible.<br>o Transport patients via an alternate route to avoid dust, schedule transportation during periods with minimal construction activity, and use appropriate face masks for susceptible patients<br>o Wet-clean wards thoroughly without raising dust<br>• Surveillance of increased risk patients to early detect cases |
| Vaccines | • None |

# Role of microbiology laboratory

**Clinical microbiology laboratory**

- Clinical microbiology laboratories process various specimens from patients, healthcare workers, and environment.
- The results of their analyses can either contribute to the everyday diagnosis and management of infection in individual patients (the clinical role), or contribute to the everyday infection prevention and control activities
- For infection control, they help in surveillance of outbreaks of healthcare-associated infections, detection of outbreaks, screening for multi-resistant organisms, advice to clinicians about the rational use of antibiotics.

# Clinical role of the microbiology laboratory

1. **Diagnosis of infectious diseases**: The microbiological processing of patient specimens and serodiagnostic analyses are fundamental to the everyday diagnosis, treatment and management of patients with infectious diseases
2. **Account for the challenges of microbiological specimens**. These are far more challenging than, for example, clinical chemistry investigations and careful attention needs to be paid to them, not least because
   - ✓ It is often impossible to re-collect
   - ✓ The numbers of organisms identified can often be important to the correct clinical diagnosis e.g. Numbers of organisms in a urine specimen
   - ✓ Lose viability (a particular issue with more delicate organisms such as streptococcus pneumoniae)
   - ✓ Sometimes difficult to isolate because of the overgrowth of other microbes e.g. commensal flora in the specimen.
3. **Set requirements of clinical specimens for microbiological analyses.**
   - ✓ Specimens should be selected properly. For example, the right indication such as clinical samples, the right source e.g. mid-stream urine, and the right timing of collection; e.g. during the acute stage of specific infections)
   - ✓ Specimens should be collected ideally before antimicrobial therapy has been initiated;
   - ✓ Specimens should be collected in sufficient volume, depending on test(s) ordered;
   - ✓ Specimens should be collected in the correct container. For example, in transport medium

- ✓ Specimen should be accompanied by information on the precise clinical site e.g. Time/date of onset, ward, and body part
- ✓ Specimens should be transported correctly. For example, consideration needs to be given to timeliness, temperature, medium and atmosphere depending on many factors

4. **Ensure quality assurance.** Laboratories should be accredited for all of their services. To do this there should be appropriate standard operating procedures in place to validate all of their work, including the specimen processing and correct interpretation of any results.
5. **Ensure appropriate microbiological laboratory methods.** To be most useful, microbiological diagnostic tests should be fast, accurate (high sensitivity and specificity), and the clinical relevance (or not) of the results explained
6. **Perform different diagnostic methods:**
   - ✓ Direct smear of the specimen. Gram stain can help with the interpretation of the culture results and provide a rapid clue as to the likely pathogen
   - ✓ Culture for bacteria and fungi
   - ✓ Identification (using classic biochemical/ antigen determination methods, or other molecular methods) and
   - ✓ Antimicrobial susceptibility testing results. This is one of the most important laboratory clinical functions.
   - ✓ Microbial antigen testing e.g. for Legionella spp.
   - ✓ Serology; as a proof of immune response to infectious agent (this usually requires specimens to be taken 10-14 days after the infection, when antibodies first appear).
   - ✓ Nucleic acid (DNA and RNA) detection in the specimen (i.e. molecular microbiology techniques).
7. **Oversee point of care tests.** Attempts are underway to move diagnosis nearer to the patient, so that less skilled staff can use simpler/automated equipment that will enable faster unambiguous diagnosis at the bedside, so reducing morbidity, mortality and reducing the need for empirical antimicrobials. Several such tests are already in use for the point of care diagnosis of e.g. malaria, HIV, HCV, syphilis, measles, respiratory viruses (especially influenza), norovirus and tuberculosis.

# Epidemiological role of microbiology laboratory

1. **Surveillance:**
   - ✓ Infection control staff review the data of microbiology laboratory to initiate the surveillance of HAIs
   - ✓ Microbiology laboratory is required to promptly and accurately detect nosocomial pathogens and indicate their antimicrobial resistance patterns.
   - ✓ The sensitivity and specificity of such surveillance will depend on whether specimens have been submitted to the laboratory. It is better for bloodstream and urinary tract infections, but for others e.g. lower respiratory tract infections, specimens are more often unavailable.
   - ✓ Active surveillance cultures for alert (including multidrug resistant) organisms, is practiced by many hospitals throughout the world. This is mainly admission screening for MRSA, but many hospitals perform it also for ESBL, CRE and VRE.
   - ✓ There should be daily listings made available for, or urgent communication with, the infection control staff of agreed alert condition e.g. cellulitis, and alert organisms.
   - ✓ Microbiology laboratory staff should work with infection control staff and the information technology (IT) department to determine how microbiology data are delivered and to link them to other surveillance data to reduce manual data collection
   - ✓ Major surveillance challenges include the continued emergence of novel infectious agents (e.g., the 2009 H1N1 influenza A virus) and novel antimicrobial-resistant pathogens (e.g., Carbapenem-resistant Enterobacteriaceae
   - ✓ Microbial analyses are especially important in the diagnosis of HAIs as:
     - Most HAIs are caused by microorganisms whose antimicrobial susceptibility is less predictable and more resistant than those causing community associated infections.
     - Correct etiological diagnosis and more targeted antimicrobial therapy will also lead to the earlier eradication of the infecting microorganisms and help prevent the patient from continuing to be the source of microbial spread to other patients
     - Normal (commensal) microorganisms cannot necessarily be ignored as they can become opportunistic HAIs pathogens. For example, an intravenous cannula can provide the portal of entry for skin flora e.g. coagulase negative staphylococci, to cause a bloodstream infection.

## 2. Outbreak investigations

- ✓ Early recognition of a cluster or outbreak. This can be achieved either through the laboratory information system or through routine observations at the bench and comparison with the baseline incidence.
- ✓ Immediate communication of cluster information with ward and infection control staff
- ✓ Further case finding (once case definitions have been agreed). After that the laboratory participates in further case finding (here there is a possibility to use specific selective media for isolation of the causative agent if it has some distinctive characteristics, e.g. the addition of specific antimicrobial(s) to the isolation media if the outbreak strain is resistant). If necessary the laboratory will process further specimens either from patients and staff (screening samples) or from the environment (e.g. food, water, instruments, devices).
- ✓ Identification of the causative agent to the species level and susceptibility testing performed together, where relevant, with detailed analysis of resistance genes/plasmids. They should be able to give diagnosis as soon as possible by use of new methods, such as PCR for Mycobacterium tuberculosis and detection of Legionella by urinary antigen EIA, etc.
- ✓ Typing of microorganisms is today one of the most important roles of microbiology in infection control staff. Usually, diagnostic laboratories routinely submit strains to reference laboratories for characterization and typing. However, over time, the distinction between diagnostic and reference laboratory functions has become less clear-cut due to the diffusion of molecular diagnostic methods. Typing data may be able to confirm or refute hypotheses about possible sources and modes of transmission of the pathogen causing the outbreak. Actively collaborate in epidemic investigations
- ✓ Give advice to the infection control staff on the appropriate collection of specimens.
- ✓ Store microorganisms and/or acute serum sample for further investigations as appropriate depending on the type of outbreak.
- ✓ Carry out internal quality control on a regular basis and participate in the external quality control programs
- ✓ Constantly review and update its laboratory methodology to keep pace with the advances in diagnosis of microbial diseases and to improve early detection and diagnosis by use of molecular and non-molecular methods.
- ✓ Before introduction of a new test or a method, it must access evidence both for

sensitivity and specificity of the test and ensure its cost-effectiveness.

3. **Antimicrobial stewardship.**
   - ✓ A major microbiology laboratory role is in the identification of etiological agent of infection and in determining its susceptibility to antimicrobials for individual patient so the patient could be treated according to the individual agent susceptibility.
   - ✓ The panel of antimicrobials should be agreed with clinical teams and Antimicrobial Committee (team) and be based on periodic laboratory reports of antimicrobial susceptibilities of local isolates, stratified by pathogen, site of infection and by unit/service (e.g. susceptibility of isolates in chronic dialysis service might not be the same as in a surgical ward).
   - ✓ Reports of antimicrobial susceptibilities are very important for the design of hospital antimicrobial formulary and hospital guide for empiric and definitive therapies and restrictive antimicrobial reporting and other agreed interventions.
   - ✓ For guiding empirical antimicrobial therapy, unit-specific and tailored antibiograms should be updated on a regular basis and provided to clinicians at the bedside. Such antibiogram data can also be used for evaluation of trends in important antimicrobial resistance rates and for education of clinicians regarding optimal antimicrobial use.
   - ✓ The antimicrobial therapy, patient-specific culture and susceptibility data are needed to allow for a prospective audit of antimicrobial use with feedback to the prescriber.
   - ✓ A medical microbiologist should usually be a member of Antimicrobial stewardship Committee
4. **More specialized infection control related services.** These can comprise microbial sampling from theatre, isolation wards, sterile preparation rooms (e.g. pharmacy) for routine or investigational analyses.
5. **Participation in infection control committee.** A clinical microbiologist chosen to be a member of this committee should have the necessary competencies required to interpret microbiological data for infection control staff. For example, he/she should be aware of specific microorganisms pertaining to the pathogenicity, virulence, natural habitat, possible habitats in hospital, resistance to adverse conditions in environment, transmissibility and a way of transmission in hospital, resistance to disinfectants and antibiotics. There are several roles of microbiology laboratory representative should be applied during the committee meeting.
   - ✓ Explain the culture results
   - ✓ Describe how changes in the methods used for detection, identification, and

susceptibility testing of nosocomial pathogens can impact the infection control activities.

- ✓ Explain annual antibiogram and to provide molecular typing support as well.

**6. Educational role.**

- ✓ Educate infection control staff, antimicrobial stewardship staff, and clinical staff about microbiological data described above

# Principles of specimen collection, storage, and transport

1. **Specimen collection:**
   - ✓ All specimens are to be collected in clear and dry containers.
   - ✓ Use containers with wide mouth.
   - ✓ Sterile containers are used to collect specimen for culture.
   - ✓ Wax lined disposable cups are used for the collection of sputum and stool specimens.
   - ✓ Large containers are used to collect 24 hours urine specimen.
   - ✓ Use the right type of tube and make sure it is not expired
   - ✓ Clean slides are used to collect smears.
   - ✓ No antiseptic solution should be present in the specimen bottles as they may hamper the growth of microorganisms
   - ✓ Equipment used for the collection of specimens should be clean and dry.
   - ✓ Label each specimen as soon as it is received with the necessary data
   - ✓ Do not to contaminate the outside of the bottle
2. **Handling**
   - ✓ Serum tubes must be placed in an upright vertical position and allowed to clot for a minimum of 30 minutes before centrifuging.
   - ✓ After the specimen has been allowed to fully clot, the tube is to be centrifuged within 1 hour of collection and no longer than 2 hours after collection
3. **Specimen storage:**
   - **Room Temp Requirements:**
   - ✓ Most specimens (such as whole blood and CSF) do not have a specific storage requirement and will be stored at room temperature (15-30°C).
   - ✓ Do not store tubes in direct contact of a heat source such as direct sunlight, top of refrigerator, heating/air vents, etc.
   - **Refrigeration:**
   - ✓ Some specimens require refrigerated temperatures (2-8°C) during storage and transport, such as urine, culture, and tissue biopsies.
   - ✓ Never store unspun serum/plasma tubes in refrigerator. Tubes must be centrifuged before storage to ensure specimen integrity.
   - **Freezing:**
   - ✓ If your test requires the specimen to be frozen after processing, the specimen must be centrifuged and serum/plasma must be transferred to an aliquot tube by pipette

without disturbing gel or packed cells.

4. **Transport:**
   - ✓ To minimize exposure to blood borne pathogens in transport of specimens, Standard Precautions must be used.
   - ✓ All specimens must be transported in a sealed biohazard bag which is color coded
   - ✓ Transport should be done at room temperature, with regular ice, or with dry ice according to the storage classification above
   - ✓ All specimens transported via courier must be transported in sealed biohazard, leak-proof, puncture resistant container tightly closed before transportation.
   - ✓ Completed requisition and addresses are to be placed in the outside pocket

# Classic methods used in the diagnosis of infections

## 1. Direct smear and staining

- In their natural state, most of the cells and microorganisms that we observe under the microscope lack color and contrast.
- Therefore, specimens are routinely stained to increase visibility and to reveal additional information to help identify the microorganisms.
- A smear is a thin film of microorganism spread out on a microscope slide
- Stains are colored dyes that impart color to the colorless microorganisms.
- Types of Staining
  - ✓ Simple staining, a single dye is used to emphasize particular structures in the specimen. A simple stain will generally make all of the organisms in a sample appear to be the same color, even if the sample contains more than one type of organism.
  - ✓ Differential staining distinguishes organisms based on their interactions with multiple stains. Differential staining techniques commonly used in clinical settings include Gram staining, acid-fast staining, endospore staining, flagella staining, and capsule staining.

| Type | Specific Dyes | Purpose | Outcome |
|---|---|---|---|
| Gram stain | Uses crystal violet, Gram's iodine, ethanol (decolorizer), and safranin | Used to distinguish cells by cell-wall type (gram-positive, gram-negative) | Gram-positive cells stain purple/violet. Gram-negative cells stain pink |
| Acid-fast stain | After staining with basic fuchsin, acid-fast bacteria resist decolonization by acid-alcohol. Non-acid-fast bacteria are counterstained with methylene blue. | Used to distinguish acid-fast bacteria such as M. tuberculosis, from non-acid-fast cells. | Acid-fast bacteria are red; non-acid-fast cells are blue. |
| Endospore stain | Uses heat to stain endospores with malachite green (Schaeffer-Fulton procedure), then cell is washed and counterstained with safranin. | Used to distinguish organisms with endospores from those without; used to study the endospore | Endospores appear bluish-green; other structures appear pink to red. |
| Flagella stain | Flagella are coated with a tannic acid or potassium alum mordant, then stained using either pararosaline or basic fuchsin | Used to view and study flagella in bacteria that have them. | Flagella are visible if present |

## 2. Culture

- Culture of microorganisms is to keep them reproducing populations alive under laboratory conditions.
- A specimen will be taken from blood, urine, skin, or other body part and then put in a special media to encourage cell growth.
- Culturing different microorganisms is challenging because of highly specific nutritional and environmental requirements and the diversity of these requirements among different species.
- Some media are considered general all-purpose media and support growth of a large variety of organisms. A prime example of an all-purpose medium is tryptic soy broth (TSB).
- Specialized media are used in the identification of bacteria and are supplemented with dyes, pH indicators, or antibiotics.
  - ✓ Chemically defined media contain only chemically known components.
  - ✓ Selective media favor the growth of some microorganisms while inhibiting others.
  - ✓ Enriched media contain added essential nutrients a specific organism needs to grow
  - ✓ Differential media help distinguish bacteria by the color of the colonies or the change in the medium.
- Steps of culture:
  - ✓ Aseptic / sterilization procedures
  - ✓ Preparation of appropriate culture media
  - ✓ Isolating and culturing microorganisms: incubation of cultures for 48-72 hours (for bacteria) or for 7-14 days (for fungi)
  - ✓ Making slides for observation under microscope
- Unlike bacteria, many of which can be grown on an artificial nutrient medium, viruses require a living host cell for replication. Infected host cells (eukaryotic or prokaryotic) can be cultured and grown, and then the growth medium can be harvested as a source of virus.

### 3. Serological tests

- Serological tests can be used to detect viral & bacterial antigens and antibodies (IgG and IgM), to help diagnose diseases and check immune status.
- A range of techniques are utilized including ELISA, chemiluminescence, agglutination, direct and indirect immunofluorescence, and Western blotting.
- Some serological tests are not limited to serum, but can be performed on other bodily fluids such as CSF and urine.
- The major groups of infectious disease-causing agents tested along with some diseases caused by such agents include:
  - ✓ Bacterial (Legionella; Leptospira; Mycoplasma; Chlamydiae)
  - ✓ Fungal (Cryptococcal, Aspergillus)
  - ✓ Parasitic (Toxoplasma gondii; Chagas disease; Strongyloides; Schistosomiasis)
  - ✓ Rickettsial (Rocky Mountain Spotted Fever; Murine typhus; Q fever)
  - ✓ Viral (Herpes Simplex; Cytomegalovirus; Epstein Barr)
  - ✓ Tick borne (Lyme Disease; Babesia; Anaplasma; Ehrlichia)

## 4. Microbial typing

- When two isolates are phenotypically or genotypically indistinguishable does not mean that they are related epidemiologically
- Definitions:
  - ✓ Microbial epidemiology: the study of the distribution and dissemination of microbial pathogens including their transmission patterns, risk factors for infection, and preventive and control measures of infectious disease.
  - ✓ Microbial Strain: a strain is an isolate or group of isolates that can be distinguished from the other isolates of the same genus or species by phenotypic and/or genotypic characteristics. When sampling for typing it is wise to pick five distinct colonies to reduce the chance of missing mixed strains.
  - ✓ Clone: bacterial cultures isolated independently from different sources in different locations and perhaps at different times, but still showing so many identical phenotypic and genotypic traits that the most likely explanation for this identity is a common origin.
  - ✓ Clonal variants: the recent descendants of a successful clone which have undergone minor evolutionary changes
  - ✓ Clonal complex/group: A group of bacterial isolates showing a high degree of similarity ideally based on near-identity of multi-locus enzyme profiles and multi-locus sequence types. Identical to a clonal group.
  - ✓ Clade: This evolutionary term is appearing increasingly in infection control and antimicrobial stewardship/resistance literature where DNA sequencing has been performed. It refers to a grouping of microbial isolates (even those that are extinct) descended from a common ancestor.
- Types of typing:
  - ✓ Phenotypic: techniques used to detect characteristics expressed by the microorganism
  - ✓ Genotypic: techniques that involve direct DNA-based analysis of genetic elements

**Phenotypic methods:**

- Antimicrobial susceptibility testing.
- Biochemical markers
- Serotyping: specialized, animals are required.
- Phage typing: difficult to do to a high standard. Cheap and can deal with large batches. Many issues regarding typeability and reproducibility. Changes of phage type over time can also be related to other changes within the organism e.g. toxin carriage.
- Toxin assays: can be difficult to setup and perform reproducibly unless commercial reagents are available. Discrimination poor but can be valuable in e.g. toxic shock cases, C. difficile infection.
- Proteomics: discrimination needs to be validated for different species and shown to be of use for local strains of these species. DNA methods are currently more popular.
- For more details, see Appendix 5

**Roles for microbial typing in outbreak investigation:**

- Which part of the microbial reservoir is serving as a source of the initial outbreak or its continuation? For example, Pseudomonas aeruginosa in sinks
- What is the route of transmission of strains and what are the patterns of their spread? Although the index case may be transmitted in a particular way e.g. in the operating theatre during surgery, subsequent routes might be, for example, via the unwashed healthcare workers' hands on the wards.
- What are the portals of entry into patients? This might be, for example, via wounds, injection/cannula sites, airborne or oral portals.
- As the outbreak spreads, so one may need to identify the enlarged reservoir: e.g. patient carriers; in many HAIs outbreaks ~70% or more of affected individuals are colonized rather than infected either of which can be the source of further spread.
- Examination of possible invaders. These are organisms isolated from patients that epidemiologically are thought to be distinct from the outbreak, but this requires confirmation.

# Environmental Cleaning

**Environmental cleaning**: cleaning and disinfection (when needed, according to risk level) of environmental surfaces (e.g., bedrails, mattresses, call buttons, chairs) and surfaces of noncritical patient care equipment (e.g., IV poles, stethoscopes).

**Important definitions:**

- **Antisepsis:** Prevention of infection usually by inhibiting growth of bacteria
- **Cleaning:** It is the physical removal of foreign material (e.g., dust, soil) and organic material (e.g., blood, secretions, excretions, microorganisms). Cleaning physically removes rather than kills microorganisms. It is accomplished with water, detergents, and mechanical action.
  - ✓ **Routine cleaning:** the regular cleaning (and disinfection, when indicated) when the room is occupied to remove organic material, reduce microbial contamination, and provide a visually clean environment. Emphasis is on surfaces within the patient zone.
  - ✓ **Scheduled cleaning:** cleaning (and disinfection, when indicated) that occurs concurrently with routine cleaning and aims to reduce dust and soiling on low-touch surfaces.
  - ✓ **Terminal (discharge) cleaning:** cleaning and disinfection after the patient is discharged or transferred. Includes the removal of organic material and significant reduction and elimination of microbial contamination.
- **Contact time:** the time that a disinfectant must be in contact with a surface or device to ensure that appropriate disinfection has occurred. For most disinfectants, the surface should remain wet for the required contact time.
- **Contamination:** the presence of any potentially infectious agent on environmental surfaces, clothing, bedding, surgical instruments or dressings, or other inanimate articles or substances, including water, medications, and food.
- **Decontamination** is the removal of pathogenic substances from objects, so they are safe to handle, use or dispose of these substances can include microorganisms (bacteria, viruses and fungi), organic matter and body fluids such as blood, feces, urine, pus, and sputum. Decontaminations steps are cleaning, and sterilization.

- **Detergent:** a synthetic cleansing agent that can emulsify and suspend oil. Contains surfactant or a mixture of surfactants with cleaning properties in dilute solutions to lower surface tension and aid in the removal of organic soil and oils, fats, and greases
- **Disinfection** is the removal or killing of most (not necessarily all) disease-causing microorganisms, not including bacterial spores. It is usually achieved by thermal or chemical methods (see Appendix 6).
  - ✓ **High-level disinfection:** kills all microorganisms, with the exception of small numbers of bacterial spores.
  - ✓ **Low-level disinfection:** inactivates most vegetative bacteria, some fungi, and some viruses in a practical contact time, but does not kill more hardy viruses (e.g. non-enveloped), bacterial genus (e.g. mycobacteria), or bacterial spores.

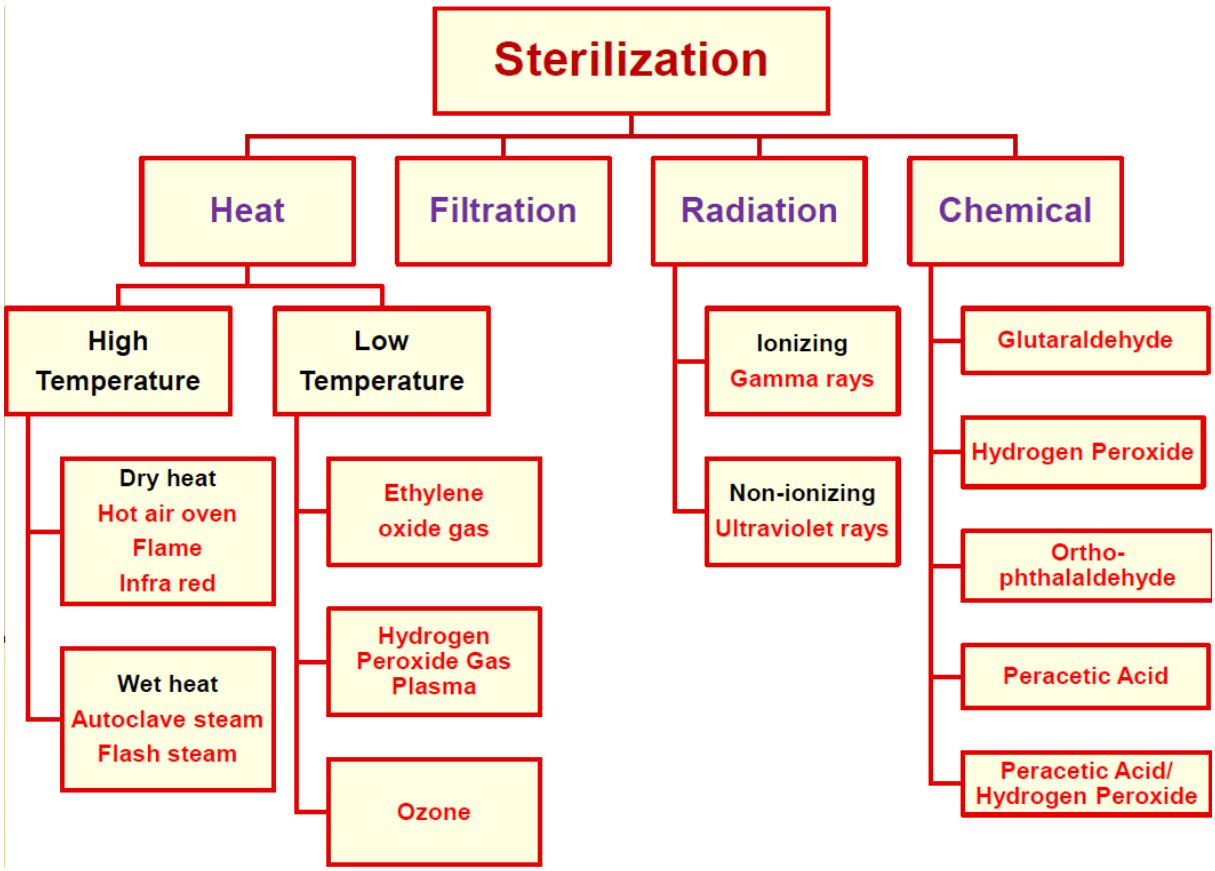
| High-level Disinfection | Low-level Disinfection |
|---|---|
| • Peracetic Acid/ Hydrogen Peroxide | • Sodium hypochlorite (5.25-6.15% household bleach diluted 1:500 provides >100 ppm available chlorine) |
| • Glutaraldehyde | • Ethyl or isopropyl alcohol (70-90%) |
| • Hydrogen Peroxide | • Phenolic germicidal detergent solution (follow product label for use-dilution) |
| • Ortho-phthalaldehyde | • Iodophor germicidal detergent solution (follow product label for use-dilution) |
| • Peracetic Acid | • Quaternary ammonium germicidal detergent solution (follow product label for use-dilution) |

- **Environmental surfaces:**
  - ✓ **High-touch surfaces:** surfaces, often in patient care areas , that are frequently touched by healthcare workers and patients. These include doorknobs, elevator buttons, light switches and computer keyboards. High-touch surfaces require cleaning and disinfection at least daily, and more frequently where the risk of contamination with germs is higher than usual (e.g., if there is an increase of illness at your site)

| | |
|---|---|
| Bedrails | Call bells |
| IV poles | Doorknobs |
| Sink handles | Light switches |
| Bedside tables | Phone |
| Counters where medications and supplies are prepared | Patient monitoring equipment (e.g., keyboards, control panels) |
| Edges of privacy curtains | Transport equipment (e.g., wheelchair handles) |

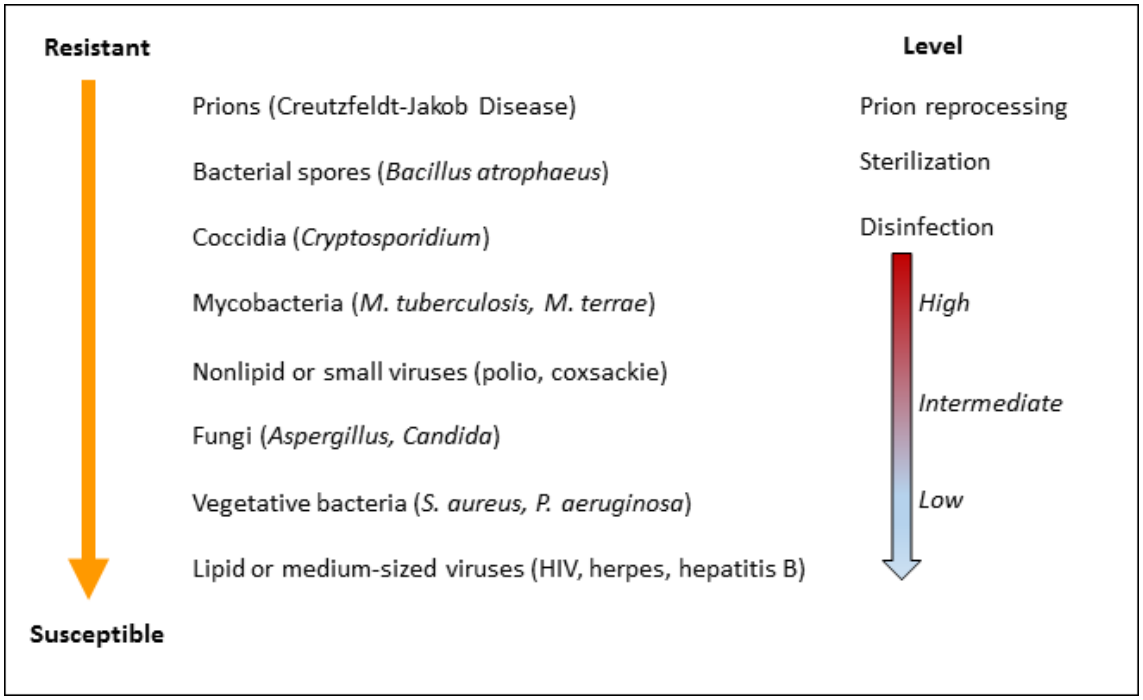
- ✓ **Low-touch surfaces:** surfaces that are touched less frequently throughout the day. These include walls, floors and windowsills. Low-touch surfaces require cleaning on regularly, but not necessarily daily, basis. However, they should be cleaned immediately when visibly soiled

- **Germicide** is a substance that kills the germs or pathogenic microorganisms; it includes:
  - ✓ **Antiseptics** destroy or stop the growing of the microorganisms in or on living tissues
  - ✓ **Disinfectants** destroy or stop the growing of the microorganisms on non-living objects
- **Sanitizatio**n: Reducing the number of microorganisms in environment to a safe level accepted by public health organization
- **Standard Precautions:** are used for all patient care. Based on a risk assessment and make use of common sense practices and personal protective and other equipment that protects healthcare providers from infection and prevent the spread of infection from patient to patient.
- **Sterilization** is the removal or killing of all living microorganisms including bacterial spores



**Factors affecting the efficacy of disinfection:**

- **Number and location of microorganisms**
  - ✓ The more microorganisms on the instruments, the longer time required for disinfection.
  - ✓ Medical devices that have fissures or channels are hard to disinfect compared to devices with flat smooth surface




- **Concentration & potency of disinfectants**
  - ✓ The more concentration the more efficacy of disinfectants
  - ✓ The more potency the shorter the time required for sterilization and disinfection
  - ✓ For more details, see Appendix 6
- **Physical and chemical environment**
  - ✓ Temperature: In most cases, the higher the temperature is, the higher activity of the disinfectant
  - ✓ PH: The pH influences the disinfecting activity by altering the germicidal molecules or cell surface of the microorganisms.
  - ✓ Relative humidity: influence the activity of gaseous disinfectants.
  - ✓ Water hardness: Magnesium and calcium may interact with soap to form insoluble precipitates
- **Presence of organic material**
  - ✓ Organic material (e.g., blood, sputum, feces) may interfere with the activity of the disinfection in at least two ways:

- ✓ Chemical interference between disinfectant and organic material may make it less germicidal or non-germicidal.
- ✓ Physical barrier: organic material may protect microorganisms from the germicidal effect of the disinfectant, which is a reason for cleaning before sterilization.

- **Duration of exposure**
  - ✓ Low-level disinfection require the exposure time to be at least 30-60 seconds.
  - ✓ The exact times for disinfecting medical items are somewhat indefinable because of the effect of the previous factors on disinfection efficacy.
  - ✓ In general, longer contact times are more effective than shorter contact times
- **Presence of biofilms**
  - ✓ Biofilms are a complex structure that attach to the surface of microorganisms and are difficult to remove.
  - ✓ Microbes with biofilm may have resistance to disinfectant.
  - ✓ If bacteria are with biofilm, it will have ~1000 times more resistance to antimicrobials.
  - ✓ The presence of biofilm may lead to severe infection in immunocompromised patients

**Factors affecting the frequency of environmental cleaning**

- **Probability of contamination:** Heavily contaminated surfaces and items require more frequent and thorough environmental cleaning than moderately contaminated surfaces, which in turn require more frequent and rigorous environmental cleaning than lightly or non-contaminated surfaces and items.
- **Vulnerability of patients to infection:** Surfaces and items in care areas containing vulnerable patients (e.g., immunosuppressed) require more frequent and rigorous environmental cleaning than surface and items in areas with less vulnerable patients.
- **Potential for exposure to pathogens:** High-touch surfaces (e.g., bed rails) require more frequent and rigorous environmental cleaning than low-touch surfaces (e.g., walls).

**General principles of environmental cleaning**

- Proceed only after a visual preliminary site assessment
- Refer to manufacturers' cleaning instructions
- Wear PPE, i.e. gloves, aprons, and goggles as appropriate
- Use wet floor or caution signs to prevent injuries.
- Wipe all surfaces including underneath, paying special attention to contact points
- Apply color coding policy
- Use appropriate disinfectant or detergent
- Proceed from cleaner to dirtier
  - ✓ During terminal cleaning, clean low-touch surfaces before high-touch surfaces.
  - ✓ Clean patient areas (e.g., patient zones) before patient toilets.
- Proceed from high to low (top to bottom)
  - ✓ Cleaning bed rails before bed legs
  - ✓ Cleaning environmental surfaces before cleaning floors
- Proceed in a systematic manner to avoid missing areas

**Frequency of routine cleaning**

| Area | Frequency | Method | Process |
|---|---|---|---|
| Outpatient, Waiting area | At least once daily | Clean | High-touch surfaces and floors |
| Outpatient, Examination | At least twice daily | Clean | High-touch surfaces and floors |
| Outpatient, Procedural | Between each procedure and at the end of the day | Clean and disinfect | High-touch surfaces and floors |
| Inpatient Wards | At least once daily | Clean | High-touch surfaces and floors Handwashing sinks |
| Private toilets | At least once daily after routine cleaning of patient care area | Clean and disinfect | High-touch and frequently contaminated surfaces in toilet areas |
| Public or shared toilets | At least twice daily | Clean and disinfect | High-touch and frequently contaminated surfaces in toilet areas |
| Patient Area Floors | At least once daily or as often as specified | Clean | General mopping process |
| Intensive Care Units | Twice daily and as needed | Clean and disinfect | High-touch surfaces |

**Monitoring, feedback, and audit elements**

- Structured monitoring programs ensure that environmental cleaning is conducted according to best practices.
- There must be organizational support and resources to address deficiencies identified during monitoring activities.
- Use a standardized methodology for monitoring, apply it on a routine basis, and provide timely feedback to cleaning staff and program leadership
- Use both direct (e.g., performance observation) and indirect methods (e.g., environmental marking).
- Use objective (e.g., ATP bioluminescence) over subjective methods (e.g., assessments of cleanliness), if resources allow

**Cleaning a room on discharge or transfer of patients**

- Daily cleaning of the environment with detergent and water is necessary to reduce build-up and dispersal of potential pathogens to staff clothing or other areas.
- Cleaning and disinfection of the environment is required for transfer or discharge of a patient who is in isolation, an outbreak situation, or as indicated by the infection prevention and control team.
- Ensure the correct color-coded system is used for cloths and mops in isolation rooms.
- An efficient discharge system is essential in terms of efficient bed utilization
- Good communication among ward staff and the hygiene services department is important to ensure patient discharges are managed accordingly
- Patients' beds/rooms will undergo a discharge clean or terminal disinfection depending on the circumstances of the patient
- Before a discharge clean or terminal disinfection can take place, patient equipment must be removed from the room, for example: pumps, urinals, bedpans, commodes, walking frames, and catering utensils
- Discharge clean includes removal/discarding items from bathrooms and lockers, and decontaminating the room according to the hospital policy

**Terminal cleaning process:**

- Remove soiled/used personal care items (e.g., cups, dishes) for reprocessing or disposal.
- Remove facility-provided linens for reprocessing or disposal.

- Inspect window treatments. If soiled, clean blinds on-site, and remove curtains for laundering.
- Reprocess all reusable (noncritical) patient care equipment
- Clean and disinfect all low- and high-touch surfaces, including those that may not be accessible when the room/area was occupied (e.g., patient mattress, bedframe, tops of shelves, vents), and floors.
- Clean (scrub) and disinfect handwashing sinks.
- For CDC Environmental Checklist for Monitoring Terminal Cleaning, See Appendix-7

**Cleaning spills of blood or body fluids:**

- Regardless of the risk-level of an area, spills or contamination from blood or body fluid (e.g., vomitus), must be cleaned and disinfected immediately.
- Wear appropriate PPE.
  - ✓ Gown and/or plastic apron
  - ✓ Reusable rubber gloves
  - ✓ Face mask with either goggles or face shield (if splash risk or large spill)
- Confine the spill and wipe it up immediately with absorbent (paper) towels, cloths, or absorbent granules (if available) that are spread over the spill to solidify the blood or body fluid (all should then be disposed as infectious waste).
- Clean thoroughly, using neutral detergent and warm water solution.
- Disinfect by using a facility-approved intermediate-level disinfectant.
- Typically, chlorine-based disinfectants at 500-5000ppm free chlorine (1:100 or 1:10 dilution of 5% chlorine-bleach; depending on the size of the spill) are adequate for disinfecting spills (however, do not use chlorine-based disinfectants on urine spills).
- In large spill, you can use absorbent granules if available (Sodium Dichloroisicyanurate granules)
- Take care to allow the disinfectant to remain wet on the surface for the required contact time (e.g., 10 minutes), and then rinse the area with clean water to remove the disinfectant residue (if required).
- Immediately send all reusable supplies and equipment (e.g., cleaning cloths, mops) for reprocessing (i.e., cleaning and disinfection) after the spill is cleaned up.

**Spaulding classification to guide cleaning reusable patient care equipment:**

| Level of risk | Critical | Semi-critical | Non-critical |
|---|---|---|---|
| **Application** | • Enter normally sterile tissues, the vascular system, or equipment through which blood flows | • Come into contact with intact mucous membranes or non-intact skin | • Contact with intact skin |
| **Example** | • Surgical instruments<br>• Implants<br>• Prosthetic devices<br>• Needles<br>• Cardiac catheters<br>• Urinary catheters<br>• Biopsy forceps of endoscope | • Flexible fiberoptic endoscopes<br>• Respiratory therapy equipment<br>• Anaesthesia equipment<br>• Endotracheal tubes<br>• Bronchoscopes<br>• Vaginal specula<br>• Cystoscope<br>• Hand-piece | • Blood pressure cuffs<br>• Crutches<br>• Stethoscopes<br>• Face mask<br>• Bedpans<br>• X-ray machine<br>• Environmental surfaces |
| **Application** | • Enter normally sterile tissues, the vascular system, or equipment through which blood flows | • Come into contact with intact mucous membranes or non-intact skin | • Contact with intact skin |
| **Process** | • Sterilization is required<br>• Either purchased as sterile or<br>• Sterilized with steam if possible | • Sterilization is preferred where possible<br>• If no, high-level chemical disinfections is required such as glutaraldehyde, hydrogen peroxide, and ortho-phthalaldehyde | • Intermediate or low chemical disinfections |

# Operation of HAIs Outbreak

**Notification Process**

- The outbreak level is determined using an Outbreak Classification Matrix
- Once an outbreak is confirmed, the hospital outbreak coordinator is required to fill all required an online outbreak process starting with

✓ Notification form within the first (2-6) hours of an outbreak onset.

✓ The filled outbreak notification form regarding the occurrence of a confirmed outbreak will be received by cluster, regional directorate coordinator and the GDIPC simultaneously.

- Hospital infection department should start the control measures immediately according to the hospital outbreak management action plan (OMAP).
- The regional outbreak coordinator is responsible for performing the outbreak investigation and following control measures applied by the hospital's outbreak management team (OMT).
- The hospital's outbreak coordinator must update the investigation form immediately when new cases or deaths occurs, otherwise data will be updated once every week.
- Meanwhile the regional directorate and GDIPC will keep an eye on the updates, status of the outbreak and classify the level of the outbreak (A, B or C) according to the provided data.
- In case the outbreak is type A or B, the regional directorate coordinator will use an outbreak risk assessment, thus the GDIPC will make a field visit, if deemed necessary.

# Outbreak Classification Matrix- Class A

- **Intervention:**
  - ✓ Follow up the corrective plan with Regional Health directorate (RHD).
  - ✓ Assess the risk assessment done by RHD.
  - ✓ Maintain close communication with RHD.
  - ✓ GDIPC will involve when above three points have not achieved their outcome.
  - ✓ Complete GDIPC risk assessment form based on GDIPC site visit.
  - ✓ Prepare the corrective plan to ensure covering the GDIPC risk assessment notes and shared with (RHD, Cluster and Hospitals).
- **Responsibility**
  - ✓ Regional responsibility.
  - ✓ GDIPC's responsibility, if needed

| | | Pathogen | No of new confirmed cases within 3-days | No of deceased with confirmed diagnosis within 3-days | Responsibility |
|---|---|---|---|---|---|
| **A** | 1 | Acinetobacter | 8 Cases & Above | 5 Deceased & Above | Regional responsibility<br><br>GDIPC's responsibility, if needed<br><br>GDIPC visit upon directive from high authority<br><br>Hospital & Cluster |
| | 2 | Klebsiella Pneumonia (CRKP) | | | |
| | 3 | MRSA / VRE / CRE | | | |
| | 4 | Pseudomonas | | | |
| | 5 | Other MDROs | | | |
| | 6 | Clostridium Difficile | | | |
| | 7 | Food - borne Organisms | | | |
| | 8 | Water - borne Organisms | | | |
| | 9 | Clostridium Botulinum | | | |
| | 10 | Legionella | 8 Cases & Above | 5 Deceased & Above | |
| | 11 | Fungal / Candida albicans | 8 Cases & Above | 5 Deceased & Above | |
| | 12 | Other Candida Species | | | |
| | 13 | Candida Auris | 3 - 4 Cases | 2 Deceased | |
| | 14 | Aspergillus Species | | | |
| | 15 | Hepatitis A virus (HAV) | 8 Cases & Above | 5 Deceased & Above | |
| | 16 | Hepatitis B virus (HBV) | | | |
| | 17 | Hepatitis C virus (HCV) | 5 Cases & Above | 3 Deceased & Above | |
| | 18 | Measles | 8 Cases & Above | 5 Deceased & Above | |
| | 19 | Chickenpox | | | |
| | 20 | Influenza or Influenza Like Illness (ILI) | 8 Cases & Above | 5 Deceased & Above | |
| | 21 | Not Known or New - Emerging Organism | Only One Case | Zero Deceased | |
| | 22 | COVID- 19 Outbreak | ≥ 11 Cases | ≥ 6 Deceased | |
| | 23 | MERS-CoV | ≥ 6 Cases | 3 Deceased & Above | |

***N.B.:** Outbreak HAIs risk assessment will be activated by RHD outbreak' coordinators and evaluated by GDIPC – MOH outbreak team

# Outbreak Classification Matrix- Class B

- **Intervention:**
  - ✓ Complete risk assessment form via the first 48 hours based on RHD coordinator site visit.
  - ✓ Check the corrective plan to ensure covering the risk assessment notes (hospital with cluster and supervision and participating by RHD).
  - ✓ Corrective plan has to be shared with GDIPC by RHD outbreak coordinator
  - ✓ Note: GDIPC will be involved when it is necessary.
- **Responsibility**
  - ✓ Regional responsibility even if the HAIs outbreaks are occurring in the hospitals of the cluster.

| | | Pathogen | No of new confirmed cases within 3-days | No of deceased with confirmed diagnosis within 3-days | Responsibility |
|---|---|---|---|---|---|
| **B** | 1 | Acinetobacter | 5 - 7 Cases | 3 - 4 Deceased | Regional responsibility<br><br>Hospital & Cluster |
| | 2 | Klebsiella Pneumonia (CRKP) | | | |
| | 3 | MRSA / VRE / CRE | | | |
| | 4 | Pseudomonas | | | |
| | 5 | Other MDROs | | | |
| | 6 | Clostridium Difficile | | | |
| | 7 | Food - borne Organisms | | | |
| | 8 | Water - borne Organisms | | | |
| | 9 | Clostridium Botulinum | | | |
| | 10 | Legionella | 3 - 4 Cases | 2 Deceased | |
| | 11 | Fungal / Candida albicans | 5 – 7 Cases | 3-4 Deceased | |
| | 12 | Other Candida Species | | | |
| | 13 | Candida Auris | 3 - 4 Cases | 2 Deceased | |
| | 14 | Aspergillus Species | | | |
| | 15 | Hepatitis A virus (HAV) | 5 - 7 Cases | 3 - 4 Deceased | |
| | 16 | Hepatitis B virus (HBV) | | | |
| | 17 | Hepatitis C virus (HCV) | 3 - 4 Cases | 2 Deceased | |
| | 18 | Measles | 5 - 7 Cases | 3- 4 Deceased | |
| | 19 | Chickenpox | | | |
| | 20 | Influenza or Influenza Like Illness (ILI) | 5 - 7 Cases | 3- 4 Deceased | |
| | 21 | COVID- 19 Outbreak | 6-10 Cases | 3-5 deceased | |
| | 22 | MERS-CoV | 3-5 Cases | 2 Deceased | |

# Outbreak Classification Matrix- Class C

- **Intervention:**
  - ✓ Full- complete notification form within (2-6 hours).
  - ✓ Complete OMAP form via the first 24 hours.
  - ✓ Full the outbreak investigation form (outbreak line list, contact tracing for patients and HCWs) via 24-48 hours
  - ✓ Prepare corrective plan to manage the outbreak (hospital with cluster, based on site visit) via 24-48 hours
  - ✓ Follow up the corrective Plan with cluster and RHD
  - ✓ Note: GDIPC will be involved when it is necessary.
- **Responsibility**
  - ✓ Hospitals' responsibility.
  - ✓ Cluster is pertaining hospitals are under the responsibility of the cluster, itself.
  - ✓ Hospitals that are still not belonging to the cluster will continue as in the past (under the regional directorate responsibility).

| | | Pathogen | No of new confirmed cases within 3-days | No of deceased with confirmed diagnosis within 3-days | Responsibility |
|---|---|---|---|---|---|
| C | 1 | Acinetobacter | 2 - 4 Cases | 1 - 2 Deceased | Hospital & Cluster |
| | 2 | Klebsiella Pneumonia (CRKP) | | | |
| | 3 | MRSA / VRE / CRE | | | |
| | 4 | Pseudomonas | | | |
| | 5 | Other MDROs | | | |
| | 6 | Clostridium Difficile | | | |
| | 7 | Food - borne Organisms | | | |
| | 8 | Water - borne Organisms | | | |
| | 9 | Clostridium Botulinum | | | |
| | 10 | Legionella | 1 - 2 Cases | 1 Deceased | |
| | 11 | Fungal / Candida albicans | 2 - 4 Cases | 1-2 Deceased | |
| | 12 | Other Candida Species | | | |
| | 13 | Candida Auris | 1 - 2 Cases | 1 Deceased | |
| | 14 | Aspergillus Species | | | |
| | 15 | Hepatitis A virus (HAV) | 2 - 4 Cases | 1 - 2 Deceased | |
| | 16 | Hepatitis B virus (HBV) | | | |
| | 17 | Hepatitis C virus (HCV) | 1 - 2 Cases | 1 Deceased | |
| | 18 | Measles | 2 - 4 Cases | 1 - 2 Deceased | |
| | 19 | Chickenpox | | | |
| | 20 | Influenza or Influenza Like Illness (ILI) | 3 - 4 Cases | 1 - 2 Deceased | |
| | 21 | COVID- 19 Outbreak | 2 - 5 Cases | 1 - 2 Deceased | |
| | 22 | MERS-CoV | 1 - 2 Cases | 1 Deceased | |

# Roles and Responsibilities in Outbreak

## 1. Healthcare Facilities level

### 1.1. Nursing Staff roles

1.1.1. Immediately notify the infection prevention and control department's personnel.

1.1.2. Direct HCWs towards their responsibilities for patients and outbreaks.

1.1.3. Implement IPC policies and practices immediately.

1.1.4. Implement the hospital outbreak management action plan provided by GDIPC.

1.1.5. Prepare a primary list of patients, staff, and their contacts.

1.1.6. Proper collection, labelling and follow up of laboratory samples.

1.1.7. Assist in the collection of environmental samples.

1.1.8. Provide information and help the hospital's OMT in the investigation.

### 1.2. Treating Consultants/Physicians on charge roles:

1.2.1 Suspect and early detect outbreaks.

1.2.2. Ensure that colonized/infected patients have received an appropriate medical care according to MOH regulations.

1.2.3. Isolate/de-isolate the patients (in coordination with IPC) depending on the type of the outbreak.

1.2.4. Identify the contacts (HCW and patients) and properly deal with them.

1.2.5. Communicate treatment information and infection control precautions to patients/relatives.

### 1.3. Infection Control Department Personnel roles:

1.3.1. Confirm whether there is an outbreak or not by reviewing the preliminary information on the number of potential cases, available laboratory results, severity of the problem, and demographic data of person(s), place and time (line list).

1.3.2. Immediately notify the hospital administration, cluster outbreak management department through the official notification form within 2-6 hours.

1.3.3. Immediately notify the hospital OMT.

1.3.4. Immediately begin acting upon the outbreak management action plan.

1.3.5. Share, help and supervise HCWs in the defined unit for well implementing the plan of outbreak's infection control measures.

1.3.6. Discuss the outbreak information with the relevant treating physicians, ID consultants, laboratory specialist, and environmental officers.
1.3.7. Compare surveillance data and laboratory records, discharge data, mortality statistics and other pertinent records.
1.3.8. Activate hospital OMT depending on the type and situation of the outbreak and distribute the responsibilities.
1.3.9. Escalate the incident of the outbreak to the hospital infection prevention control committee in its upcoming meeting.
1.3.10. Assist the cluster coordinator in the investigation processes by primarily preparing at least line listing and contact list of HCWs and patients.
1.3.11. Visit regularly and on demand the unit to review the patient's clinical findings, laboratory results and relevant outbreak data.
1.3.12. Conduct daily rounds to follow up the cases, notify new cases and report the deceased.
The hospital outbreak coordinator is held responsible for the above action, in front of the IPC head in the hospital.
**1.3.13.** Observe staff practices about basic IC measures and identify any breach of practice. Conduct retraining & education session for HCWs about basic infection control measures as per OMAP

- The hospital's IPC department is held responsible in front of the regional IPC and GDIPC.

**1.4. Hospital Laboratory roles:**

1.4.1. Immediate notification of patients' abnormal and critical results to the IPC personnel and treating physicians.
1.4.2. Provide microbiology services (swab, diagnostic and confirmatory tests etc., for patients and HCWs) during the investigation of outbreaks.
1.4.3. Assist in the environmental sample collection and analysis.
1.4.4. Appoint a member to participate in the activities of OMT.
1.4.5. Store and refer specimens to the relevant regional reference laboratories.

**1. 5. Environmental Health Officer Roles:**

1.5.1. Plan (methods of collection, sites, etc...) and arrange for environmental sampling.
1.5.2. Collect specimens of suspected food from kitchens and outbreak defined places.

1.5.3. Assess the statue and condition of water (distribution systems, sinks and faucets).

1.5.4. Asses the condition of heating, ventilation and air conditioning (HVAC System) and look for a possibility of taking an air sampling.

**1.6. Hospital OMT roles:**

1.6.1. Confirm the existence of an outbreak.

1.6.2. Establish case definition.

1.6.3. Report the outbreak within 2-6 hours, and provide interim and status reports when deemed necessary.

1.6.4. Determine the extent of the outbreak through active-case finding.

1.6.5. Investigate the source and cause of the outbreak.

1.6.6. Make sure laboratory tests are undertaken appropriately and promptly.

1.6.7. Generate a hypothesis on the occurrence of the outbreak whenever possible.

1.6.8. Define and implement control measures.

1.6.9. Implement a screening policy during the outbreak for patients and staff.

1.6.10. Asses the requirement for additional supplies and staff in case of a large outbreak.

1.6.11. Coordinate with the hospital managers for assisting the OMT.

1.6.12. Keep the HCWs in the hospital aware of the outbreak, regularly update them on its situation, and provide training and clear recommendations.

1.6.13. Declare the end of the outbreak after the regional OMT and GDIPC's consultation and approval.

1.6.14. Make sure prompt, consistent, accurate and adequate information is available.

1.6.15. Maintain the confidentiality of the outbreak data.

## 2. Cluster Level

**2.1. Outbreak Coordinator roles**:

2.1.1. Immediately after receiving the notification from the determined hospital, start the outbreak investigation process in step by step matter.

2.1.2. Fill the necessary outbreak forms and documents (line list, contact list (HCW), contact list (patients) completely and correctly.

2.1.3. Draw the Epidemic Curve.

2.1.4. Send the necessary outbreak forms and documents (line list, contact list (HCW), contact list (patients) along with the epidemic curve to RHD within 24-48 hours.

2.1.5. Monitor the implementation of the hospital outbreak management action plan (OMAP) and evaluate control measures instituted by the hospital.
2.1.6. Supervise and follow up the hospital outbreak management action plan in the determined hospital.
2.1.7. Provide technical and administrative support to contain the outbreak.
2.1.8. Daily update and inform GDIPC outbreak management department with the number of new cases and the deceased.
2.1.9. Weekly and on demand visit the determined hospital in order to contain the outbreak.
2.1.10. Communicate with the other relevant regional departments for coordinating with e.g. (Public Health Department, Regional Laboratory...etc.).
2.1.11. According to the available data and information classify the level of outbreak (A, B or C).
2.1.12. If it is level C cluster (if available) is required to prepare corrective action plan based on site visit with the hospital.
2.1.13. If it is level B or A, RHD will manage the situation with cluster team.

**2.2. Cluster Outbreak Management Team (OMT)**

- Generally, the members of an OMT are as follows:
  - ✓ Infection Control coordinator.
  - ✓ Epidemiologist.
  - ✓ Clinical Microbiologist.
  - ✓ Infectious disease consultant.
  - ✓ Public health (Environmental health).
  - ✓ Supportive services department.
  - ✓ Supplies department.
  - ✓ Pharmacy Administration.

N. The cluster OMT may require additional members according to the nature of the outbreak.

- ✓ In case of the members' turnover (very common), an alternate should be assigned.
- ✓ Hospital-associated infection outbreaks (HAIO) occur unexpectedly, therefore a local OMT for each region must be assigned to immediately intervene and apply control

measures instead of arranging with an external OMT, to avoid a delay in control measurements application.

- ✓ It is recommended for the local teams to be close to the outbreak field and available once called.
- ✓ During HAIO, the coordinator of OMT should contact the team members to assemble and preliminary discuss (online or face to face) the notification and decide the course of investigation and field team members required based on the outbreak's nature.
- ✓ The field team is dedicated to follow the investigative fieldwork, and control measures. The team is not authorized to communicate with or give any information to anybody except to the head of OMT.
- ✓ The field team should have a senior assigned as a leader four main members are preferred to be present in the field team to investigate a HAIO:
  - Epidemiologist.
  - Laboratory Specialist.
  - Environmental Investigator.
  - Infection Control Specialist.
- ✓ The OMT assigned members do not have to be from one hospital or in one place at all times, and only need to assemble during the outbreak.
- ✓ The final decision about the outbreak status or control measures should be made by the OMT after final discussion.

**Cluster OMT roles**

2.2.1. Follow, monitor and evaluate the same activities and steps taken by the hospital's OMT.

2.2.2. Perform corrective plan methods and apply appropriate preventive measures as needed.

2.2.3. Declare the end of the outbreak after the RHD consultation and approval.

## 3. Regional Directorate Level

**3.1. Outbreak Coordinator roles**:

3.1.1. If the outbreak classified as level C, the role of RHD coordinators in the region will be supervise and ensure meeting the previous mentioned points above in cluster section.

3.1.1.1. Review and monitor the corrective plan done by cluster and hospital for level C outbreak.

3.1.2. If the outbreak classify as level B and A the role of RHD coordinators in the region will be:

3.1.2.1 Review and check all required outbreak forms that filled by the hospital, for example (line list, contact list (HCW), contact list (patients) to guarantee correct data.

3.1.2.2. Send the necessary outbreak forms and documents (line list, contact list (HCW), contact list (patients) along with the epidemic curve to GDIPC within 24-48 hours.

3.1.2.3. Monitor the implementation of the hospital outbreak management action plan (OMAP) and evaluate control measures instituted by the hospital.

3.1.3. Supervise and follow up the hospital outbreak management action plan in the determined hospital.

3.1.4. Provide technical and administrative support to contain the outbreak.

3.1.5. Daily update and inform GDIPC outbreak management department with the number of new cases and the deceased.

3.1.6. Weekly and on demand visit the determined hospital in order to contain the outbreak.

3.1.7. Communicate with the other relevant regional departments for coordinating with e.g. (Public Health Department, Regional Laboratory...etc.).

3.1.8. According to the available data and information classify the level of outbreak (A, B or C).

3.1.9. If it is level B or A, activate the regional OMT and regional IPC committee.

3.1.10. If it is level B or A, complete the Outbreak risk assessment tool based on site visit. See Appendix 8

3.1.11. Based on the risk assessment tool results, RHD is required to prepare corrective plane.

3.1.12. Discuss data, information, results of the outbreak risk assessment tool and corrective plan with the GDIPC.

**3.2. Regional Outbreak Management Team (OMT)**

- Generally, the members of an OMT are as follows:
- Infection Control coordinator.
- Epidemiologist.
- Clinical Microbiologist.
- Infectious disease consultant.
- Public health (Environmental health).
- Supportive services department.
- Supplies department.

- Pharmacy Administration.

  Note:

  - ✓ The regional OMT may require additional members according to the nature of the outbreak.
  - ✓ In case of the members' turnover (very common), an alternate should be assigned.
- HAIO occur unexpectedly, therefore a local OMT for each region must be assigned to immediately intervene and apply control measures instead of arranging with an external OMT, to avoid a delay in control measurements application.
- It is recommended for the local teams to be close to the outbreak field and available once called.
- During HAIO, the coordinator of OMT should contact the team members to assemble and preliminary discuss (online or face to face) the notification and decide the course of investigation and field team members required based on the outbreak's nature.
- The field team is dedicated to follow the investigative fieldwork, and control measures. The team is not authorized to communicate with or give any information to anybody except to the head of OMT.
- The field team should have a senior assigned as a leader four main members are preferred to be present in the field team to investigate a HAIO:
  - ✓ 1. Epidemiologist.
  - ✓ 2. Laboratory Specialist.
  - ✓ 3. Environmental Investigator.
  - ✓ 4. Infection Control Specialist.
- The OMT assigned members do not have to be from one hospital or in one place at all times, and only need to assemble during the outbreak.
- The final decision about the outbreak status or control measures should be made by the OMT after final discussion.
- GDIPC Central OMT is contacted based on the judgement of the internal OMT, and the decision of the higher authority in the following cases:
  - ✓ 1. There is no internal OMT in the region.
  - ✓ 2. The internal team is unable to control the outbreak.
  - ✓ 3. In case of a new disease e.g. new and internationally unknown MDRO.
  - ✓ 4. High incidence of the disease.
  - ✓ 5. Severity of the disease reflected by case-fatality rate, specific-mortality rate,

disability, and hospitalization.

- ✓ 6. Vast or wide spread area.

**Regional OMT roles**

3.2.1. Follow, monitor and evaluate the same activities and steps taken by the hospital's OMT.

3.2.2. Perform corrective investigation methods and apply appropriate preventive measures as needed.

3.2.3. Declare the end of the outbreak after the GDIPC's consultation and approval.

## 4. General Directorate of Infection Prevention and Control level:

- Provide approved guidelines, new publications, scientific studies or references for the management of an outbreak.
- Develop outbreak strategic and annual plans for prevention and control in collaboration with the Regional Directorates and Healthcare Facilities.
- Communicate with the Infection Control Personnel in Regional Directorates to confirm that the Hospital Outbreak Infection Control Management Plan (is immediately and properly instituted.
- Provide technical support and feedback to Regional Directorates and IPC departments in healthcare facilities.
- Prepare preliminary and summary reports for the known outbreaks, to be presented to the Higher Authorities in MOH.
- Classify the levels of outbreaks into an A, B or C, and receive the notification form depending on available data, interviews, follow up and criteria judgment.
- Coordinate with the GDIPC relevant programs e.g. Surveillance, Training, Audit Programs and others.
- Train HCWs who work in the outbreak field in the Healthcare Facility.
- Share in the formation of academic curriculum of the diploma and alike.
- Design specific projects of prevention and control to contain certain types of outbreaks whether they are new emerging diseases or concern/raising healthcare facilities events.
- Provide researches, scientific papers and references...etc.
- Hold seminars and conferences.
- Develop partnership with the related bodies outside MOH.
- Give feedback and disseminate the findings and reports to the concerned personnel,

specifically the Regional Coordinators and the Hospital Outbreak Coordinators.

- Create Key Performance Indicators (KPIs) to evaluate the outbreak programs at all levels.
- Develop the criteria of selection, for the regional and hospital outbreak coordinators.

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# Appendix-1: Survival of Microorganisms

| Bacteria | Range of survival (environment) |
|---|---|
| Acinetobacter spp. | 3 days to 1 year (in-vitro) |
| | 36 days within biofilm vs. 15 days for non-biofilm-forming strains |
| Bordetella pertussis | 3 to >10 days; in pernasal swabs: >4 days |
| Campylobacter jejuni | >6 days, in water >60 days |
| Clostridium difficile spores | 5 months |
| C. difficile, vegetative form | 15 min (dry surface) |
| | 6 h (moist surface) |
| Chlamydia pneumoniae | ≤96 h |
| C. trachomatis | <1 week |
| Chlamydia psittaci | 15 days to months (environment) |
| Corynebacterium diphtheriae | 7 days to 6 months |
| Corynebacterium pseudotuberculosis | 1–8 days, up to several weeks (environment) |
| Enterococcus spp. including VRE | 5 days up to 30 months |
| Escherichia coli | 1.5 h to 16 months |
| E. coli O157:H7 | 27 days on spinach leaves, 179 days in soil, 98 days in water |
| Haemophilus influenzae | 12 days |
| Helicobacter pylori | ≤90 min; in water: 2–30 days |
| Klebsiella spp. | 2 h to >30 months, ≤144 h in detergent solution |
| Listeria spp. | 1 day–months, 141 days in water |
| Mycobacterium bovis | >2 months |
| Mycobacterium tuberculosis | 1 day up to 4 months |
| Neisseria gonorrhoeae | 1–3 days |
| Neisseria meningitidis | 72 h |
| Parachlamydia acanthamoebae | <4 weeks, in presence of blood <7 weeks |
| Proteus vulgaris | 1–2 days |
| Pseudomonas aeruginosa | 6 h up to 16 months; on dry floor: 5 weeks; in aerosol: few hours |
| Salmonella typhi | 6 h up to 4 weeks |
| Salmonella typhimurium | 10 days up to 4.2 years |
| Salmonella spp. | 1 day |
| Non typhoid Salmonella spp. | 336 days |
| Salmonella enteritidis (broiler farms) | 1 year |

| | |
|---|---|
| Salmonella enteritica sv. Tennessie | 30 days (dried in desiccated milk powder) |
| Serratia marcescens | 3 days up to 2 months; on dry floor: 5 weeks |
| Shigella spp. | 2 days up to 5 months |
| | 3–11 days in water |
| MRSA and MSSA | 7 days up to 1 year (in-vitro) |
| | 9–12 days (plastic surfaces) |
| | 72 h (stainless steel) |
| | 6 h (copper) |
| | ≤28 days (dry mops) |
| | ≤14 days (in water) |
| Streptococcus pneumoniae | 1 day up to 30 month |
| Streptococcus pyogenes | 3 days up to 6.5 months |
| Vibrio cholerae | 1–7 days |
| Yersinia enterocolitica | Up to 64 weeks (in water) |
| Yersinia pestis | Up to 5 days |

| Viruses | Range of survival (environment) |
|---|---|
| Adenovirus | <6 h up to 3 months (type dependent), ≤301 days (in water) |
| Astrovirus | 7–90 days |
| Avian metapneumonovirus | ~48 h up to 6 days |
| SARS Coronavirus | <5 min up to 24 h (on paper) |
| | 5–28 days (at room temp.) |
| | 28 days (at 4 °C) |
| Coxsackievirus | 7–10 days, up to >2 weeks |
| Cytomegalovirus | 1–8 h |
| Echovirus | Up to 7 days |
| Hepatitis A virus | 2 h up to 60 days |
| Hepatitis B virus | ≥1 week |
| Human immunodeficiency virus | Up to 7 days, 7 days (in peritoneal dialysis effluent), 48 h (on peritoneal dialysis exchange and tubing), 4–8 weeks (on glass cover slides) |
| Herpes simplex virus, Type 1 & 2 | <2 h up to 8 weeks |
| Influenza virus | 1–28 days (strain dependent) |
| | 1–3 days (on banknotes), up to 8 days (admixed in mucous) |
| Marburg virus (strain Popp) | 4–5 days |
| Para-influenza virus | 10 h |
| Norovirus | 8 h up to 7 days, MNV > 40 days (in diapers and gauze) |
| Papillomavirus 16 | ≤7 days |
| Papovavirus | 8 days |
| Parvovirus | >1 year |
| Poliovirus type 1 | 4 h to <8 days |
| Poliovirus type 2 | 1 day up to 8 weeks |
| Pseudorabies virus | ≥7 days, <1 h (in aerosol infectivity decreases by 50 % per hour) |
| Respiratory syncytial virus | up to 6 h |
| Rhinovirus | 2 h up to 7 days |
| Rotavirus | 30 min, 6–60 days |
| Vacciniavirus | 3 weeks up to >20 weeks |

| Fungi | Range of survival (environment) |
|---|---|
| Aspergillus spp. | >30 days |
| Candida albicans | 1 up to 120 days, 24 weeks (in soil-water mixture) |
| Candida parapsilosis | >30 days |
| Candida krusei | 11 days |
| Cryptococcus spp. | 24 weeks (in soil-water mixture) |
| Fusarium spp. | >30 days |
| Mucor spp. | >30 days |
| Paecilomyces spp. | 11 days |
| Torulopsis glabrata | 102–150 days |

# Appendix-2: Environmental Sampling

- Microbiologic sampling of air, water, and inanimate surfaces (i.e., environmental sampling) is an expensive and time-consuming process that is complicated by many variables in protocol, analysis, and interpretation.

## 1. Air Sampling

- Microbiologic air sampling is used as needed to determine the numbers and types of microorganisms, or particulates, in indoor air. Air sampling for quality control is, however, problematic because of lack of uniform air-quality standards.
- Preliminary concerns for conducting air sampling
  - ✓ Consider the possible characteristics and conditions of the aerosol, including size range of particles, relative amount of inert material, concentration of microorganisms, and environmental factors.
  - ✓ Determine the type of sampling instruments, sampling time, and duration of the sampling program.
  - ✓ Determine the number of samples to be taken.
  - ✓ Ensure that adequate equipment and supplies are available.
  - ✓ Determine the method of assay that will ensure optimal recovery of microorganisms.
  - ✓ Select a laboratory that will provide proper microbiologic support.
  - ✓ Ensure that samples can be refrigerated if they cannot be assayed in the laboratory promptly.
- Bacteria, fungi, and particulates in air can be identified and quantified with the same methods and equipment. The basic methods include
  - ✓ Impingement in liquids,
  - ✓ Impaction on solid surfaces,
  - ✓ Sedimentation,
  - ✓ Filtration,
  - ✓ Centrifugation,
  - ✓ Electrostatic precipitation, and
  - ✓ Thermal precipitation.

- Selection of an instrument for air sampling requires a clear understanding of the type of information desired and the particular determinations that must be made. Information may be needed regarding
  - ✓ One particular organism or all organisms that may be present in the air,
  - ✓ The concentration of viable particles or of viable organisms,
  - ✓ The change in concentration with time, and
  - ✓ The size distribution of the collected particles.
- The following factors must be considered when choosing an air sampling instrument:
  - ✓ Viability and type of the organism to be sampled
  - ✓ Compatibility with the selected method of analysis
  - ✓ Sensitivity of particles to sampling
  - ✓ Assumed concentrations and particle size
  - ✓ Whether airborne clumps must be broken (i.e., total viable organism count vs. particle count)
  - ✓ Volume of air to be sampled and length of time sampler is to be continuously operated
  - ✓ Background contamination
  - ✓ Ambient conditions
  - ✓ Sampler collection efficiency
  - ✓ Effort and skill required to operate sampler
  - ✓ Availability and cost of sampler, plus back-up samplers in case of equipment malfunction
  - ✓ Availability of auxiliary equipment and utilities (e.g., vacuum pumps, electricity, and water)

## 2. Water Sampling

- Water sampling in health-care settings is used detect waterborne pathogens of clinical significance or to determine the quality of finished water in a facility's distribution system.
- Routine testing of the water in a health-care facility is usually not indicated, but sampling in support of outbreak investigations can help determine appropriate infection-control measures.
- Health-care facilities that conduct water sampling should have their samples assayed in a laboratory that uses established methods and quality-assurance protocols.

- Water specimens are not “static specimens” at ambient temperature; potential changes in both numbers and types of microbial populations can occur during transport. Consequently, water samples should be sent to the testing laboratory cold (i.e., at approximately 39.2°F [4°C]) and testing should be done as soon as practical after collection (preferably within 24 hours).
- Because most water sampling in health-care facilities involves the testing of finished water from the facility’s distribution system, a reducing agent (i.e., sodium thiosulfate [Na2S2O3]) needs to be added to neutralize residual chlorine or other halogen in the collected sample. If the water contains elevated levels of heavy metals, then a chelating agent should be added to the specimen.
- The minimum volume of water to be collected should be sufficient to complete any and all assays indicated; 100 mL is considered a suitable minimum volume. Sterile collection equipment should always be used.
- Sampling from a tap requires flushing of the water line before sample collection. If the tap is a mixing faucet, attachments (e.g., screens and aerators) must be removed, and hot and then cold water must be run through the tap before collecting the sample. If the cleanliness of the tap is questionable, disinfection with 500–600 ppm sodium hypochlorite (1:100 v/v dilution of chlorine bleach) and flushing the tap should precede sample collection.
- Use of aerobic, heterotrophic plate counts allows both a qualitative and quantitative measurement for water quality. If bacterial counts in water are expected to be high in number (e.g., during waterborne outbreak investigations), assaying small quantities using pour plates or spread plates is appropriate.

### 3. Environmental Surface Sampling

- Routine environmental-surface sampling (e.g., surveillance cultures) in health-care settings is neither cost-effective nor warranted.
- When indicated, surface sampling should be conducted with multidisciplinary approval
- The following factors should be considered before engaging in environmental-surface sampling:
  - ✓ Background information from the literature and present activities (i.e., preliminary results from an epidemiologic investigation)
  - ✓ Location of surfaces to be sampled
  - ✓ Method of sample collection and the appropriate equipment for this task

- ✓ Number of replicate samples needed and which control or comparison samples are required
- ✓ Parameters of the sample assay method and whether the sampling will be qualitative, quantitative, or both
- ✓ An estimate of the maximum allowable microbial numbers or types on the surface(s) sampled (refer to the Spaulding classification for devices and surfaces)
- ✓ Some anticipation of a corrective action plan

- Effective sampling of surfaces requires moisture, either already present on the surface to be sampled or via moistened swabs, sponges, wipes, agar surfaces, or membrane filters. Dilution fluids and rinse fluids include various buffers or general purpose broth media
- If disinfectant residuals are expected on surfaces being sampled, specific neutralizer chemicals should be used in both the growth media and the dilution or rinse fluids.
- The inclusion of appropriate control specimens should be included to rule out both residual antimicrobial activity from surface disinfectants and potential toxicity caused by the presence of neutralizer chemicals carried over into the assay system

- Methods of environmental-surface sampling

| Method | Suitable for appropriate surface(s) | Assay technique | Procedural notes | Points of interpretation | Available standards |
|---|---|---|---|---|---|
| Sample/rinse (Moistened swab/rinse) | Non-absorbent surfaces, corners, crevices, devices, and instruments | Dilutions; qualitative or quantitative assays | Assay multiple measures areas or devices with separate swabs | Report results per measured areas or if assaying an object, per the entire sample site | YES: food industry; NO: heath care |
| Sample/rinse (Moistened sponge/rinse) | Large areas and housekeeping surfaces (e.g., floors or walls) | Dilutions; qualitative or quantitative assays | Vigorously rub a sterile sponge over the surface | Report results per measured area | YES: food industry; NO: health care |
| Sample/rinse (Moistened wipe/rinse) | Large areas and housekeeping surfaces (e.g., countertops) | Dilutions; qualitative or quantitative assays | Use a sterile wipe | Report results per measured area | YES: food industry; NO: health care |
| Direct immersion | Small items capable of being immersed | Dilutions; qualitative or quantitative assays | Use membrane filtration if rinse volume is large and anticipated microbiological concentration is low | Report results per item | NO |
| Containment | Interior surfaces of containers, tubes, or bottles | Dilutions; qualitative or quantitative assays | Use membrane filtration if rinse volume is large | Evaluate both the types and numbers of microorganisms | YES: food and industrial applications for containers prior to fill |
| RODAC (Replicate Organism Direct Agar Contact) | Previously cleaned and sanitized flat, non-absorbent surfaces; not suitable for irregular surfaces | Direct assay | Overgrowth occurs if used on heavily contaminated surfaces; use neutralizers in the agar if surface disinfectant residuals are present | Provides direct, quantitative results; use a minimum of 15 plates per an average hospital room | NO |

# Appendix-3: Intensified interventions to prevent MDROs

**Intensified interventions to prevent MDROs Transmission according to CDC guideline**

| | |
|---|---|
| **1- Indication and Approach** | • When incidence of MDROs is not decreasing despite implementation of and correct compliance to the routine control measures described above.<br>• When an outbreak of an epidemiological important MDRO is identified for the first time in the healthcare facility. |
| **2- Administrative measures.** | • Assess healthcare system constituents for their role in creating and continuing transmission of MDROs.<br>• Develop, implement and monitor action plans to correct system failures.<br>• Keep good communication and feedback to update on the progress and effectiveness of interventions. |
| **3- Educational interventions:** | • Increase the frequency of MDRO educational programs for those who work in areas with high MDRO rates. Additional review of wise utilization of antimicrobial agents:<br>• Review the role of antimicrobial use in continuing the MDRO problem.<br>• Antimicrobial agents that may be targeted cover vancomycin anti-anaerobic agents for VRE, 3rd generation cephalosporin for ESBL, quinolones and carbapenems.<br>• Give education on prevention and control of MDROs to all HCWs.<br>• Do the assessment and evaluation of the staff's knowledge and skills by field observation and the online Infection Control module when available |
| **4-. Judicious use of Antimicrobial Agents** | • Use antimicrobial prophylaxis in surgical patients and monitor it in terms of type of antibiotic, timeline between antibiotic administration and incision, antibiotic re-dosing during long duration surgeries and discontinuation of antibiotics.<br>• Discontinue antimicrobial surgical prophylaxis within 24 hours from anesthesia end time for all surgeries including cardiovascular surgeries |
| **5- Surveillance:** | A- Collect, calculate and analyze prevalence and incidence rates of targeted MDRO infections and colonization in populations at risk.<br><br>• Include only one-isolated bacteria per patient, not multiple isolates from the same patient, when calculating rates.<br>• Increase the frequency of collecting and monitoring antimicrobial susceptibility summary reports for a targeted MDRO, as indicated by increase in incidence of infection or colonization with that MDRO. |

| | |
|---|---|
| | • Develop and implement protocols to obtain active surveillance cultures (ASC) for targeted MDROs from patients in populations at risk.<br><br>B- Obtain ASC from areas of skin breakdowns and draining wounds. In addition, includes the following sites:<br><br>• For MRSA: swab from anterior nares is usually sufficient in adults. For pediatric age group and neonates, swab axillae and groins.<br>• For VRE: rectal swab.<br>• For MDR-GNB: rectal swab.<br><br>C-Take surveillance cultures for the target MDRO from patients at the time of admission to high -risk areas, and at periodic intervals as needed to assess MDRO transmission.<br><br>D-Carry out culture surveys to evaluate the effectiveness of the enhanced MDRO control interventions.<br><br>E- Conduct serial (e.g. weekly, until transmission has ceased and then decreasing frequency) unit specific point-prevalence culture surveys of the target MDRO to decide if transmission has reduced or stopped.<br><br>If indicated, collect cultures to assess colonization status of roommates and other patients with substantial exposure to patients with known MDRO infection.<br><br>G-Obtain cultures of HCW for target MDRO when there is epidemiological evidence that HCW is a source of ongoing transmission. |
| **6- Enhanced Infection Control Precautions** | **Transmission-Based Precautions**<br><br>• Start contact precautions in addition to standard precautions and place contact precautions sign on the door.<br>• Practice strict hand washing.<br>• Cohort non-critical items to the patient (in the patient room).<br>• Minimize the amount of supplies in the patient room.<br>• Use isolation cart outside the patient room.<br>• Limit patient's activity outside the room for treatment or tests.<br>• Make sure that same time and terminal cleaning of isolation room and equipment is per housekeeping procedures.<br>• Handle/discard contaminated objects as per Standard Precautions.<br>• Request Infectious Diseases consultation as needed.<br>• Discharge patient if medical condition allows.<br>• Discontinue isolation after prior consultation with the ICP. |

| | |
|---|---|
| | **Notification OF MDROs:**<br><br>• Report all MDROs by phone to the ICP & to the ward of the MDRO patient.<br>• Assign ICP to key areas to observe the staff compliance to infection control guidelines regarding isolation and contact precautions for patients with MDROs.<br>• Identify patients with MDROs by daily review of microbiology results.<br>• Provide feedback on MDRO by patient-care units quarterly to hospital administration and infection control committee.<br><br>**Screening**<br><br>• Manage the Outbreak in coordination with ICP and the cooperation of medical, nursing, laboratory and other departments.<br>• Screen Healthcare workers (HCWs) and the environment only when indicated e.g . When there is an epidemiological link to an ongoing outbreak.<br>• Do not routinely culture HCW or environment since it is not indicated and causes unnecessary costs.<br>• Consult ICP before screening<br><br>**DO MDROs screening for**:<br><br>• Patients transferred from other hospitals<br>• Patient with history of Hospitalization in the last 90 days.<br>• All patients in ICU/NICU …on admission.<br>• Patient who undergo the following surgeries: neurosurgery, cardiac surgery, and orthopedic surgery<br><br>**N.B**; according to type of microorganisms / indication of screening / site of sampling |
| **7- Patient admission and Placement** | • Perform contact precautions routinely for all patients colonized or infected with the target MDROs.<br>• Put on gowns and gloves before or upon entry to the patient's room. Start maximum contact precautions until the surveillance culture is reported negative.<br>• Start policies for patient admission and placement as needed to prevent transmission of MDROs.<br>• Place MDROs patients in single patient-rooms.<br>• Cohort patients with the same MDROs.<br>• Assign dedicated nurses and ancillary service staff to the care of MDROs patients only.<br>• Stop new admissions to the unit if transmission continues despite the implementation of the increased control measures. |

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| **8-Enhanced Environmental Measures:** | • Start patient-dedicated or single use disposable non-critical equipment (e.g. blood pressure cuff, stethoscope), instruments, and devices.<br>• Monitor compliance to environmental cleaning policies.<br>• Monitor cleaning performance to make sure of consistent cleaning and disinfection of surfaces in close proximity to the patient.<br>• Obtain environmental cultures when there is epidemiological evidence than an environmental source is associated with on-going transmission of the targeted MDROs.<br>• Empty units for environmental intensive cleaning when previous efforts have failed.<br>• Clean patient's room.<br>• Clean rooms everyday by the designated personnel with disposable or dedicated equipment.<br>• Change mop water after each isolation patient's room is completed.<br>• Wipe mop handles with disinfectant and the mop head will be bagged and sent to the laundry.<br>• Clean all equipment with hospital approved disinfectant after each use.<br>• Do terminal cleaning of the room: This includes changing the curtains and wet disinfectant/mopping of floors, walls, bed, bedside table, telephone, and IV poles, etc. curtains, sheets, and other durable items will be bagged and sent to the laundry.<br>• Use single-use or disposable equipment for the care of patients with MDROs- whenever possible.<br>• Clean when durable equipment is used, including but not limited to portable x-ray machines, ABG machines, dialysis machines, etc., the equipment with hospital approved disinfectant and/or according to manufacturer's recommendations before the equipment is used to care for another patient.<br>• Keep all medical items such as dressings, syringes, IV fluids, etc. to minimal in the patient room; if these items found in the patient room after diagnosis with MDROs - all should be discarded.<br>• Keep linen in water-soluble bag and send to laundry as per hospital policy.<br>• If the patient bed and /or other equipment such as an IV pole accompany the patient the patient on the transport, the bedrails and equipment should be wiped down with hospital approved disinfectant prior to the transport.<br>• HCWs should wear PPE to handle the patient at the transport destination.<br>• Clean the testing and procedure area with hospital approved disinfectant after MDROs- patient leaves the area.<br>• Do all procedures in the patient's room if applicable.<br>• Do not allow sitter except if medically indicated.<br>• Educate the sitter to follow infection control precautions.<br>• Make sure all visitors of patients who are on contact isolation for MDROs should follow the isolation requirements. This means that |

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|---|---|
| | visitors should use a gloves and gown when in the patient's room. A mask should also be worn if the organism is in the patient's sputum. When the visitor exits, the gown, gloves, and mask should be removed inside the room and hand washing with water and soap or alcohol-based hand cleanser should be performed. If visitors follow these requirements, there is no restriction on their movement in the hospital.<br>• Make sure isolation requirements are followed whenever possible in the case of visitors who sleep in the patient's room (i.e. parents staying with a child on isolation for MDROs).<br>• Put on a clean change of clothes and perform thorough hand hygiene must be followed by the visitors prior to exiting the patient's room if gowns and gloves are not worn (i.e. when sleeping or during prolonged hospitalizations). If these isolation requirements cannot be met for any reason, then when leaving the patient's room the visitor should proceed directly out of the hospital without visiting other patients or any common-use areas.<br>• Reprocess ventilators used by patients with MDROs according to manufacturer recommendations.<br>• Designate respiratory therapist to provide care to patients with MDROs.<br>• Make sure patients with MDROs are seen last or at the end of the day if possible, including patient travelling to wound care room or physiotherapy |
| **9-Decolonization**<br><br>. | • Consult with Infection Control Practitioner (ICP) on a case-by-case basis regarding the appropriate use of decolonization therapy.<br>• When decolonization for MRSA is practiced, perform sensitivity testing for the decolonizing agent.<br>• Monitor susceptibility to detect emergence resistance to decolonizing agent.<br>• Test for mupirocin resistance.<br>• Limit decolonization of HCW discovered to be colonized with MRSA / C. auris to people who have been epidemiologically linked as a likely original source of ongoing transmission.<br>• Consider reassignment of HCW if decolonization is not successful and on-going transmission to patients persists.<br>• No recommendation for decolonizing cases with MDR-GNB or VRE. Regimens and efficacy of decolonization protocols for these VRE and MDR-GNB have not been established.– CRE PROTOCOL )<br>• Discuss, analyze and approve all issues to the Infection Control committee in control, prevention and surveillance of MDRO infection |

# Appendix-4: MRSA Decolonization

**Assessment of MRSA decolonization**

- Assessment for decolonization will be performed by the Infection Control Practitioner (ICP).
- Consult with ICP on a case-by-case basis regarding the appropriate use of decolonization therapy.
- When decolonization for MRSA is practiced, perform sensitivity testing for the decolonizing agent.
- Monitor susceptibility to detect emergence resistance to decolonizing agent.
- Test for mupirocin resistance.
- Limit decolonization of HCW discovered to be colonized with MRSA to people who have been epidemiologically linked as a likely original source of ongoing transmission.
- Consider reassignment of HCW if decolonization is not successful and on-going transmission to patients persists.
- No recommendation for decolonizing cases with MDR gram negative pathogens such as VRE, CRE

**Requirements:**

- Maintain Contact Isolation during decolonization treatment.
- Supplies:
    - ✓ Chlorhexidine 4%.
    - ✓ Mupirocin/Bactroban, per MD order.
    - ✓ Clean linens for the bed and patient.
    - ✓ Personal protective equipment (PPE).

**Process**

- Spread full-strength Chlorhexidine 4% solution from neck to toes, making sure of coverage of underarms, groin, and between fingers and toes.
- Cover the patient with a sheet and wait for 10 minutes.
- Rinse with warm water.
- Change the bed linens and the patient's clothing completely after each bath/shower.
- Repeat this process twice a day.
- Shampoo hair with the Chlorhexidine solution for 3 days.

- Apply Mupirocin/Bactroban ointment to anterior nares (inside nose) after Chlorhexidine treatment, when the patient is dry and dressed as ordered by the MD.
- Mupirocin should not be applied to open wounds.
- These treatments must be given for 7 consecutive days.
- Take a complete set of cultures from nares and previously positive sites 72 hours after decolonization.
- If 1st set of samples is negative repeat cultures 48 hours later.
- Three negative cultures are required before the patient is cleared of MRSA and can be taken out of isolation.
- These results will be assessed by the ICP.
- NOTES:
- The patient must not be on antibiotics at the time of screening.
- If any swab is positive, stop the screening process until further assessment.
- Please complete all documentation on this form. The ICP will collect the form when completed.

**MRSA DECOLONIZATION RECORD**

START DATE:_____

| TREATMENT TIME | CHLORHEXIDINE 4% WASH & SHAMPOO | MUPIROCIN/BACTROBAN OINTMENT | INITIALS |
|---|---|---|---|
| DAY 1 | | | |
| | | | |
| DAY 2 | | | |
| | | | |
| DAY 3 | | | |
| | | | |
| DAY 4 | | | |
| | | | |
| DAY 5 | | | |
| | | | |
| DAY 6 | | | |
| | | | |
| DAY 7 | | | |
| | | | |

# Appendix-5: Molecular typing methods

| Method | Principle | Advantages | Limits |
|---|---|---|---|
| Pulsed-field gel electrophoresis (PFGE) | Whole genome restriction polymorphism | ○ Excellent discriminatory power<br>○ High intra- and inter-laboratory reproducibility<br>○ High epidemiological concordance<br>○ Moderate cost | ○ Limited ease of use<br>○ Not rapid<br>○ Limited portability<br>○ Moderate interpretation<br>○ Low resolution for similar fragments size |
| Amplified fragment length polymorphism (AFLP) | Selective PCR amplification of a subset of restriction fragments | ○ Excellent discriminatory power<br>○ High reproducibility | ○ Limited ease of use<br>○ Not rapid<br>○ High cost |
| Random Amplification of Polymorphic DNA (RAPD) | PCR amplification of random segments of genomic DNA with single primer of arbitrary nucleotide sequence | ○ High rapidity<br>○ Ease of use<br>○ Low cost | ○ Low discriminatory power<br>○ Low intra-laboratory reproducibility |
| Repetitive-element polymerase chain reaction (rep-PCR) | PCR amplification of non coding intergenic repetitive sequences | ○ High rapidity<br>○ High discriminatory power<br>○ Ease of use<br>○ Low cost | ○ Low inter- laboratory reproducibility (improved by semi-automated commercial systems) |
| Variable-Number Tandem Repeat (VNTR) typing and Multilocus VNTR analysis (MLVA) | PCR amplification of polymorphisms of genomic variable number tandem repeat elements | ○ Excellent reproducibility<br>○ High discriminatory power<br>○ Ease of use<br>○ Accessibility<br>○ High Rapidity<br>○ Moderate cost | ○ Moderate inter-laboratory reproducibility |

| | | | |
|---|---|---|---|
| Single Locus Sequence Typing (SLST) | Sequencing of single target gene | ○ High discriminatory power for some species (e.g. spa-typing for S. aureus)<br>○ Ease of use<br>○ High rapidity<br>○ Moderate cost | ○ Potential misclassification of particular types, due to recombination and/or homoplasy |
| Multilocus sequence typing (MLST) | Sequencing of allelic variants of 7 housekeeping genes. | ○ Excellent reproducibility<br>○ Portability<br>○ Standard nomenclature<br>○ High discriminatory power (not for all species) | ○ Limited ease of use<br>○ Not rapid<br>○ Limited accessibility<br>○ High cost |
| Comparative genomic hybridisation (CGH): microarrays | Labelled cDNA/RNA, hybridized with specific probes | ○ High throughput technique<br>○ Simultaneous genotyping and profiling | ○ Poor accessibility<br>○ The intra- and inter-laboratory reproducibility of microarray data needs to be established prior to the application<br>○ High cost |
| Whole Genome - Next generation Sequencing (WG -NGS) | Sequencing of multiple, overlapped regions | ○ High throughput technique | ○ Limited ease of use<br>○ Limited accessibility |

# Appendix-6: Common Disinfectants

**Appendix 6.1: Summary of advantages and disadvantages of High-level disinfectants**

| Sterilization Method | Advantages | Disadvantages |
|---|---|---|
| **Peracetic Acid/Hydrogen Peroxide** | • No activation required<br>• Odor or irritation not significant | • Materials compatibility concerns (lead, brass, copper, zinc) both cosmetic and functional<br>• Limited clinical experience<br>• Potential for eye and skin damage |
| **Glutaraldehyde** | • Numerous use studies published<br>• Relatively inexpensive<br>• Excellent materials compatibility | • Respiratory irritation from glutaraldehyde vapor<br>• Pungent and irritating odor<br>• Relatively slow mycobactericidal activity<br>• Coagulates blood and fixes tissue to surfaces<br>• Allergic contact dermatitis<br>• Glutaraldehyde vapor monitoring recommended |
| **Hydrogen Peroxide** | • No activation required<br>• May enhance removal of organic matter and organisms<br>• No disposal issues<br>• No odor or irritation issues<br>• Does not coagulate blood or fix tissues to surfaces<br>• Inactivates Cryptosporidium | • Material compatibility concerns (brass, zinc, copper, and nickel/silver plating) both cosmetic and functional<br>• Serious eye damage with contact |
| **Ortho-phthalaldehyde** | • Fast acting high-level disinfectant<br>• No activation required<br>• Odor not significant<br>• Excellent materials compatibility claimed<br>• Does not coagulate blood or fix tissues to surfaces claimed | • Stains skin, mucous membranes, clothing, and environmental surfaces<br>• Repeated exposure may result in hypersensitivity in some patients with bladder cancer<br>• More expensive than glutaraldehyde<br>• Eye irritation with contact<br>• Slow sporicidal activity |
| **Peracetic Acid** | • Rapid sterilization cycle time (30-45 minutes)<br>• Low temperature (50-55°C) liquid immersion sterilization<br>• Environmental friendly by-products (acetic acid, O2, H20)<br>• Fully automated<br>• Single-use system eliminates | • Potential material incompatibility (e.g., aluminum anodized coating becomes dull)<br>• Used for immersible instruments only<br>• Biological indicator may not be suitable for routine monitoring<br>• One scope or a small number of instruments can be processed in a |

| | | |
|---|---|---|
| | need for concentration testing<br>• Standardized cycle<br>• May enhance removal of organic material and endotoxin<br>• No adverse health effects to operators under normal operating conditions<br>• Compatible with many materials and instruments<br>• Does not coagulate blood or fix tissues to surfaces<br>• Sterilant flows through scope facilitating salt, protein, and microbe removal<br>• Rapidly sporicidal<br>• Provides procedure standardization (constant dilution, perfusion of channel, temperatures, exposure) | cycle<br>• More expensive (endoscope repairs, operating costs, purchase costs) than high-level disinfection<br>• Serious eye and skin damage (concentrated solution) with contact<br>• Point-of-use system, no sterile storage |

**Appendix 6.2: Comparison of the characteristics of selected High-level disinfectants**

| Chemical Characteristics | Hydrogen Peroxide (7.5%) | Peracetic Acid (0.2%) | Glutaraldehyde (≥2.0%) | Ortho-phthalaldehyde (OPA) (0.55%) | Hydrogen Peroxide / Peracetic Acid (7.35%/ 0.23%) |
|---|---|---|---|---|---|
| High-level disinfectant claim | 30 minutes @ 20°C | Not Applicable | 20-90 minutes @ 20o-25°C | 12 minutes @ 20°C, 5 minutes @ 25°C in AER | 15 minutes @ 20°C |
| Sterilization Claim | 6 hours @ 20°C | 12 minutes @ 50-56°C | 10 hours @ 20o-25°C | None | 3 h @ 20°C |
| Activation | No | No | Yes (alkaline glutaraldehyde) | No | No |
| Reuse life (number of days a product can be reused as determined by re-use protocol) | 21 days | Single use | 14-30 days | 14 days | 14 days |
| Shelf life stability (time a product can remain in storage (unused)) | 2 years | 6 months | 2 years | 2 years | 2 years |
| Materials Compatibility | Good | Good | Excellent | Excellent | No data |
| Monitor MEC of solution | Yes (6%) | No | Yes (1.5% or higher) | Yes (0.3% OPA) | No |
| Safety | Serious eye irritant (safety glasses) | Serious eye and skin irritant (conc soln) 5 | Respiratory irritant | Eye irritant, stains skin | Eye irritant |
| Processing | Manual or automated | Automated | Manual or automated | Manual or automated | Manual |
| Organic material resistance | Yes | Yes | Yes | Yes | Yes |
| Cost profile (per cycle) | + (manual) ++ (automated) | +++++ (automated) | + (manual) ++ (automated) | ++ (manual) | ++ (manual) |

**Appendix 6.3: Summary of advantages and disadvantages of Low-level disinfectants**

| Sterilization Method | Uses | Advantages | Disadvantages |
|---|---|---|---|
| **Sodium hypochlorite** | • Treatment of water<br>• Disinfection of laundry items,<br>• Disinfection of dental appliances<br>• Clean environmental surfaces after blood spills | • Readily available and widely used<br>• Very good microbicidal activity<br>• Disinfectant of choice for decontaminating blood spills<br>• Disinfectant of choice for water treatment systems | • Highly corrosive<br>• Releases fumes that can easily irritate respiratory system<br>Free available chlorine in diluted hypochlorite solutions are lost by up to 50% at the end of one month<br>• Must be stored in closed, opaque containers. |
| **Alcohol** | • Disinfect surfaces of some equipment e.g., stethoscope diaphragm, thermometers resuscitation manikins<br>• Disinfect the surface of ampoules/vials prior to access<br>• Disinfect cleaned surfaces (following initial clean with detergent and water) | • Highly microbicidal (at high concentrations)<br>• Cheap, readily available | • Max effectivity at a range of 60-90%<br>• Not recommended for sterilizing due to lack sporicidal action and cannot penetrate protein-rich materials.<br>• Some material incompatibility<br>• Storage considerations due to flammability<br>• Very volatile |
| **Phenolics (e.g. Dettol)** | • Has been used for decontaminating environmental surfaces and non-critical items | • Tuberculocidal, fungicidal, virucidal, and bactericidal<br>• Not inactivated by organic matter. | • Leaves residual film on surfaces.<br>• Harmful to the environment.<br>• May cause tissue irritation.<br>• Not recommended for use in nurseries and food contact surfaces. |

| | | | |
|---|---|---|---|
| **Quaternary Ammonium Compounds** | • Suitable for low-level disinfection of clean surfaces<br>• Antiseptic, for cleaning dirty wounds | • Stable with good detergent properties (cationic detergent).<br>• Usually non-irritating<br>• Not recommended for routine use in health care facilities | • Not effective against some Gram-negative bacteria, but range of activity can be expanded when combined with other agents, e.g., alcohols.<br>• Inactivated in the presence of organic matter |

**Appendix 6.4: Choosing disinfection & sterilization methods for different items/ processes:**

| Item | Recommended methods |
|---|---|
| • Glassware–syringes, petridishes, test tubes, flasks, universal container<br>• Oily fluids<br>• Powders | • Hot air oven |
| • Surgical instruments<br>• Respiratory therapy and anesthesia equipment<br>• Glass or metal instruments<br>• Articles with glass & metal components<br>• Rubber & plastic articles<br>• Culture media<br>• Pharmaceutical products<br>• Gowns, towels, dressings, linen | • Autoclaving |
| • Quick sterilization of OR instruments | • Flash steam Sterilization |
| • Sterilization of heat-senstive items such as some plastics, electrical devices, and corrosion-susceptible metal alloys | Ethylene Oxide<br>Hydrogen Peroxide Gas Plasma |
| • High disinfection of endoscopes | Glutaraldehyde<br>Peracetic Acid<br>• Ortho-phthalaldehyde (OPA) |
| • Hemodialyzers | Peracetic Acid/ Hydrogen Peroxide<br>• Glutaraldehyde |
| Blood spills<br>Clostridium difficile | Household bleach (5% sodium hypochlorite solution)<br>Concentration= 10,000 ppm<br>(1:5 dilution, 250 ml/L, i.e. 1%) |
| Regular cleaning<br>• Body fluid spill | Household bleach (5% sodium hypochlorite solution)<br>Concentration= 1,000 ppm<br>• (1:50 dilution, 25 ml/L, i.e. 0.1%) |
| • Toilets / bathrooms | • Bleaching powder 7g/litre with 70% available chlorine |

| | |
|---|---|
| Disinfect surfaces of some equipment e.g., stethoscope diaphragm, thermometers, resuscitation manikins<br>Disinfect the surface of ampoules/vials prior to access<br>• Disinfect cleaned surfaces (following initial clean with detergent and water) e.g., trolleys & laboratory benches | • Alcohol (70%) Isopropyl, ethyl alcohol |
| • Low-level disinfection of clean surfaces | • Quaternary Ammonium Compounds |
| • Antiseptic, for cleaning dirty wounds | • Quaternary Ammonium Compounds |
| • Disinfection of HBV-, HCV-, HIV- or TB-Contaminated Devices | • 2% glutaraldehyde for 20 minutes |
| • Disinfection of Coronavirus, Rotavirus, Human Papilloma Virus, Norovirus | • Most chemical disinfectants |
| • Disinfection of nurseries | • Any disinfectants but not phenols |
| • Antiseptic, for skin and mucous membranes, preoperative skin preparation | • Chlorhexidine Combined with alcohol |
| • Toxins, sera, sugars, antibiotic solutions | • Filtration |

# Appendix-7: CDC Environmental Checklist

**CDC Environmental Checklist for Monitoring Terminal Cleaning**

| | |
|---|---|
| **Date:** | |
| **Unit:** | |
| **Room Number:** | |
| **Initials of ES staff (optional):**[2] | |

**Evaluate the following priority sites for each patient room:**

| High-touch Room Surfaces[3] | Cleaned | Not Cleaned | Not Present in Room |
|---|---|---|---|
| Bed rails / controls | | | |
| Tray table | | | |
| IV pole (grab area) | | | |
| Call box / button | | | |
| Telephone | | | |
| Bedside table handle | | | |
| Chair | | | |
| Room sink | | | |
| Room light switch | | | |
| Room inner door knob | | | |
| Bathroom inner door knob / plate | | | |
| Bathroom light switch | | | |
| Bathroom handrails by toilet | | | |
| Bathroom sink | | | |
| Toilet seat | | | |
| Toilet flush handle | | | |
| Toilet bedpan cleaner | | | |

**Evaluate the following additional sites if these equipment are present in the room:**

| High-touch Room Surfaces[3] | Cleaned | Not Cleaned | Not Present in Room |
|---|---|---|---|
| IV pump control | | | |
| Multi-module monitor controls | | | |
| Multi-module monitor touch screen | | | |
| Multi-module monitor cables | | | |
| Ventilator control panel | | | |

**Mark the monitoring method used:**

☐ Direct observation ☐ Fluorescent gel
☐ Swab cultures ☐ ATP system ☐ Agar slide cultures

1 selection of detergents and disinfectants should be according to institutional policies and procedures

2 hospitals may choose to include identifiers of individual environmental services staff for feedback purposes.

3 sites most frequently contaminated and touched by patients and/or healthcare workers

# Appendix-8: Risk Assessment Tool for MDRO

| Risk Assessment for Multiple Drug Resistant Organisms | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Risk Event** | **Probability the Risk Will Occur** | | | | **Potential Severity if the Risk Occurs** | | | | **How Well Is the Organization Prepared to Risk Event Address This Risk?** | | | **Risk Priority** |
| | **High** | **Med** | **Low** | **None** | **Life Threatening** | **Permanent Harm** | **Temporary Harm** | **None** | **Poorly** | **Fairly Well** | **Well** | |
| **Score** | **4** | **3** | **2** | **1** | **4** | **3** | **2** | **1** | **3** | **2** | **1** | |
| **Increasing incidence of infections with MDROs** | | | | | | | | | | | | |
| Methicillin-resistant *Staphylococcus aureus* (MRSA) | | | | | | | | | | | | |
| Vancomycin-resistant Enterococci (VRE) | | | | | | | | | | | | |
| *Clostridium difficile* | | | | | | | | | | | | |
| Multidrug-resistant *Pseudomonas* | | | | | | | | | | | | |
| Multidrug-resistant *Enterobacter* ssp | | | | | | | | | | | | |
| Multidrug-resistant *Klebsiella* | | | | | | | | | | | | |
| Multidrug-resistant *Acinetobacter* | | | | | | | | | | | | |
| Other | | | | | | | | | | | | |
| **Increasing MDRO infections of specific type/site** | | | | | | | | | | | | |
| Catheter-associated bloodstream infections (CABSI) | | | | | | | | | | | | |
| Ventilator-associated pneumonia (VAP) | | | | | | | | | | | | |
| Catheter-associated urinary tract infections (CAUTI) | | | | | | | | | | | | |