

ii. Antimicrobial resistance, Immune response by microorganisms, Sterilization and disinfection

Controlling **infectious diseases** hinges on three major concepts: **(1) Antimicrobial Resistance (AMR)**, **(2) Immune responses** to microbes, and **(3) Sterilization & disinfection** techniques. Below is a comprehensive overview of each, integrating key points from modern biomedical science.

Table Of Contents

Add a header to begin generating the table of contents

Antimicrobial Resistance (AMR)

Definition

- **Antimicrobial Resistance (AMR)** is the ability of microorganisms (bacteria, viruses, some parasites) to withstand the effects of antimicrobials (antibiotics, antivirals, antimalarials) that once were effective against them.
- Poses a critical threat to global health, food security, and economic development, potentially rendering routine infections untreatable.

Mechanisms of Resistance

1. Intrinsic Resistance

- Natural trait of a microbe, e.g., an **outer membrane** limiting antibiotic permeability or intrinsic **efflux pumps** that expel drugs.
- Example: **Pseudomonas aeruginosa** intrinsically resistant to many antibiotics due to low outer membrane permeability.

2. Acquired Resistance

- Microbes gain resistance via **mutations** or **horizontal gene transfer** (transformation, transduction, conjugation).
- Genes may encode **β -lactamases** (penicillin inactivation), **modified targets** (altered PBPs), or **efflux pumps**.

Contributing Factors

1. Environmental

- Antibiotic use in agriculture, livestock feed, and improper disposal driving resistant strains in soil/water.

2. Drug-Related

- Overuse/misuse of antimicrobials, prescribing broad-spectrum agents unnecessarily.

3. Patient-Related

- Incomplete antibiotic courses, self-medication, cross-infection in hospitals.

4. Physician-Related

- Diagnostic uncertainties, prescribing antibiotics “just in case,” or lacking rapid diagnostic tools.

Immune Response by Microorganisms

Host Defense: Innate and Adaptive Immunity

1. Innate Immunity

- **Immediate**, non-specific defense including skin barriers, mucous membranes, **phagocytes** (macrophages, neutrophils), **NK cells**, and complement proteins.
- Inflammation is a hallmark response to local infection or injury.

2. Adaptive Immunity

- **Antigen-specific** response, involving **B cells** (antibody production) and **T cells** (cell-mediated cytotoxicity or helper functions).

- Memory T/B cells confer long-lasting immunity post-infection or vaccination.

Microbial Survival and Pathogenicity

1. Immune Evasion Strategies

- Altered surface antigens, secretion of toxins that disable immune cells, intracellular hiding (e.g., Mycobacterium tuberculosis in macrophages).
- Viruses like HIV attack immune cells (CD4+ T cells), crippling adaptive immunity.

2. Tissue Injury and Disease

- Partly from direct microbial toxins, but often from **host immune** overreaction (e.g., cytokine storms, granuloma formation).
- Balancing an effective immune response without excessive inflammation is key to resolving infection with minimal tissue damage.

Sterilization and Disinfection

Definitions and Importance

1. Sterilization

- Complete elimination or destruction of **all** forms of microbial life (including spores).
- Essential for surgical instruments, culture media. Methods: **Autoclaving** (steam under pressure), dry heat, chemical sterilants (ethylene oxide).

2. Disinfection

- Destruction of **most** pathogenic microbes (excluding spores) on **inanimate objects**.
- Techniques: Boiling, chemical disinfectants (e.g., chlorinated compounds, iodophores), or UV radiation.

Types of Disinfection

1. Concurrent Disinfection

- Immediately neutralizing pathogens as soon as they leave an infected source.
- Example: Disposing contaminated fluids during infectious patient care.

2. Terminal Disinfection

- Thorough cleaning after a patient's discharge or death to ensure the environment is pathogen-free.
- Common in hospital isolation wards.

3. Precurrent (Prophylactic) Disinfection

- Preventive measures, e.g., water chlorination, pasteurization of milk.
- Minimizes disease spread before an outbreak occurs.

Common Disinfectants

1. Dettol (Chloroxylenol)

- Widely used antiseptic, moderate spectrum, requires adequate contact time (≥ 15 minutes).

2. Iodophores (Povidone-Iodine)

- Sustained release of free iodine, non-irritant, used in wound cleaning and preoperative skin prep.

3. Bleaching Powder

- Effective chlorinated lime (1–3% solutions) for general disinfection.
- Key in outbreak control (e.g., for contaminated surfaces, latrines).

Summary and Integration

1. **AMR** demands **judicious antibiotic usage**, improved diagnostics, infection control, and antibiotic stewardship programs.
2. **Immune Response** shapes disease outcome—both protective and potentially injurious if hyperactivated. Microbes evolved evasion tactics, necessitating vaccination, immunomodulators, and supportive therapies.
3. **Sterilization and Disinfection** remain fundamental in preventing nosocomial infections, controlling outbreaks, and achieving microbial control in surgical or laboratory settings.



In **Ayurvedic** contexts, infection control parallels *dhūpana* (fumigation), external cleansing, and an emphasis on immunity (*vyādhikṣamatva*). Merging these classical measures with advanced modern methods fosters a **multilayered** approach to infection prevention and safe healthcare environments.

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