Hospital Acquired Infectious Diseases

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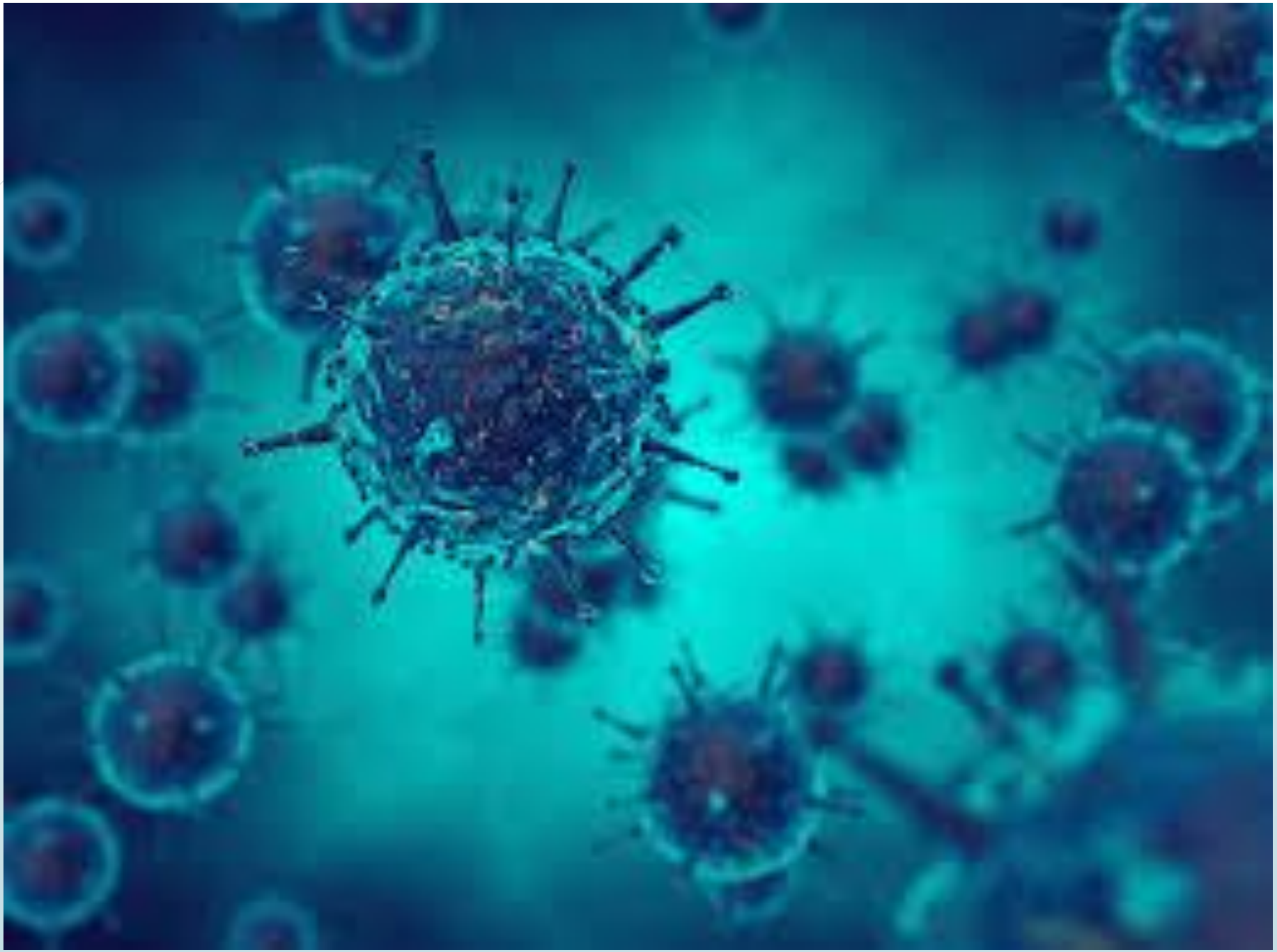


Objectives

- Nosocomial infection (HAI)
- CDC hot list
- Common nosocomial pathogens
- Modes of transmission
- Antibiotic-resistant nosocomial pathogens
- Control of nosocomial infections

Introduction for Nosocomial Infections

- Acquired during hospital stay
- Asymptomatic and symptomatic patient can be considered infected
- Infection may be carried by:
  - Healthcare workers
  - Family members
- New antibiotic research is decreasing
- Account for 5% to 10% infection rates in USA
- > 40% in other developing countries
- Huge $$ cost involved in treatment

Types of nosocomial infections

- The CDC has classified 13 types of nosocomial infections based on biological and clinical data:
  - UTI
  - Surgical sites
  - Gastroenteritis
  - Meningitis
  - Respiratory infections
- Increasing rates occur because of cancer therapy, organ transplants, immunotherapy, invasive diagnostic techniques
- Not so good news! HAI have increased 17% to 30% in last 5 years

Types of nosocomial infections

- Bacteria are responsible for about 90% of infections
- Protozoans, fungi, viruses and mycobacteria are less contributing compared to bacterial infections
- Out of these- these are of "concern"
  - Enterococci
  - *P. aeruginosa*
  - *S. aureus*
  - *E. coli*

Commonly isolated nosocomial pathogens found in health care facilities

- *Acinetobacter baumannii*
- *Clostridium difficile*
- Carbapenem-Resistant *Enterobacteriaceae (CRE)*
- *Escherichia coli*
- *Klebsiella pneumonia*
- Methicillin-Resistant *Staphylococcus aureus*
- *Psuedomonas aeruginosa*
- *Staphylococcus aureus*
- Vancomycin-Resistant *Enterococci*

Virulence factors

- Virulence factors:
  - Innate ability of bacteria to survive and thrive
  - Invade the host
  - Cause disease
- Adherence Factors
  - Many pathogenic bacteria colonize mucosal sites by using pili(fimbriae) to adhere to cells
- Toxins
    - Endotoxins
      - Part of cell wall of gram negative bacteria
      - Create fever and inflammation
    - Exotoxins
      - Secreted by bacteria causing inhibition of immune responses
      - E-coli and C-Diff
- Destructive enzymes- break down cell walls
- Immune modulators- break down the host's immunoglobulins using proteases

S. aureus

- *Staphylococcus* genus is considered one of the most important pathogens
- Gram-positive cocci, non-spore forming, catalase- and coagulase-positive, immotile, facultatively anaerobe
- Mainly colonizes in nasal passages and skin

S. aureus

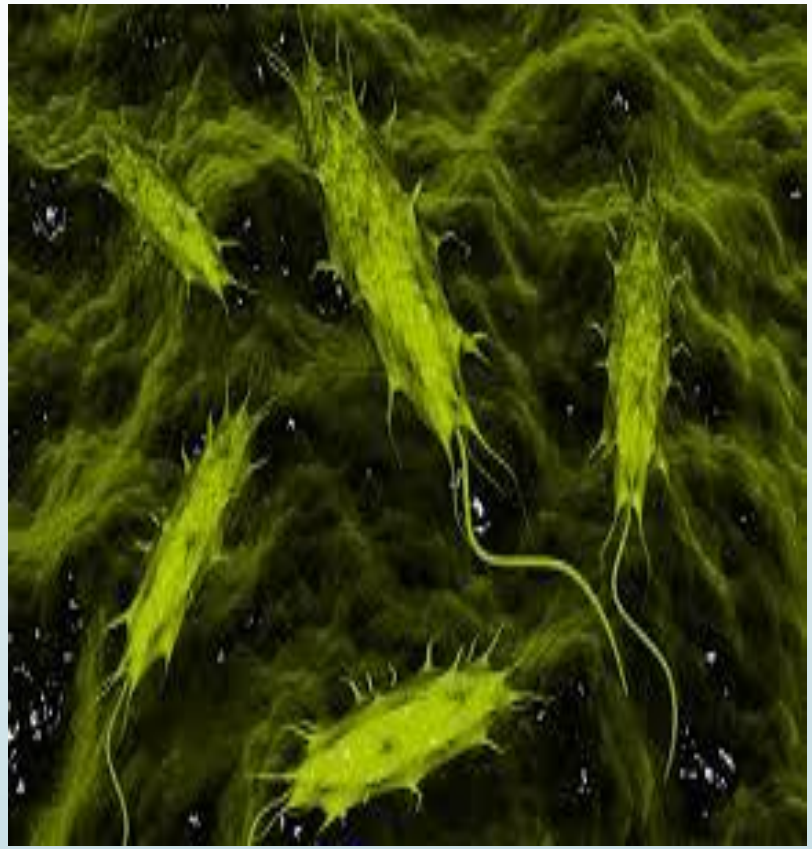
- 20% individuals have persistent colonization of *S. aureus*
- Decreased immunity and immunocompetent patients
- *S. aureus* infects not only the superficial but also the deep tissues
  - Toxin-mediated diseases of *S. aureus* include:
    - Food poisoning
    - Toxic shock syndrome
    - Scalded skin syndrome
- Virulence mechanisms of *S. aureus* include:
  - Toxins
  - Enzymes
  - Immune modulators

S. aureus

- In hospitals these infections can be fatal:
  - Bacteremia or sepsis when bacteria spread to the bloodstream
  - Pneumonia, which predominantly affects people with underlying lung disease including those on mechanical ventilators
  - Endocarditis (infection of the heart valves), which can lead to heart failure or stroke
  - Osteomyelitis (bone infection), which can be caused by staph bacteria traveling in the bloodstream

E-coli

- *E. coli* is an emerging nosocomial pathogen
- *E. coli* is Gram-negative and oxidase-negative facultative anaerobe bacteria
- Colonize in GI tract of human beings and other animals



E-coli

- *E. coli* is responsible for a number of diseases:
  - UTI
  - Septicemia
  - Pneumonia
  - Neonatal meningitis (Group B Streptococci)
  - Peritonitis
  - Gastroenteritis
- Virulence factors are endotoxins, capsule, adhesions and type 3 secretion systems
- Specialized virulence factors are seen in cases of UTI and gastroenteritis

Vancomycin-Resistant Enterococci (VRE)

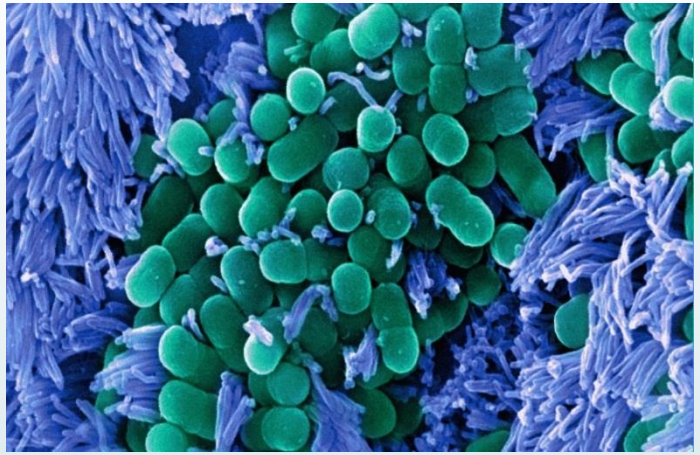
- Vancomycin-Resistant Enterococci
- 17 different species of Enterococci
- Resistant to Vancomycin
  - Used to treat infections caused by enterococci
- Normally present in the human intestines and in the female genital tract
- Can sometimes cause infections
- Most Vancomycin-Resistant Enterococci infections occur in hospitals

Enterococci

- 2nd leading cause of hospital acquired infections worldwide
  - Nursing home admissions?
- 20%–30% of all infections in the USA
- Facultative anaerobic Gram-positive enteric microbes
- Part of normal microbiota in female genital tract and gastrointestinal tract as well
- Involved in the blood-borne infections; UTI, wound infections, and surgical procedures infections
- Virulence factors include extracellular surface proteins, cytolysin, adhesions, hemolysins, gelatinase, extracellular superoxide and aggregation substances

Clostridium difficile (C. difficile)

- *Nosocomial* pathogen which mainly causes diarrhea worldwide
- Gram-positive bacillus
- Anaerobic and spore-forming bacteria
- Colonizes in intestinal tract and serves as part of normal microbiota
- Diseases caused by toxins produced by *C. difficile:*
  - Colitis 15%–25% cases
  - Diarrhea
- Major virulence factors for *C. difficile* are toxins, fimbriae, capsule and hydrolytic enzymes



Modes of transmission

- S. aureus
  - Infected individuals' skin or contact via shared items and surfaces like door handles, benches, towels and taps
- E. coli
  - *T*ransmitted through person to person, environment or contaminated water and food
- Vancomycin-resistant enterococci
  - Patients with diarrhea
  - Room items such as surfaces and equipment's act as reservoirs
  - Can survive on theses surfaces for days or weeks

Modes of transmission

- Klebsiella pneumonia
  - *T*ransmitted by person-to-person contact
    - Healthcare professionals do not wash or clean hands after checking a contaminated patient
    - Ventilators, catheters or exposed wounds can be the source of its transmission
    - *T*ransmitted through stool , patients' hands and pharynx
- P. aeruginosa
  - Common reservoirs include breast pumps, incubators, sinks and hands of hospital staff and hand soaps

Modes of transmission

- C. difficile
  - Spores of C. *difficile* can hold for months
  - Infected intestinal patients are major sites acted as reservoirs
    - Inanimate objects such as door knobs, stethoscopes, ventilators, etc
  - Hospital staff along with hospital settings are also part of the problem

Antibiotic-resistant nosocomial pathogens

- Multi-drug-resistant nosocomial organisms include
  - MRSA
  - Vancomycin-Resistant Enterococci
  - *P. aeruginosa*
  - *K. pneumonia*
  - *C. difficile* shows natural resistance
- 50% to 60% of hospital-acquired infections are caused by resistant pathogens
- Improper use of antibiotics is the major cause of this drug resistance

Antibiotic-resistant nosocomial pathogens

- MRSA
  - β-Lactamase antibiotics including penicillin became resistant in the 1940s
  - Resistance of penicillin due to its improper use
  - Staphylococcal species have penicillinase enzyme that makes penicillin infective
    - Penicillinase-resistant antibiotics were developed such as cephalosporin's and methicillin's
  - By the 1960s, methicillin-resistant species of *S. aureus* were first reported
  - Resistance was due to the modification of penicillin-binding proteins
  - β-lactam antibiotics along with their derivatives are now ineffective

Antibiotic-resistant nosocomial pathogens

- Vancomycin-Resistant Enterococci
  - Resistance in the enterococcal species due to the *vanA* and *vanB* genes
  - Part of plasmid and would spread resistance to other microbes
  - Enterococci are resistant to many different classes of antibiotics which include:
    - Penicillin
    - Ampicillin
    - Aminoglycosides
    - Tetracycline's
    - Carbapenem
    - Fluoroquinolones
    - Macrolides
  - Linezolid, daptomycin, and tigecycline current treatment options

Antibiotic-resistant nosocomial pathogens

- *P. aeruginosa* is becoming resistant due to different mechanisms
  - These mechanisms include:
    - Restricted uptake of drug
    - Modification and altered targets sites for antibiotics
- Due to this increasing resistance, complications are seen in these infections
- Ineffective drugs showing resistance:
  - Cephalosporin's
  - Trimethoprim
  - Macrolides
  - Chloramphenicol
  - Tetracycline's
  - Fluoroquinolones
- Current treatment combination of Cephalosporins and Aminoglycoside

Antibiotic-resistant nosocomial pathogens

- Klebsiella pneumonia
  - Resistance to β-lactam antibiotics
  - 3rd and 4th generation Cephalosporin's show resistance for *K. pneumonia*
  - Treatment with combination therapy Aminoglycosides and Imipenem

- C. difficile
  - Increased use of broad-spectrum antibiotics is associated diseases resistance
  - Improper antibiotic use was the cause of increasing infections of *C. difficile*
  - Treatment with Vancomycin

Control of nosocomial infections

- Need statistics on antimicrobial susceptibility
- Resistant organisms make it extremely difficult to devise a proper plan for control
- Each hospital has variant strains making it difficult to compare and share information
- Different healthcare settings at some hospitals don't share data

Need to know the types of microorganism involved in infection

- Infectious organisms are heterogeneous in nature which makes them different from one another
- Compare the infection rates
  - Type of healthcare settings is important and services they provide
  - Admissions from nursing homes
- Management of infections differs greatly between institutions

Development of infection control programs

- Guidelines for the sterilization and disinfection
- Guidelines for the prevention of catheter-associated UTI
- Create protocols that reduce the transmission of nosocomial infections
- Surveillance of nosocomial infections along with investigation of major outbreaks
  - CDC Helps with this
- Training of healthcare professionals is extremely important for the control and prevention of infection

Surveillance of nosocomial infections

- Ongoing, systematic collection, analysis, and interpretation of health data
- Control the infections by evaluating the efficacy of treatment and clusters of breakout infections
- Surveillance can lead to better infection control practices
- People practice better infection control practices if they are being ‘watched”

Summary

- Even with the best antibiotics, nosocomial infections are still uncontrollable
- Control of organisms responsible for nosocomial infections is much needed as they cause great economic as well as production loss
- Transmission of these infections in the hospital settings through healthcare workers can be avoided by the use of infection control practices
- Improper and frequent use of antibiotics is an important cause of drug-resistant organisms that are difficult to treat
- Hospitals should devise the infection control programs through which infection rates can be compared and controlled
- A well-managed surveillance methodology is required
- Best practice should be shared among hospitals to stop the spread of nosocomial infections.

References

- Anderson, D. J., Jenkins, T. C., Evans, S. R., Harris, A. D., Weinstein, R. A., Tamma, P. D., ... & Lautenbach, E. (2017). The Role of Stewardship in Addressing Antibacterial Resistance: Stewardship and Infection Control Committee of the Antibacterial Resistance Leadership Group. *Clinical Infectious Diseases*, *64*(suppl_1), S36-S40.
- De Angelis, G., Cataldo, M. A., De Waure, C., Venturiello, S., La Torre, G., Cauda, R., ... & Tacconelli, E. (2014). Infection control and prevention measures to reduce the spread of vancomycin-resistant enterococci in hospitalized patients: a systematic review and meta-analysis. *Journal of Antimicrobial Chemotherapy*, dkt525.
- Rosenthal, V. D., Maki, D. G., Mehta, Y., Leblebicioglu, H., Memish, Z. A., Al-Mousa, H. H., ... & Apisarnthanarak, A. (2014). International Nosocomial Infection Control Consortiu (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. *American journal of infection control*, *42*(9), 942-956.
- Zingg, W., Holmes, A., Dettenkofer, M., Goetting, T., Secci, F., Clack, L., ... & Pittet, D. (2015). Hospital organisation, management, and structure for prevention of health-care-associated infection: a systematic review and expert consensus. *The Lancet Infectious Diseases*, *15*(2), 212-224.