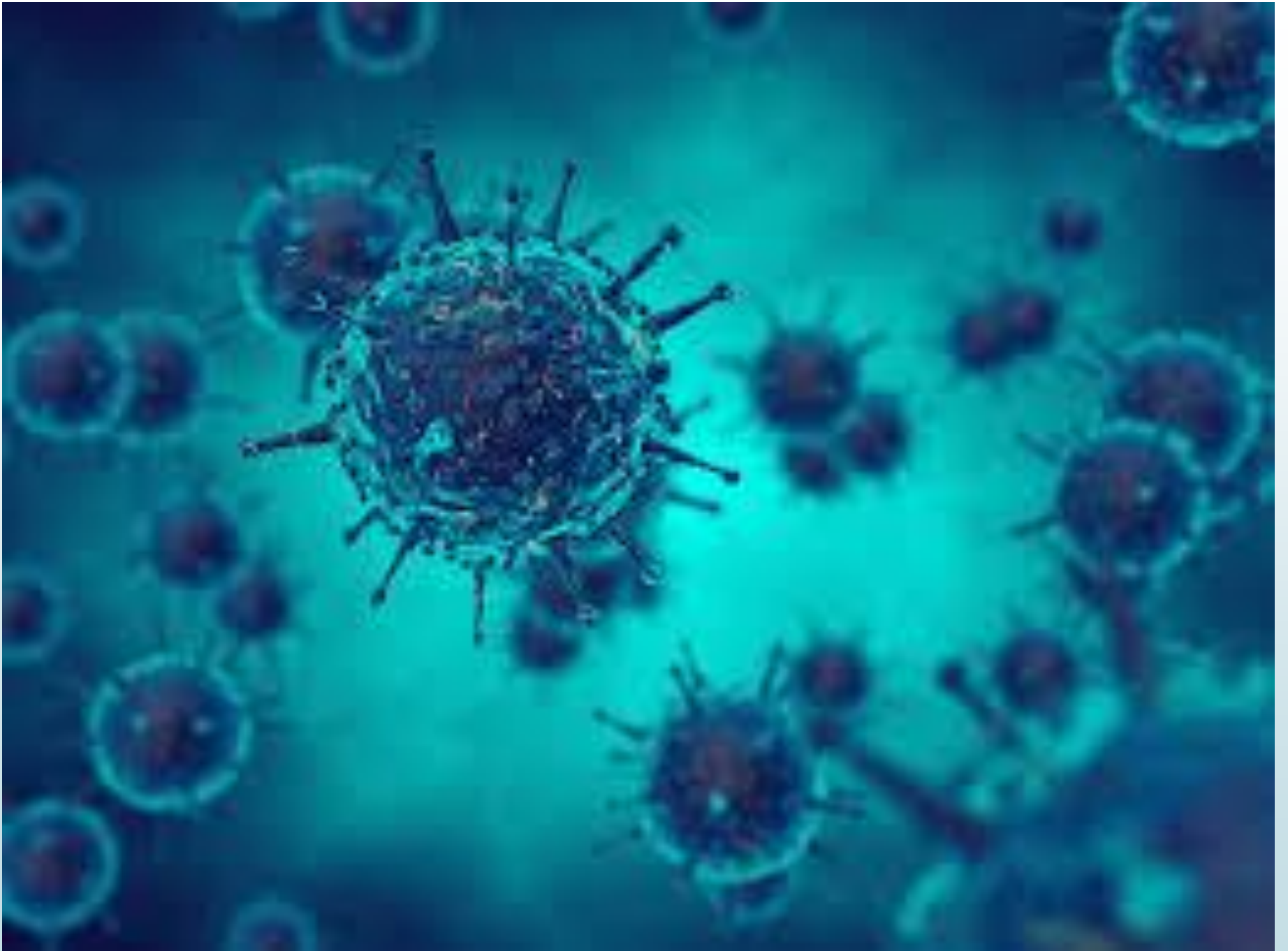
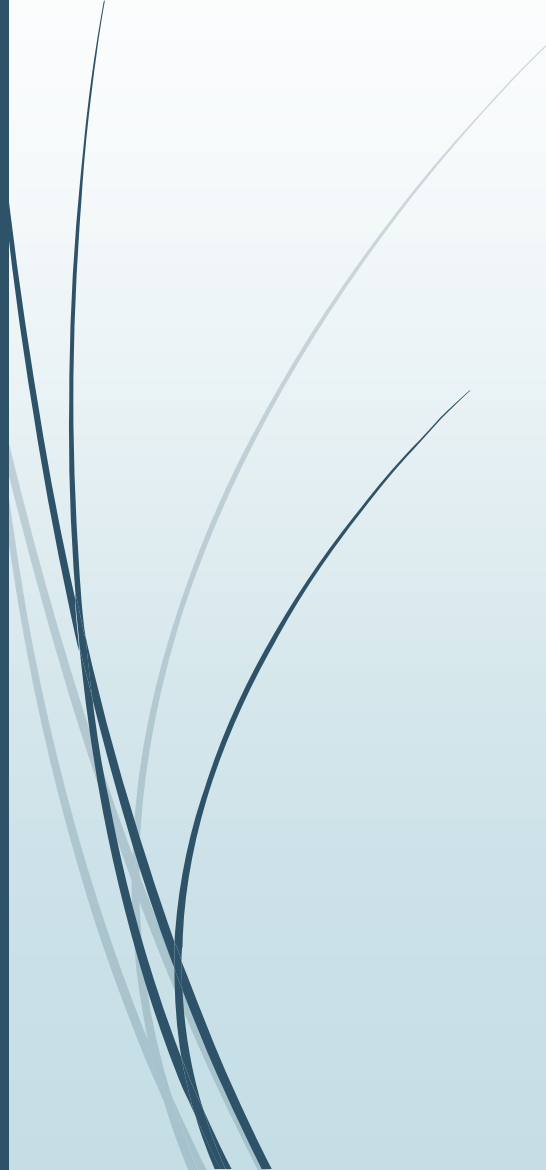




Hospital Acquired Infectious Diseases

Terrence Shenfield MS, RRT-ACCS, RPFT, NPS, AE-C





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*



A dark grey arrow points to the right from the left edge of the slide. Several thin, curved lines in shades of blue and grey originate from the left side and sweep across the slide, framing the text.

Commonly isolated nosocomial pathogens found in health care facilities

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

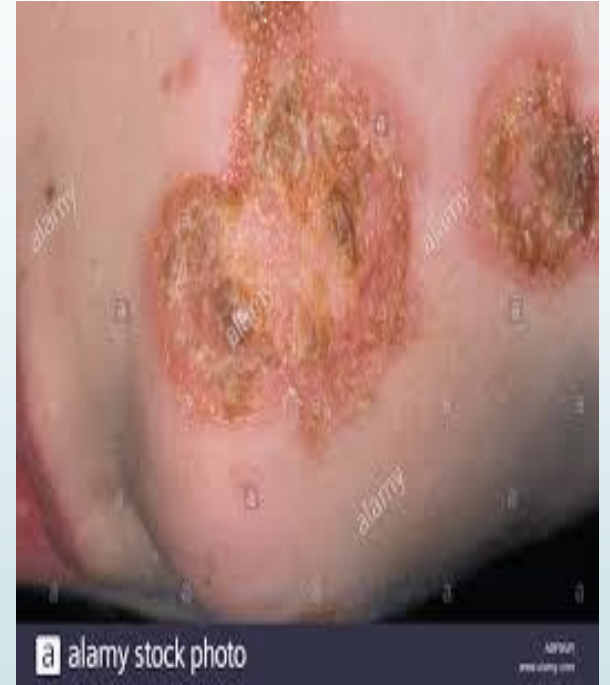


Virulence factors

- ▶ 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



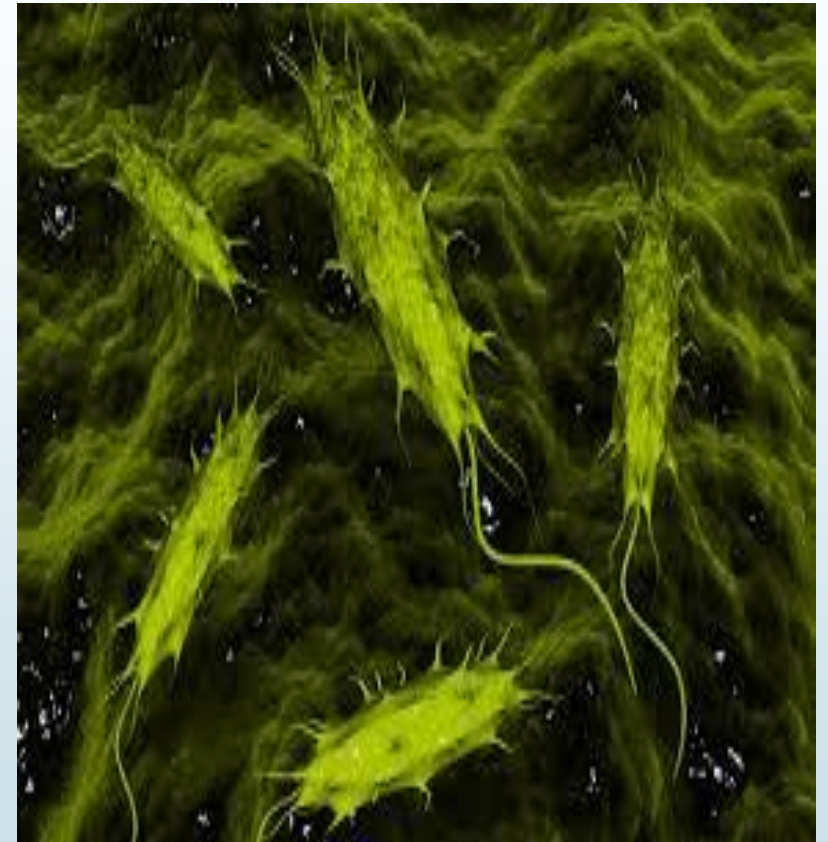


S. aureus

- ▶ 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



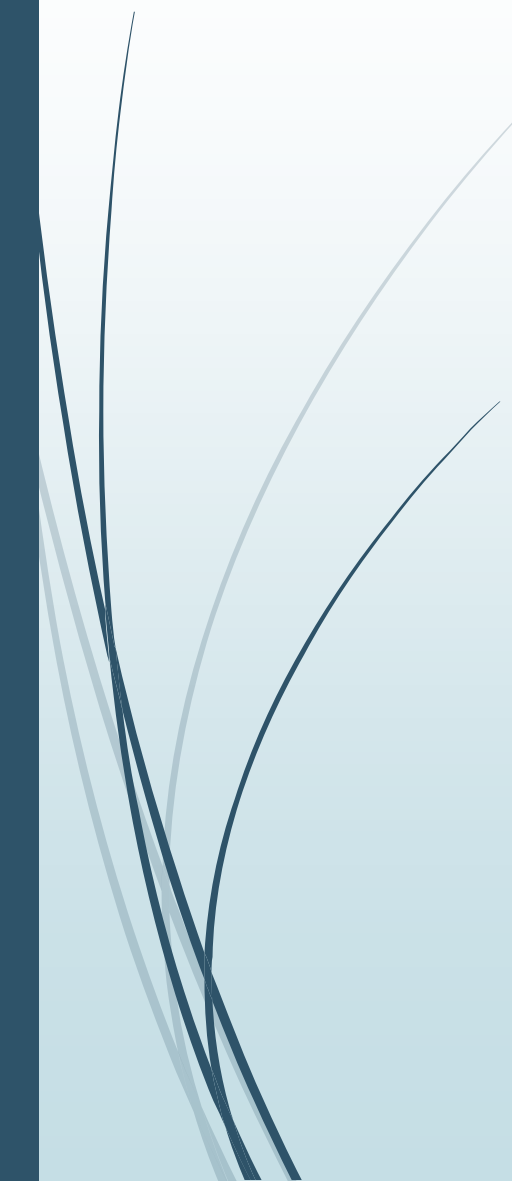


E-coli

- *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

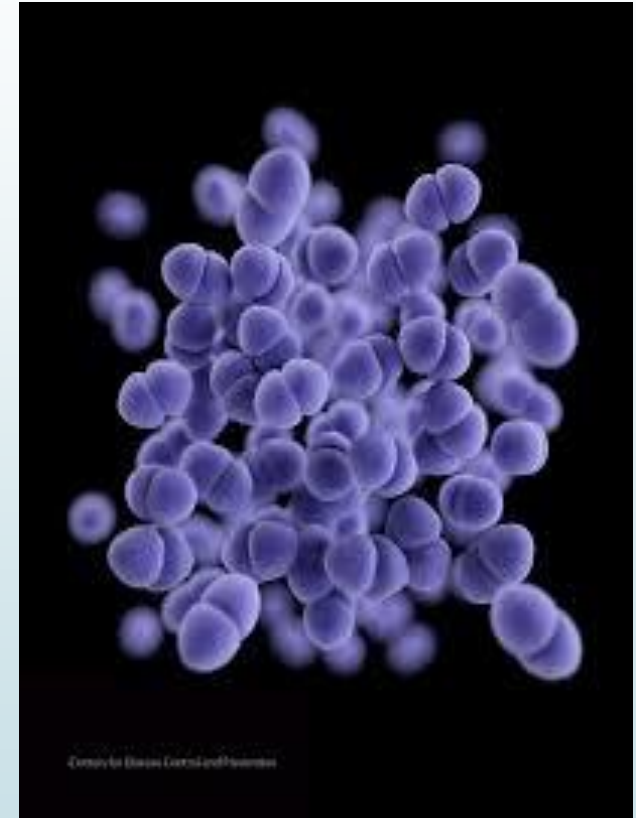


Vancomycin-Resistant Enterococci (VRE)

- ▶ 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
- 

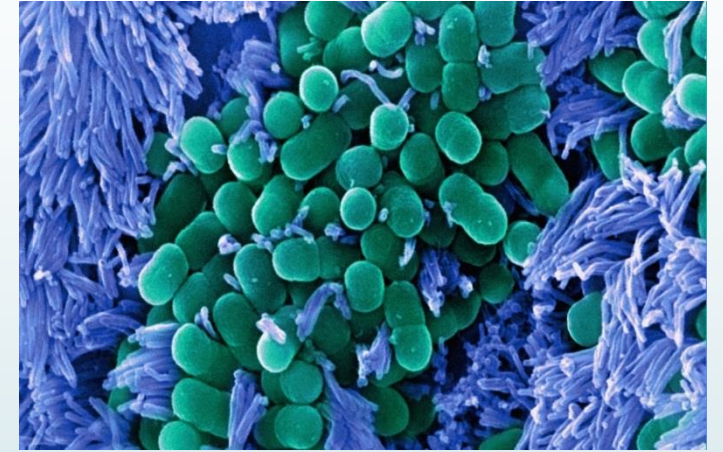
Enterococci

- ▶ 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



A dark grey arrow points to the right at the top left. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

Modes of transmission

- ▶ *S. aureus*
 - ▶ Infected individuals' skin or contact via shared items and surfaces like door handles, benches, towels and taps
- ▶ *E. coli*
 - ▶ Transmitted 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 these surfaces for days or weeks



Modes of transmission

- Klebsiella pneumonia
 - Transmitted 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
 - Transmitted 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 pneumoniae*
 - ▶ Resistance to β -lactam antibiotics
 - ▶ 3rd and 4th generation Cephalosporin's show resistance for *K. pneumoniae*
 - ▶ 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

A dark grey arrow points to the right at the top left. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

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

A dark grey arrow points to the right from the left edge of the slide. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

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

A dark grey arrow points to the right at the top left. Below it, several thin, curved lines in shades of blue and grey sweep across the left side of the slide.

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.