HEALTHCARE ASSOCIATED INFECTIONS(HAI) AND THEIR SURVEILLANCE

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ABSTRACT

Nosocomial or healthcare associated infections are those which are acquired after 48 hours of admission to the hospital. Risk factors include patient, pathogen and hospital factors. These are sourced either endogenously or exogenously and are caused by a variety of organisms but most commonly the ESKAPE group of pathogens. The major HAIs are device associated such as CAUTI, CLABSI, VAP, and SSI. Apart from the care bundle approach, standard and transmission based precautions should be followed diligently in all healthcare facilities. Periodic surveillance and audits can aid in sustainable infection prevention and control practices thus reducing the HAI associated morbidity and mortality in hospitalized patients.

Keywords- CAUTI, CLABSI, HAI, MDR, Nosocomial, SSI, Surveillance, VAP

I. INTRODUCTION

A. Definition[1, 2]

Healthcare associated infections (HAI) are defined as the infections which are acquired in the hospital after 48 hours of admission. These are not incubating at the time of admission and the patient was admitted for reasons other the infection in question. These are also known as nosocomial infections. Centers for Disease Control and Prevention, USA (CDC) monitors the rates of nosocomial infections through National Healthcare Safety Network (NHSN).

B. EPIDEMIOLOGY[2]

1. Burden of HAI

World Health Organization (WHO) estimates that at least 7% patients in developed nations and 10% patients in developing patients acquire minimum one HAI. Morbidity and mortality from HAI makes it one of the most catastrophic adverse events of the healthcare delivery system with treatment putting huge financial constraints on public as well as the healthcare facility.

2. Risk factors for HAI

a) **Patient factors:**

1) Impaired immune status due to pre existing illnesses as such diabetes, malignancy,organ dysfunction, improper nutritional status, burns
2) Receipt of immunosuppressive drugs such as steroids, anticancer therapy
3) Previous history of prolonged hospitalization, multiple transfusions

b) **Pathogen factors:** Infection by virulent or multidrug resistant organisms due to indiscriminate antimicrobial use leading to eventual replacement of susceptible strains in the hospital environment.

c) **Hospital factors:**

1) Diagnostic or therapeutic interventions carried under unsterile environment
2) Improper disinfection and sterilization practices
3) Unscreened blood transfusions and organ transplantation
4) Inefficient hospital infection control committee (HICC) administration

3. Sources of HAI

a) **Endogenous source:** Infection originates from within the patient's body. The microbial flora of the patient becomes invasive during external manipulations such as surgery or instrumentation.

b) **Exogenous source:** Infection originates from outside the patient's body. Sources include-

i) Hospital environment-
1) Medical equipments such as endoscope, catheters
2) Drugs, contaminated food and water,bed rails, side tables and other fomites contaminated with blood and body fluids.

ii) Other patients- immunocompromised patients and patient attendants can also become sources of contact or droplet transmitted infections.

iii) Healthcare workers (HCWs)- contaminated hands of HCWs can also transmit potentially dangerous pathogens such as Methicillin-resistant *Staphylococcus aureus* (MRSA) or Vancomycin Resistant Enterococci (VRE).

4. Causative agents

Almost all microorganisms have the potential to cause HAI but only those who can survive in hospital environment for long periods and are resistant to commonly used antimicrobials and disinfectants are of paramount importance.

ESKAPE group pathogens[3]

These bacteria pose a global threat as they are largely multidrug or pan drug resistant and can lead to life threatening HAIs.[4] These include:

- ***E****nterococcus faecium*
- ***S****taphylococcus aureus*
- ***K****lebsiella pneumoniae*
- ***A****cinetobacter baumannii*
- ***P****seudomonas aeruginosa*
- ***E****nterobacter* species

Apart from these, there are other microorganisms also that can spread in healthcare facilities-
- SARS-CoV2(COVID-19)
- *Mycobacterium tuberculosis*

- *Candida* species
- Blood borne viruses such as Hepatitis-B and C, HIV through needle stick injury or mucocutaneous exposure.
- *Escherichia coli*

5. Modes of Transmission

Microorganisms can spread and cause infections through various modes of transmission such as droplet, airborne and contact.

a) Droplet mode: Transmission occurs through large respiratory droplets (> 5µm size) that travel shorter distances. These are generated by a patient who is talking, laughing, sneezing or coughing. These droplets can also settle on environmental surfaces within 1 meter distance and can lead to contact transmission.

- **Agents transmitted:**

- *Corynebacterium diphtheriae*
- *Haemophilus influenzae* type b and *Neisseria meningitidis* (meningitis, pneumonia)
- SARS-CoV2 (COVID-19)
- Viral haemorrhagic fevers such as Ebola, Lassa, Marburg viruses
- Adenovirus, Parvovirus B19, Rubella
- *Mycoplasma pneumoniae* , Pneumonic plague

b) Airborne mode: Transmission occurs through small respiratory droplets (< 5µm size) that remain suspended in the air for long periods. These can be generated by an infectious person during coughing, sneezing or by aerosol generating procedures such as intubation or bronchoscopy.

- **Agents transmitted:**

- *Mycobacterium tuberculosis*
- Pulmonary aspergillosis
- Varicella (Chickenpox and herpes zoster)
- Variola (smallpox) and monkeypox virus
- Measles virus
- *Bacillis anthracis* through spore containing powders

c) Contact mode: Transmission occurs when a person touches a contaminated surface and subsequently touches their eyes, nose, mouth or other mucosal surfaces.

- **Direct method:** Infectious agents can be transmitted directly from person-to-person during hand shaking or direct contact with blood and blood fluids.

- **Indirect method:** Indirect transmission occurs through contaminated intermediate objects such as environmental surfaces, fomites, patient care devices or clothes.

- **Agents transmitted:**

- MRSA, VRE, CRE (Carbapenem resistant Enterobacteriaceae)
- Diarrheal agents like Rotavirus, parasites such as *Cryptosporidium spp, Clostridioides difficile, Vibrio cholerae*, Enterovirus A71, Coxsackievirus A16 [5, 6]
- Multidrug resistant (MDR) pathogens such as *Acinetobacter, Pseudomonas, Burkholderia*
- Skin lesions due to *Staphylococcus, Herpes simplex*, scabies
- Agents of conjunctivitis such as *Adenovirus, Chlamydia, Neisseria gonorrheae*

II. TYPES of HAI[7]

There are several types of HAI but for surveillance purposes the following are monitored-

A. CATHETER ASSOCIATED URINARY TRACT INFECTION (CAUTI)

It is the most common type of HAI worldwide accounting for 40% of nosocomial infections. It is defined as the presence of UTI in a catheterized patient.

B. CATHETER RELATED BLOOD STREAM INFECTION (CRBSI)

It is defined as the presence of bloodstream infection (BSI) in a hospitalized patient due to a central line. It should be a primary BSI and not secondary to other causes of infection. Only for surveillance purposes, the term Central Line Associated Blood Stream Infection (CLABSI) is used.

C. VENTILATOR ASSOCIATED PNEUMONIA (VAP)

It is the second most common HAI after CAUTI accounting for 20% of total nosocomial infections. However, it is the most common cause of HAI mortality especially in intensive care units (ICUs). It is defined as nosocomial pneumonia due to a mechanical ventilator and can be early onset (≤4 days) or late onset (≥5 days). For surveillance purposes, the term Ventilator Associated Events (VAE) is used.

D. SURGICAL SITE INFECTIONS (SSI)

These are the infections that develop at a surgical site within 30 days of surgery or within 90 days of breast, cardiac or implant surgeries.

III. HAI SURVEILLANCE[8]

The International Federation of Infection Control defines surveillance as an 'ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health'[9]. The NHSN division of CDC has provided guidelines for targeted surveillance of HAIs (Table 1- 5).

A. What to monitor- Major types of HAI such as CAUTI, CLABSI, SSI, VAP through HAI Surveillance Cycle (Figure 1)

B. Where to monitor- Only in high risk locations such as ICUs

C. Who will monitor- The Infection Control Nurses (ICNs) under the supervision of Infection Control Officer (ICO) and HICC Chairperson

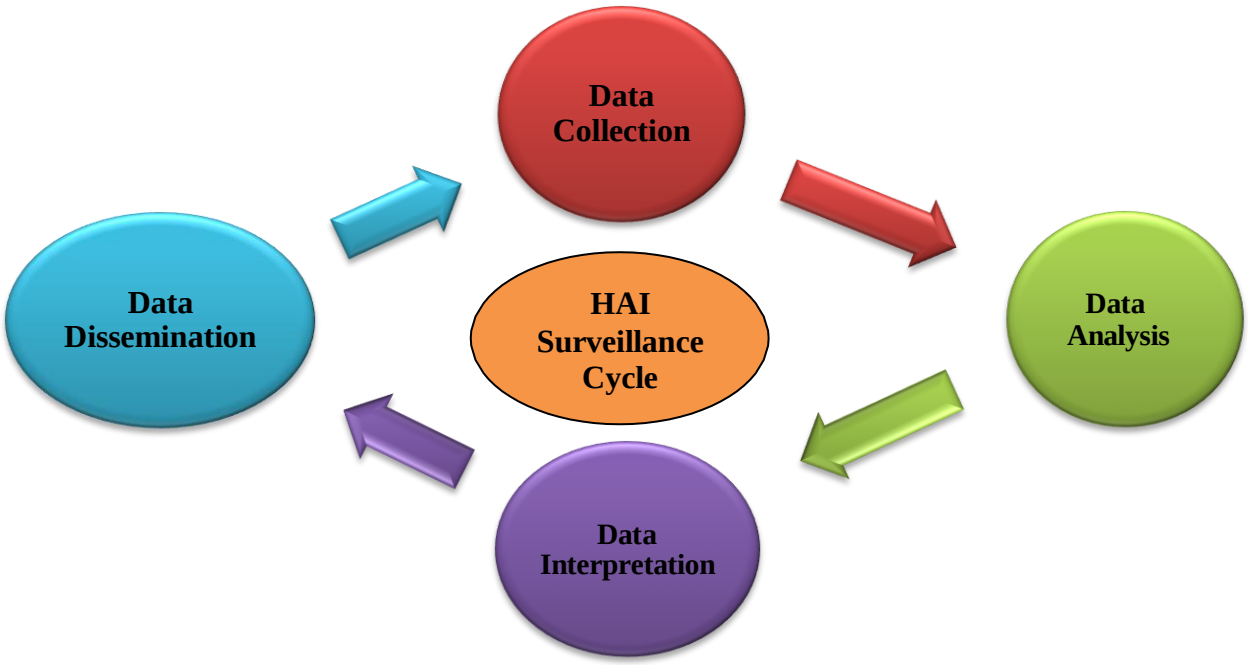

FIGURE 1: SHOWING HAI SURVEILLANCE CYCLE

TABLE 1: CAUTI SURVEILLANCE CRITERIA	
Device Criteria	Presence of urinary catheter > 2 calendar days
Clinical Criteria	Presence of any one of suprapubic tenderness, urinary frequency, urgency or dysuria, fever
Culture Criteria	Isolation of significant count ($\geq 10^5$ CFU/ml) of a UTI pathogen from urine

TABLE 2: SSI SURVEILLANCE CRITERIA	
Clinical Criteria	Presence of purulent pus discharge from surgical site or local signs of infection
Culture Criteria	Positive pus culture from discharge collected
Other evidence	Histopathological, radiological or gross anatomical evidence of abscess should be present

TABLE 3: CLABSI SURVEILLANCE CRITERIA	
Device Criteria	Presence of central line catheter > 2 calendar days
Culture Criteria	Isolation of a lab confirmed bloodstream infection (LCBI) pathogen (Primary BSI)
Differential Time to Positivity (DTP)	Central line blood culture should come positive at least 2 hours before the peripheral line blood culture with both growing the same organism

TABLE 4: VENTILATOR ASSOCIATED PNEUMONIA (VAP)	
Device Criteria	Presence of mechanical ventilator > 2 calendar days
Clinical Criteria	Worsening oxygenation (Increased FiO_2 by ≥20% or PEEP by ≥3cm water) for > 2 calendar days plus any one of fever/ hypothermia/ leukocytosis/ leukopenia
Antibiotic Criteria	New antibiotic started and continued for ≥ 4 days
Culture Criteria	Isolation of significant count ($\geq 10^5$ CFU/ml) of a pneumonia pathogen from respiratory secretions such as endotracheal tube (ETT) secretions, bronchoalveolar lavage (BAL)

TABLE 5: CALCULATION OF HAI RATES	
HAI INFECTIONS	**FORMULAE**
CAUTI RATE	Number of CAUTI cases/ Total number of urinary catheter days x 1000
CLABSI RATE	Number of CLABSI cases/ Total number of central line days x 1000
VAE RATE	Number of VAE cases/ Total number of ventilator days x 1000
SSI RATE	Number of SSI cases/ Total number of surgeries done x 100

IV. PREVENTION OF HAI [2, 10]

1) CARE BUNDLE APPROACH

A. Maintenance bundle for mechanical ventilator

- Elevation of head end of the bed to 30°- 45° for preventing oropharyngeal aspiration into lungs
- Daily oral care with 2% chlorhexidine solution
- Strict adherence to hand hygiene
- Deep vein thrombosis prophylaxis if needed
- Peptic ulcer disease prophylaxis if needed (use only sucralfate)
- Daily assessment of readiness to remove mechanical ventilator must be documented

B. Care bundle for central line

- Strict adherence to hand hygiene before insertion and during handling
- Skin preparation with antiseptics such as chlorhexidine; allow to dry before insertion
- Site of insertion: subclavian vein is preferred; avoid femoral vein in adults
- Daily documentation of local signs of infection if present
- Daily aseptic central line care during handling (catheter hub, injection port, connectors to be decontaminated by alcohol)
- Change of dressing with 2% chlorhexidine solution
- Daily assessment of readiness to remove central line must be documented

C. Care bundle for urinary catheter

- Catheter is inserted by non-touch technique with strict asepsis
- Daily catheter care using hand hygiene and single use gloves
- Catheter is properly secured at all times

- Drainage bag must be always above floor and below bladder level
- Closed drainage system must be used at all times
- Daily assessment of readiness to remove catheter must be documented

D. Prevention of SSI[11]

i) Pre operative measures

- **Pre operative bathing** should be performed with antibacterial soap to reduce the bacterial load especially at the site of incision
- **Hair removal** if needed should be done only with a clipper but is otherwise discouraged
- **Decolonization** using mupirocin ointment should be carried out for surgery of MRSA carriers

ii) Intra operative measures

- **Surgical hand hygiene** should be performed for 3-5 minutes using a chlorhexidine or alcohol based hand solution
- **Site preparation** should be performed using chlorhexidine-alcohol antiseptic solution before the start of surgery
- **Surgical Antimicrobial Prophylaxis (SAP)** should be started 15- 60 minutes before the incision as a single intravenous dose. It is repeated in cases of prolonged surgery (>4 hours), extensive blood loss (upto1500ml) or if the duration of surgery exceeds two half lives of the antibiotic.[11, 12]
- **Perioperative maintenance** of oxygenation (target FiO_2 80%), blood glucose levels (target <200mg/ dl), sound nutritional status, temperature (normothermia) and circulating volume (normovolemia) should be carried out

iii) Post operative measures

- Daily **wound dressing** should be performed using aseptic hand hygiene techniques
- Periodic monitoring of **OT air quality** such as routine culture, temperature, humidity, air changes per hour should be carried out
- **OT disinfection** with a high level disinfectant should be carried out before the first case, in between the cases and after the last case
- **SAP prolongation** beyond 48 hours is not recommended as it leads to increased antimicrobial resistance and emergence of antibiotic resistant diarrhea strains (such as *Clostridioides difficile)*.

2) STANDARD PRECAUTIONS[2]

It is a group of infection control practices that are indicated while handling specimens, all individuals and sharps whether they appear infectious or not. This has now replaced the term 'Universal Precautions' which was earlier used for contact with blood and body fluids. These include-

- Strict aseptic hand hygiene preferably with soap and water; alcohol based hand rub can also be used
- Personal protective equipment (PPE) such as gowns, face shield, gloves, mask, cap, shoe cover
- Disinfection of patient care items before reuse for another patient
- Safe disposal of sharps in puncture proof containers
- Respiratory hygiene and cough etiquettes using N95 mask covering nose and mouth
- Spill management using 1% sodium hypochlorite for blood and other body fluids
- Biomedical waste management using color coded bins
- Environmental cleaning of surface and floor

3) TRANSMISSION BASED PRECAUTIONS[2]

These are specific precautions that are followed over and above the standard precautions. These are followed for infectious agents that have specific modes of transmission such as contact, droplet or airborne (Table 6).

TABLE 6: TRANSMISSION BASED PRECAUTIONS

Mode of transmission	Precautions
Contact	• Utilize single use patient dedicated equipment • Patient should be placed in single isolation room • Cohorting in same ward/ cubicle if single room not available with 3 feet spatial separation and privacy curtains between two beds should be followed • Transfer of patients to be limited to medically necessary purposes with covering of infected part during transfer • Disinfection of patient room at least once daily should be followed • Hand hygiene and appropriate PPE (gowns, gloves) should be used
Droplet	• Surgical mask to be worn by both HCW and patient (for source control) • Respiratory hygiene and cough etiquettes to be followed diligently • Patient should be placed in single isolation room • Strict adherence to hand hygiene should be followed • Transfer of patients is limited to medically necessary purposes with patient masked during transfer • Patient room should be disinfected at least once daily
Airborne	• Both HCW and patient should use N95 mask with fit checking • Patient should be placed in an Airborne Infection Isolation Room (AIIR) • Adequate natural or mechanical ventilation (negative pressure room) with at least 12 air changes per hour (ACH) in high risk areas and 6 ACH in low risk areas should be present • High efficiency particulate air filters (HEPA) should be placed in AIIR • Transfer of patients is limited to medically necessary purposes only with patient masked during transfer • Respiratory hygiene and cough etiquettes should be followed • Entry of visitors should be absolutely restricted

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