

Healthcare-Associated Infections and Control Strategies

* IGUNMA AJ, *ADEBUDO OS

*Department of Medical Microbiology,
University of Benin Teaching Hospital,
Benin City.

Correspondence

Dr A. Jeremiah Igunma
Department of Medical Microbiology,
University of Benin Teaching Hospital,
Benin City.
Email: docigunma@gmail.com

ABSTRACT

Background: According to the WHO, HAI is an infection occurring in a patient during the process of care in a hospital or other healthcare facility which was not present or incubating at the time of admission. This includes infections appearing more than 48 hours after admission, those acquired in the hospital but appearing up to 30 days after discharge, occupational infections among staff as well as, neonatal infections acquired either at birth or during hospitalization. The triage of HAI includes susceptible hosts, the presence of pathogenic organisms in the healthcare environment, and an appropriate vehicle for the transfer of the pathogens. HAI is estimated to cause about 40% of all neonatal deaths depending on environmental factors and differences in clinical practices. Generally, 16% of all hospitalized patients in developing countries are diagnosed with HAI.

Predisposing factors: This includes; admission as an emergency, ICU admission, hospital stay longer than seven days, and invasive procedures.

Aetiology: Although all microorganisms are capable of causing HAI, few organisms are notorious in this regard such as Staphylococci (MRSA), Escherichia coli (ESBL), Klebsiella pneumoniae (ESBL strains), and Pseudomonas aeruginosa

Prevention: Hand washing, screening, and categorization of patients into cohorts. Transmission-based precautions, and Antibiotic stewardship are the common measures to mitigate HAI

Conclusion HAIs constitute a major barrier to the safety of patients and care providers in the healthcare space. It is opined that hand and environmental hygiene, with antibiotic stewardship among other strategies when adequately practiced will help in minimizing HAIs and improve treatment outcomes.

Key words: Healthcare-associated infection, HAI, risk factors

INTRODUCTION

Health Care Associated Infections (HAI) is a major problem for patient safety and its surveillance and prevention must be a first priority for settings and institutions committed to making health care safer (Forder, 2017). Health Care-Associated Infections (HAI) were earlier known as "Nosocomial infections" and the term was derived from the Greek words "nosus" meaning disease and

"komeion" meaning to take care of (Brennan et al., 1991). It is the single largest factor that adversely affects both the patient and the hospital. The most common types of adverse events affecting hospitalized patients are; Adverse drug reactions, HAIs, and Surgical complications (Brennan et al., 1991)

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According to *Hounton et al.* in the 21st century, it is unacceptable that a person who is ill runs the additional risk of acquiring an infection while seeking respite from his present ailment (Hounton et al., 2013).

HISTORICAL PERSPECTIVES

Hippocrates made the relatively profound statement "Primum non nocere" that is if you wish to become a physician, always follow the maxim, first do no harm (Gill, 2021). Similarly, though in a different era, Florence Nightingale made another profound statement "The very first requirement in a hospital is that it should do the sick no harm" (Morrow, 2021)

In 1854, during the Crimean War, Florence Nightingale demonstrated that hygiene could make a difference in HAI. She demonstrated this by cleaning up the military hospital with antiseptic, application of rat poisons to eradicate rodents, scrub-brushing the floors, and using fresh linen would result in a reduction of the combat wounded death rates from 40% to 2% in a matter of six months (Fee & Garofalo, 2010).

At the same time Joseph Lister, a British Surgeon also demonstrated that infection of amputated limbs reduced from 47% to 17% following the introduction of the ritual of hand washing and the use of carbolic acid as antiseptics (Michaleas et al., 2022).

The present era of healthcare-associated infections (HAI) awareness started with the formation of the Center for Disease Control and Prevention (CDC) in 1946, with the primary tasks of field investigation, training, and control of communicable diseases and encouragement of the development of formal infection control programs. This got expanded in 1970 with the establishment of the National Nosocomial Infection Surveillance System (NNIS) now named the National Healthcare Safety Network (NHSN) and used by

nearly all infection preventionists across the world to report and track nosocomial infections (Smith et al., 2012).

In 1974 CDC initiated another study known as the Study on the Efficacy of Nosocomial Infection Control (the SENIC Project). This study was aimed at thoroughly assessing infection control effectiveness globally (Smith et al., 2012). It was observed that one-third of healthcare-associated infections were preventable through effective infection control (Collins, 2010).

Definition of HAI

The World Health Organization (WHO) defines HAI as an infection occurring in a patient during the process of care in a hospital or other healthcare facility which was not present or incubating at the time of admission (Revelas, 2012). This includes infections that:

- ❖ appeared more than 48 hours after admission,
- ❖ were acquired in the hospital but appeared up to 30 days after discharge,
- ❖ occupational infections among staff such as Needle Stick Injury/exposure to blood & body fluids e.g. HBV, HCV & HIV.
- ❖ neonatal infections acquired either at birth or during hospitalization, unless there is evidence of trans-placental transmission.

However, the following conditions are not infections

Colonization, which means the presence of microorganisms on the skin, on mucous membranes, in open wounds, or in excretions or secretions but is not causing adverse clinical signs or symptoms. Although within hours after admission, a patient's flora begins to acquire characteristics of the surrounding bacterial pool. Most infections that become clinically evident after 48 hours of hospitalization are considered hospital-acquired.

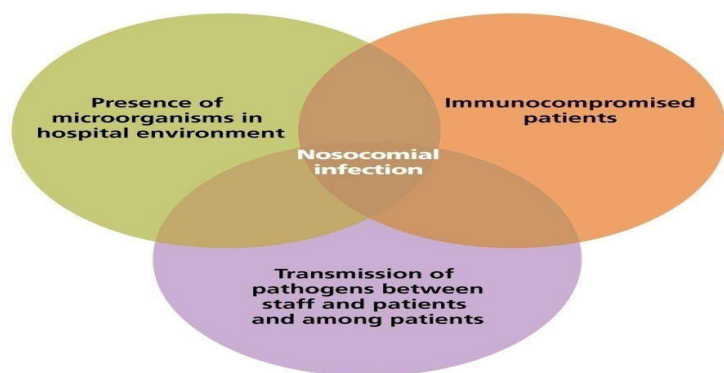


Figure 1: Cardinal agents for the occurrence of healthcare-associated infections.

Epidemiology

HAI is estimated to cause about 40% of all neonatal deaths depending on environmental factors and differences in clinical practices (Agbalaya et al., 2021). In general, 16% of all hospitalized patients in developing countries are diagnosed with HAI (Magill et al., 2014). HAIs prolonged hospital stay by 5–21 days with mortality ranging from 7% to 46% (Abubakar et al., 2022). Out of every 100 hospitalized patients, seven patients in advanced countries and ten patients in developing countries acquire an HAI (Danasekaran et al., 2014). The WHO reports however that HCAs usually receive public attention only when there are epidemics (WHO, 2018). HAIs also have an impact on critically ill patients with around 0.5 million episodes of HAIs being diagnosed every year in the Intensive Care Units (ICU) alone (Haque et al., 2018). ICU patients are often in a very critically ill, immunocompromised status which increases their susceptibility to HAIs (Haque et al., 2018).

Predisposing factors to healthcare-associated infections

Patients admitted to the hospital acquire infection because of the following reasons; the hospital environment often serves as a reservoir for infectious agents, patients harboring various pathogens are admitted into the hospital, and other patients with Immunodeficiency of varying degrees are seen in the healthcare settings. Understanding the risk factors for developing HAI in settings with a high burden of healthcare-associated infections is a recommendable step to curbing the menace (Murni et al., 2022).

Specific Risk factors for HAI include but are not limited to; admission as an emergency, ICU admission, hospital stay longer than seven days, and invasive procedures such as central vein catheterization, urethral catheterization, and endotracheal tube insertion. Others are neutropenia, placing patients on immune-suppressing medications, and other immunosuppressive conditions, increase patients to staff ratio. Also, everything in the hospital environment including contaminated air, other patients, fomites, visitors, and healthcare workers can serve as a vehicle for HAI when optimal IPC is not in place (Ghali et al., 2019).

The hands are a notable vehicle for the transmission of HAI, for example, a person can pick between 100 - 1000 bacteria with their hand by doing simple procedures like assisting the patient up from bed, changing the patient gown, and changing the bed sheet. About 80% of infectious diseases are transmitted by unclean hands touching contaminated surfaces.²⁹ Pathogens

survive for days and months and are transferred via people's hands through frequently touch surfaces such as tap heads, door handles, stair railings, light/socket switches, –drip stands, and Nursing stations (WHO, 2009).

AETIOLOGY AGENTS OF HAI

Although all microorganisms (Bacteria, Viruses, Fungi, and Parasites) can cause infection few organisms are notorious for causing HAI. Examples and common infections include **Methicillin-Resistant Staphylococci (MRSA)** – wound infection, bloodstream infections (BSI), and sepsis. **Escherichia coli** – urinary tract infection, sepsis. **Klebsiella pneumoniae**-urinary tract infections and wound, sepsis, **Pseudomonas aeruginosa**–ventilator-associated pneumonia (VAP), wound infections, BSI, sepsis, **Streptococci**–wound infection, **Proteus spp**–wound infection, urinary tract infections, sepsis. **C. difficile**–antibiotics-associated diarrhea. **Hepatitis B & C**–infectious hepatitis, **Human immunodeficiency virus [HIV]**–Acquired Immunodeficiency Syndrome **Candida spp**- candidemia, **Aspergillus spp**- Aspergillosis (WHO, 2009). Among these pathogens, 16%–20% include multidrug-resistant (MDR) strains such as MRSA, vancomycin-resistant *E. faecium*, carbapenem-resistant *aeruginosa*, extended-spectrum cephalosporin-resistant *K. pneumoniae*, *K. oxytoca*, *E. coli*, and *Enterobacter species*, and carbapenem-resistant *aeruginosa*, *K. pneumoniae*/*K. oxytoca*, *E. coli*, *Enterobacter species*, and *A. baumannii* (Haque et al., 2018). In general, the organisms isolated from device-associated HAIs have the highest antimicrobial resistance phenotypes (Haque et al., 2018).

Even though the term is a healthcare-associated infection, patients' flora contributes up to 50% to the aetiology of this infection, this in some cases occurs as autoinfection, especially in surgical site infection. It's been reported that more than 30% of the general population harbor *Staphylococcus aureus* in their anterior nares, similarly, 15.2% harbor enterobacterales resistant to carbapenems (CRE) in their stool. All these contribute significantly to HAI especially in settings with poor IPC and no active surveillance cultures prior to admission to high dependency units. The cumulative exogenous contributors to HAI constitute the other 50%. this includes Air-5%, instruments-10%, and another patient/staff- Cross Infection (35%) (WHO, 2009; Wangchinda et al., 2022).

TYPES OF HAI

Besides infections resulting from cross-contamination between patients and health workers, patients can be susceptible to common infections due to diminished immune responses, and infections at surgical sites (Surgical Site Infections), many other (Centers for Disease Control and Prevention, 2018). HAIs are also due to implants and prostheses. These include catheter-associated UTIs, central line-associated bloodstream infections (CLABSIs), and ventilator-associated pneumonia (VAP)

Surgical Site Infection (SSI)

Defined as one in which there is any skin eruption or drainage at the surgical site and is positive for bacteria by culture within 30 days of a surgical procedure or within one year if an implant was placed. SSI has been used as a prototype of HAI as a result, it is therefore used as a good index of nosocomial infection. The common sources of pathogens for SSI include patient flora, surgical personnel, the physical environment and ventilation, tools/equipment/materials in the operation theatre (Haque et al., 2018; Centers for Disease Control and Prevention, 2018).

Why do we border about SSI?

The widespread of multidrug-resistant (MDR) bacteria including MRSA, CRE, and other multidrug-resistant organisms (MDRO) in our environment, suboptimal IPC practices, high propensity for BSI, increase risk of sepsis and septic shock (Centers for Disease Control and Prevention, 2018).

Catheter-Associated Urinary Tract Infections

Catheter-associated urinary tract infections (CAUTIs) continue to be among the most common healthcare-associated infections worldwide. CAUTIs account for 40% of all hospital-acquired infections and 80% of all healthcare-associated (UTIs). It is estimated that 10–12% of hospitalized patients and 4% of patients in the community have urinary catheters *in situ* at any given time (Tenke et al., 2017). At the time of catheter insertion, up to 20% of patients will be colonized immediately, 0.4 - 4% of catheterized patients with catheter-associated bacteriuria develop bacteremia. Urine from patients with chronic indwelling catheters has been found to be the most common site of isolation of resistant gram-negative organisms in healthcare settings. Current data do not support the treatment of catheter-associated asymptomatic bacteriuria (Tenke et al., 2017).

The key principles to prevent CAUTI include avoiding unnecessary catheterization and limiting duration of catheterization.

Ventilator-Associated Pneumonia (VAP)

This is defined as an airway infection that develops more than 48 hours after the patient was intubated. A subset of healthcare-associated pneumonia and the most fatal of all hospital-acquired infections. Between 9% and 27% of patients with assisted ventilation develop this kind of pneumonia. The average critical time to develop VAP following endotracheal intubation and mechanical ventilation is usually 2–3 days. Common clinical presentations usually include fever, altered bronchial sounds, reduced white cell counts, changes in sputum, and causative organisms that are often identified (Kalanuria et al 2014). This subset of pneumonia is often associated with the administration of inappropriate antibiotics treatment because the common empiric antibiotics such as coamoxi-clav and ceftriaxone do not cover the frequent causative organisms such as *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and MRSA (Haque et al., 2018).

Central Line Associated Blood Stream Infection (CLABSI)

CLABSI is a laboratory-confirmed bloodstream infection not related to any known focus of infection, and develops within 48 hours of a central line placement (Haddadin et al., 2023). Two types of central line exist: (1) Tunneled catheters, these are implanted surgically into the internal jugular, subclavian, or femoral vein, they are indicated for long term use such as chemotherapy or hemodialysis and (2) Non tunneled catheters, are more commonly used especially in the ICU. They are central lines inserted percutaneously and account for most CLABSIs.

Diagnostic criteria; CLABSI occurs when these three criteria exist:

- ▶ Clinical signs of infection e.g., fever, rigors, altered mental status, hypotension
- ▶ No alternate source of bloodstream infection
- ▶ Positive blood culture from a peripheral vein with any one of the following:
 - Catheter tip/segment culture that matches organism grown from blood
 - At least a threefold higher number of organisms grown from the catheter versus the peripheral blood culture on simultaneously drawn cultures
 - Growth from the catheter-drawn blood culture occurs at least two hours before the growth of the same organism from a peripheral vein (Haddadin et al., 2023).

Pathogenesis

Within 7 days of the catheter insertion, bacteria on the skin surface migrate along the external surface

of the catheter from the skin exit site towards the intravascular space. However, for tunneled catheters there is a cuff that causes a fibrotic reaction around the catheter, thus creating a barrier to bacterial migration. The absence of such fibrotic reaction places non-tunneled catheters at higher risk for CLABSIs (Bell & O'Grady, 2017).

Common mechanisms for CLABSI occurrences include

- Pathogen migration along external surfaces is the most common cause of early CLASBI (< 7 days)
- Hub contamination with intraluminal colonization common cause of CLABSI occurring >10 days

Less Common Mechanisms of CLABSI include:

- Hematogenous seeding from another source
- Contaminated infusates

Commonly implicated organisms are those found on the skin such as Gram-positive organisms (coagulase-negative staphylococci, 34.1%; *Enterococci*, 16%; and *Staphylococcus aureus*, 9.9%) are the most common followed by gram negatives (*Klebsiella*, 5.8%; *Enterobacter*, 3.9%; *Pseudomonas*, 3.1%; *E.coli*, 2.7%; *Acinetobacter*, 2.2%), *Candida species* (11.8%), and others (10.5%) (Haddadin et al., 2023). Management includes removal of the catheter when appropriate plus adequate antibiotics based on local antibiogram until blood culture results are available.

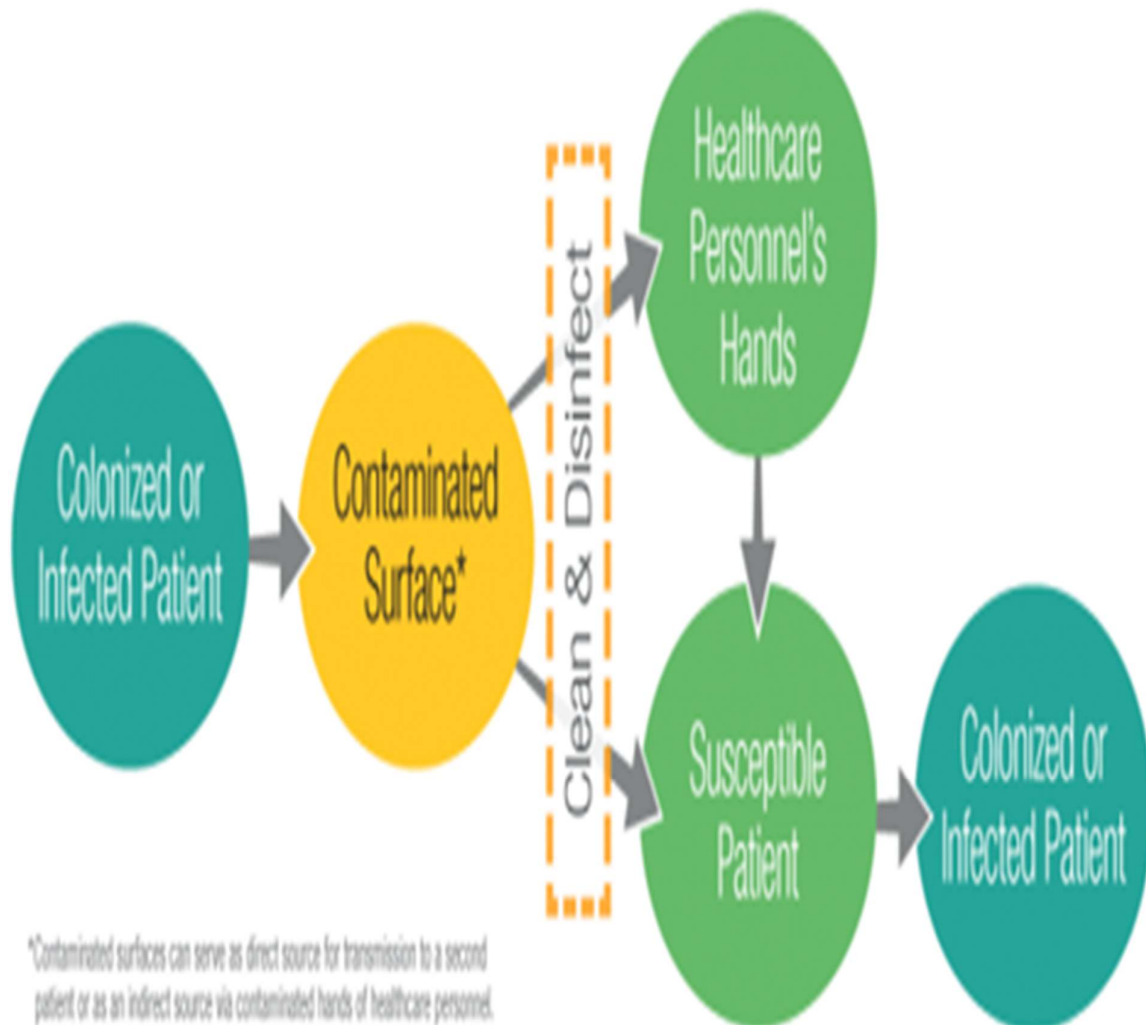


Fig 2 Role of infection control in breaking the chain of transmission

STRATEGIES TO PREVENT HAI

HAIs have constituted a significant global public health burden attracting the concerns of all

stakeholders in the healthcare space, including health professionals, patients, and the public (Haque et al., 2020). It is widely known that

prevention and control of HAI is indeed very complicated, and requires a multi-dimensional approach and strategies to address it. To achieve the desired results a number of strategies have been put together to be used collectively for optimal outcomes.

Standard precautions

These are the minimum infection prevention practices that apply to all patient care, regardless of the infection status of the patient in any setting where health care is delivered. The Rationale is to consider all patients infectious. Standard precaution has the following components which must be strictly adhered to, for adequate safety of the personnel and patients. Hand Hygiene, environmental cleaning, Injection, and Medication Safety, Appropriate use of personal protective equipment (PPE), Waste management, and Respiratory hygiene/cough etiquette (Akagbo et al., 2017).

Screening and categorizing patients into cohorts

This help select patients for specific transmission-based precautions. This often applies to patients with known or suspected diagnoses.

Transmission-based precautions

These are specific infection preventive measures instituted based on patients' diagnoses. They include contact precautions, droplet precautions, and airborne precautions.

Antibiotic stewardship:

A set of coordinated strategies to improve the use of antimicrobial medications with the goal of enhancing patient health outcomes, reducing resistance to antibiotics, and decreasing unnecessary costs (Haque et al., 2020). The aim of AMS is to halt overall antimicrobial overuse, misuse, and abuse, above all **to halt or slow the expansion of antibiotic resistance**. It also emphasizes the appropriate use of empirical antibiotics based on precise clinical diagnosis and local antibiogram of the institution. It also encompasses a mandatory de-escalation policy for pathogen-directed therapy based on laboratory results, and the culture of compulsory documentation of start and stop dates for prescribed antibiotics (Haque et al., 2020).

CONCLUSION

HAIs are a major safety concern for both patients and healthcare providers. The incidence continues to escalate at an alarming rate, especially in developing countries where infection rates are 3–20 times higher than in developed countries. HAIs increase morbidity, mortality, length of hospital

stays, and costs, therefore, its recommended that hand and environmental hygiene with antibiotic stewardship among other strategies be incorporated as the principal measures for minimizing HAIs and improving treatment outcomes.

LIMITATIONS

HAIs are a very broad topic, and it is therefore not been possible to cover all aspects in a single write-up; Therefore, key aspects commonly encountered in our settings were selected for this discussion.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

REFERENCES

- Abubakar U, Amir O, Rodríguez-Baño J (2022). Healthcare-associated infections in Africa: a systematic review and meta-analysis of point prevalence studies. *J Pharm Policy Pract*; 15(1):99. doi: 10.1186/s40545-022-00500-5.
- Agbalaya OV, Osuagwu C, Oduyebo O (2021). Environmental reservoirs of healthcare associated infections in the neonatal wards of a university teaching hospital in Lagos, Nigeria. *Med Microbiol Diagn*; 10:1-5.
- Akagbo, SE, Nortey, P, Ackumey, MM (2017). Knowledge of standard precautions and barriers to compliance among healthcare workers in the Lower Manya Krobo District, Ghana. *BMC Res Notes*; 10:432. doi.org/10.1186/s13104-017-2748-9
- Bell T, O'Grady NP (2017). Prevention of Central Line-Associated Bloodstream Infections. *Infect Dis Clin North Am*; 31(3):551-559.
- Brennan TA, Leape L, Laird NM, Lucian JD, Liesi H, Localio RA, et al (1991). Incidence of Adverse Events and Negligence in Hospitalized Patients: Results of the Harvard Medical Practice Study I. *The New Engl J Med*; 324 (6):370-376.
- Centers for Disease Control and Prevention (2018). Surgical Site Infection (SSI) Event. [Accessed September 2, 2022]. Available from: <https://www.cdc.gov/nhsn/pdfs/pscmanu al/gpscscscurrent.pdf>.

- Collins AS (2008). Preventing Health Care–Associated Infections. In: Hughes RG, editor. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US); Chapter 41. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK2683/>
- Danasekaran R, Mani G, Annadurai K (2014). Prevention of healthcare-associated infections: protecting patients, saving lives. *Int J Community Med Public Health*; 1(1):67–68.
- Fee E, Garofalo ME (2010). Florence Nightingale and the Crimean War. *Am J Public Health*; 100(9):1591. doi: 10.2105/AJPH.2009.188607.
- Forder AA (2007). A brief history of infection control past and present. *S Afr Med*; 97:1161–1164.
- Ghali H, Cheikh AB, Bhiri S, Aissa KS, Dhidah L, Rejeb BM, et al (2019). Risk factors of healthcare associated infections: prevalence surveys over five years. *Euro J Public Health*; 29(4), ckz186.505, doi.org/10.1093/eurpub/ckz186.505
- Gill NS (2021). "Is 'First Do No Harm' Part of the Hippocratic Oath?" Thought Co, Feb. 16, 2021, thoughtco.com/first-do-no-harm-hippocratic-oath-118780.
- Haddadin Y, Annamaraju P, Regunath H (2023). Central Line Associated Blood Stream Infections. In: StatPearls. Treasure Island (FL): StatPearls Publishing; Available from: <https://www.ncbi.nlm.nih.gov/books/NBK430891>
- Haque M, McKimm J, Sartelli M, Dhingra S, Labricciosa FM, Islam S, et al (2020) Strategies to Prevent Healthcare-Associated Infections: A Narrative Overview. *Risk Manag Healthc Policy*; 13:1765-1780.
- Haque M, Sartelli M, McKimm J, Abu Bakar M (2018). Health care-associated infections - an overview. *Infect Drug Resist*; 11:2321-2333.
- Hounton S, Bernis LD, Hussein J, Graham WJ, Danel I, Byass P et al (2013). Towards elimination of maternal deaths: maternal deaths surveillance and response. *Reprod Health*;10(1). doi.org/10.1186/1742-4755-10-1
- Kalanuria AA, Ziai W, Zai W, Mirski M (2014). Ventilator-associated pneumonia in the ICU. *Crit Care*;18(2):208. doi: 10.1186/cc13775.
- Magill SS, Edwards JR, Bamberg W (2014), Emerging Infections Program Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey Team Multistate point-prevalence survey of health care-associated infections. *N Engl J Med*;370(13):1198–1208.
- Michaleas SN, Laios K, Charalabopoulos A, Samonis G, Karamanou M (2022). Joseph Lister (1827-1912): A Pioneer of Antiseptic Surgery. *Cureus*; 14(12):e32777. doi: 10.7759/cureus.32777.
- Morrow BM (2021). Building a culture of early mobilization in the pediatric intensive care unit-a nuts and bolts approach. *Transl Pediatr*; 10(10):2845-2857.
- Murni IK, Duke T, Kinney S (2022). Risk factors for healthcare-associated infection among children in a low-and middle-income country. *BMC Infect Dis*; 22, 406 doi.org/10.1186/s12879-022-07387-217
- Revelas A (2012). Healthcare - associated infections: A public health problem. *Niger Med J*; 53(2):59–64.
- Smith PW, Watkins K, Hewlett A (2012). Infection control through the ages. *Am J Infect Control*; 40(1):35-42.
- Tenke P, Mezei T, Bóde I, Köves B (2017). Catheter-associated Urinary Tract Infections. *Euro Urol Suppl*; 16(4):138–143.
- Wangchinda W, Laohasakprasisit K, Lerdlamyong K, Thamlikitkul V (2022). Epidemiology of Carbapenem-Resistant *Enterobacteriales* Infection and Colonization in Hospitalized Patients at a University Hospital in Thailand. *Infect Drug Resist*; 15:2199-2210.
- WHO (2009). Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care. Geneva: World Health Organization;7, Transmission of pathogens by hands. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK144014/>
- WHO (2018). *Healthcare-associated infections. Fact Sheet*. [Accessed April 1, 2018]. Available from: http://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf