

## Nosocomial Infections Associated with Caesarean Section

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### Abstract:

Nosocomial infections, also called health-care-associated or hospital-acquired infections, are a subset of infectious diseases acquired in a health-care facility. Historically, Staphylococci, Pseudomonas, and Escherichia coli have been the common known as nosocomial infection bacteria. Moreover, nosocomial pneumonia, surgical wound infections, and vascular access-related bacteremia have caused the most illness and death in hospitalized patients; and intensive care units have been the epicenters of antibiotic resistance .

Acquired antimicrobial resistance is the major problem, and vancomycin-resistant Staphylococcus aureus is the pathogen of greatest concern. The shift to outpatient care is leaving the most vulnerable patients in hospitals. Aging of our population and increasingly aggressive medical and surgical interventions, including implanted foreign bodies, organ transplantations, and xenotransplantation, create a cohort of particularly susceptible persons. Moreover, renovation of aging hospitals increases risk of airborne fungal and other infections.

To prevent and control these emerging nosocomial infections, we need to increase national surveillance, "risk adjust" infection rates so that inter hospital comparisons are valid, develop more noninvasive infection-resistant devices, and work with health-care workers on better implementation of existing control measures such as hand washing.

In this review we aimed to review the previous projects which study incidence of hospital infection among delivery women with caesarean section in hospitals. Also, to discuss about the nosocomial infections and its types. We will also review the most common way a nosocomial infection is acquired, and the most common cause of nosocomial infection. In order to the modes of transmission of infection. In addition to a way to prevent nosocomial infections in hospitals.

KEYWORDS: nosocomial infections, caesarean section

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## INTRODUCTION

A hospital-acquired infection, also known as a nosocomial infection, is an infection that is acquired in a hospital or other health care facility (Rosenthal et al., 2012). To emphasize both hospital and nonhospital settings, it is sometimes instead called a healthcare-associated infection, such an infection can be acquired in hospital, nursing home, rehabilitation facility, outpatient clinic, diagnostic laboratory or other clinical settings.

Infection is spread to the susceptible patient in the clinical setting by various means. Health care staff also spread infection, in addition to contaminated equipment, bed linens, or air droplets. The infection can originate from the outside environment, another infected patient, staff that may be infected, or in some cases, the source of the infection cannot be determined. In some cases, the microorganism originates from the patient's own skin microbiota, becoming opportunistic after surgery or other procedures that compromise the protective skin barrier. Though the patient may have contracted the infection from their own skin, the infection is still considered nosocomial since it develops in the health care setting (Monegro et al., 2020). An easy way to understand the term is that the infection tends to lack evidence that it was incubating, or present when the patient entered the healthcare setting, thus meaning it was acquired post-admission. (Sydnor et al., 2011). Nosocomial infections can cause severe pneumonia and infections of the urinary tract, bloodstream and other parts of the body (Burke A Cunha., 2018).

### Types of nosocomial infection:

**Ventilator-associated pneumonia:** Ventilator-associated pneumonia (VAP) is a type of lung infection that occurs in people who are on mechanical

**Urinary tract infection:** A urinary tract infection (UTI) is an infection that affects part of the urinary tract. When it affects the lower urinary tract it is known as a bladder infection (cystitis) and when it affects the upper urinary tract it is known as a kidney infection (pyelonephritis). Symptoms from a lower urinary tract infection include pain with urination, frequent urination, and feeling the need to urinate despite having an empty bladder. Symptoms of a kidney infection include fever and flank pain usually in addition to the symptoms of a lower UTI (Lane et al., 2011). Rarely the urine may appear bloody. In the very old and the very young, symptoms may be vague or non-specific (Salvatore et al., 2011, George, 2011). The most common cause of infection is *Escherichia coli*, though other bacteria or fungi may sometimes be the cause Risk factors include female anatomy, sexual intercourse, diabetes, obesity, and family history) Flores et al., 2015).

**Hospital-acquired pneumonia:** Hospital-acquired pneumonia (HAP) or nosocomial pneumonia refers to any pneumonia contracted by a patient in a hospital at least 48–72 hours after being admitted. It is thus distinguished from community-acquired pneumonia. It is usually caused by a bacterial infection, rather than a virus (Gerald L et al., 2004, David and Warrell , 2003). Pneumonia as seen on chest x-ray. A: Normal chest x-ray. B: Abnormal chest x-ray with shadowing from pneumonia in the right lung (left side of image). HAP is the second most common nosocomial infection (after urinary tract infections) and accounts for 15–20% of the total (Bennett et al.,2004, Edward and Benz, 2003).

ventilation breathing machines in hospitals. As such, VAP typically affects critically ill persons that are in an intensive care unit (ICU) (Michetti et al., 2012). VAP is

a major source of increased illness and death. Persons with VAP have increased lengths of ICU hospitalization and have up to a 20–30% death rate. The diagnosis of VAP varies among hospitals and providers but usually requires a new infiltrate on chest x-ray plus two or more other factors. These factors include temperatures of  $>38\text{ }^{\circ}\text{C}$  or  $<36\text{ }^{\circ}\text{C}$ , a white blood cell count of  $>12 \times 10^9/\text{ml}$ , purulent secretions from the airways in the lung, and/or reduction in gas exchange (Koenig et al., 2006). A different less studied infection found in mechanically ventilated people is ventilator-associated tracheobronchitis (VAT). As with VAP, tracheobronchial infection can colonise the trachea and travel to the bronchi. VAT may be a risk factor for VAP (Craven et al., 2009).

**Gastroenteritis:** Gastroenteritis, also known as infectious diarrhea and gastro, is inflammation of the gastrointestinal tract—the stomach and intestine (Schlossberg et al., 2015). Symptoms may include diarrhea, vomiting and abdominal pain (Singh et al., 2015). Fever, lack of energy and dehydration may also occur. This typically lasts less than two weeks. It is not related to influenza, though it has erroneously been called the "stomach flu" (Ciccarelli., 2013, Schlossberg and David, 2015, Shors, 2013). Gastroenteritis is usually caused by viruses. However, bacteria, parasites, and fungus can also cause gastroenteritis (Helms et al., 2006). In children, rotavirus is the most common cause of severe disease (Tate et al., 2012). In adults, norovirus and Campylobacter are common causes. Eating improperly prepared food, drinking contaminated water or close contact with a person who is infected can spread the disease (Marshall., 2013, Man, 2011). Eating improperly prepared food, drinking contaminated water or close contact with a person who is infected can spread the disease. Treatment is generally the same with or without a definitive diagnosis, so testing to confirm is usually not needed (Ciccarelli et al., 2013). Prevention includes hand

washing with soap, drinking clean water, breastfeeding babies instead of using formula and proper disposal of human waste. The rotavirus vaccine is recommended as a prevention for children (Ciccarelli et al., 2013).

**Postpartum infections:** Postpartum infections, also known as childbed fever and puerperal fever, are any bacterial infections of the female reproductive tract following childbirth or miscarriage (Williams et al., 2014). Signs and symptoms usually include a fever greater than  $38.0\text{ }^{\circ}\text{C}$  ( $100.4\text{ }^{\circ}\text{F}$ ), chills, lower abdominal pain, and possibly bad-smelling vaginal discharge (McGraw et al., 2014).

It usually occurs after the first 24 hours and within the first ten days following delivery ( Hiralal Konar., 2014). The most common infection is that of the uterus and surrounding tissues known as puerperal sepsis, postpartum metritis, or postpartum endometritis ( Elsevier ., 2015). Risk factors include Caesarean section (C-section), the presence of certain bacteria such as group B streptococcus in the vagina, premature rupture of membranes, multiple vaginal exams, manual removal of the placenta, and prolonged labour among others. Most infections involve a number of types of bacteria. Diagnosis is rarely helped by culturing of the vagina or blood. In those who do not improve, medical imaging may be required. Other causes of fever following delivery include breast engorgement, urinary tract infections, infections of an abdominal incision or an episiotomy, and atelectasis (Williams et al., 2014). Due to the risks following Caesarean section, it is recommended that all women receive a preventive dose of antibiotics such as ampicillin around the time of surgery. Treatment of established infections is with antibiotics, with most people improving in two to three days. In those with mild disease, oral antibiotics may be used; otherwise intravenous antibiotics are recommended. Common antibiotics include a combination of ampicillin and gentamicin following vaginal delivery or

clindamycin and gentamicin in those who have had a C-section. In those who are not improving with appropriate treatment, other complications such as an abscess should be considered (Williams et al., 2014).

**Central venous catheter:** A central venous catheter (CVC), also known as a central line, central venous line, or central venous access catheter, is a catheter placed into a large vein. It is a form of venous access. Placement of larger catheters in more centrally located veins is often needed in critically ill patients, or in those requiring prolonged intravenous therapies, for more reliable vascular access. These catheters are commonly placed in veins in the neck (internal jugular vein), chest (subclavian vein or axillary vein), groin (femoral vein), or through veins in the arms (also known as a PICC line, or peripherally inserted central catheters). Central lines are used to administer medication or fluids that are unable to be taken by mouth or would harm a smaller peripheral vein, obtain blood tests (specifically the "central venous oxygen saturation"), administer fluid or blood products for large volume resuscitation, and measure central venous pressure (McKean *et al.*, 2012, Cavallazzi and Pan, 2012). The catheters used are commonly 15–30 cm in length, made of silicone or polyurethane, and have single or multiple lumens for infusion.

### **Causative Organisms:**

Pathogens responsible for nosocomial infections include bacteria, viruses, and fungi. Specific microorganisms have unique characteristics that favor particular types of infections in susceptible hosts. The prevalence of infections caused by particular microorganisms varies depending on the healthcare facility location, healthcare setting, and patient population. Overall, bacteria are the most common pathogens, followed by fungi and viruses. The organisms causing most nosocomial infections usually come from the patient's normal flora of the skin and mucous membranes (endogenous flora), when host

factors that alter susceptibility to infection permit these organisms to behave as pathogens (Abdel-Fattah., 2005). In general, endogenous infection is best prevented by attention to individual patient susceptibility factors such as use of good surgical technique, preservation of the integrity of mechanical barriers to infection, and judicious use of immunosuppressive agents. Nosocomial infections can also be transmitted by direct contact by the hands of hospital staff members (cross-contamination), other patients, contaminated instruments and needles, and the inanimate environment (exogenous flora) (Farber., 1987).

Bacteria may originate from an exogenous or endogenous source as part of the natural flora. Opportunistic bacterial infections occur when there is a breakdown of the host immune system functions. Common Gram-positive organisms include coagulase-negative Staphylococci, *Staphylococcus aureus*, *Streptococcus* species, and *Enterococcus* species (e.g. *faecalis*, *faecium*). Of all HAI associated pathogens, *Clostridium difficile* accounts for the most commonly reported pathogen in US hospitals (15% of all infections with a reported pathogen) (Brooks et al., 2018, Maloney and McAllister-Hollod, 2014). Common Gram-negative organisms include species of the Enterobacteriaceae family, including *Klebsiella pneumoniae* and *Klebsiella oxytoca*, *Escherichia coli*, *Proteus mirabilis*, and *Enterobacter* species; *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and *Burkholderia cepacia*. *Acinetobacter baumannii* is associated with high mortality within the intensive care setting owing to its inherent multi-drug resistant properties (Falagas ME, Kopterides P, 2006, Vincent JL, Rello J, Marshall J, 2009, Jernigan JA, Hatfield KM., 2012-2017). Multidrug-resistant bacteria are commonly seen in HAI and are associated with significant mortality (Wolford et al., 2020). One study found that approximately 20% of all reported pathogens show multidrug-resistant patterns (Sievert

et al., 2009). Notorious pathogens include methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-intermediate *Staphylococcus aureus* (VISA) and Vancomycin-resistant *Staphylococcus aureus* (VRSA), Enterobacteriaceae with extended-spectrum cephalosporin resistance consistent with extended-spectrum beta-lactamase (ESBL) production, vancomycin-resistant *Enterococcus* (VRE), carbapenem resistant Enterobacteriaceae and *Acinetobacter* species, and multi-drug resistant *Pseudomonas aeruginosa* (Srinivasan et al., 2013).

Fungal pathogens are usually associated with opportunistic infections in immunocompromised patients and those with indwelling devices, such as central lines or urinary catheters. *Candida* species, such as *C. albicans*, *C. parapsilosis*, *C. glabrata* are the most commonly encountered fungal organisms associated with HAI (Leaprot et al., 2018). *Candida auris* poses a serious problem as a globally emerging multidrug-resistant organism with high morbidity and

**Routes of Transmission:** Pathogens associated with healthcare-associated infection (HAI) may have different routes of transmission. The most common route of transmission is through contact, whereby the organisms are transmitted by direct or indirect contact. Common microorganisms that may be transmitted through contact are multidrug-resistant bacteria (such as MRSA, ESBL-producing Gram-negative organisms, VRE), *C. difficile*, and rotavirus. Droplet transmission may occur when microorganisms are transmitted from the respiratory tract by large droplets (greater than 5 microns) and travel less than 3 feet. Examples of infectious pathogens that are transmitted via the droplet route include influenza, *Bordetella pertussis*, and *Neisseria meningitidis*. Airborne transmission involves the transmission of organisms from the respiratory tract by small droplets (less than 5 microns) that travel long distances. Chickenpox virus, tuberculosis, measles, and the novel SARS-COV-2

mortality due to difficulty with diagnoses and high rates of treatment failure (Spivak et al., 2018). Altogether, *Candida* species make up the fourth most common pathogen across all types of HAIs (Weiner et al., 2016). *Aspergillus fumigatus* may be acquired by airborne environmental contamination in areas of healthcare construction. However, infected hospitalized patients may be a primary source (Park et al., 2019, Lemaire and Normand, 2018).

Infections due to viral pathogens are the least reported, making up 1-5% of all HAIs pathogens (Aitken et al., 2001). Healthcare-acquired hepatitis B and C and human deficiency virus (HIV) has been implicated in unsafe needle practices. Globally 5.4% of all HIV infections are healthcare-associated and frequently occur in developing countries. (Ganczak et al., 2008) Other reported viral pathogens include rhinovirus, cytomegalovirus, herpes simplex virus, rotavirus, and influenza.

#### **PATHOPHYSIOLOGY:**

virus may be transmitted through the airborne route (Ferioli et al., 2020).

**Central Line-Associated Blood Stream Infection (CLABSI):** CLABSI occurs in the setting of a central venous line (CVC) and is the most preventable type of HAI. In the United States, 55% of ICU patients and 24% of non-ICU patients have CVC. (Climo et al., 2003) CLABSI typically occurs when bacteria on the skin proliferate along the external portion of the catheter toward the intravascular part. Contamination of the CVC during insertion or manipulation process or by hematogenous seeding are other ways. CLABSI can occur. Bacterial and fungal pathogens responsible for CLABSI and CAUTI frequently have virulence properties that result in biofilm production, which increases adherence and proliferation on external devices (Bell et al., 2017). A recent study in the United States listed the common organisms

associated with CLABSI as *S. aureus* (23%), *Candida* species (13%), coagulase-negative *Staphylococcus* (12%), *Enterococcus* species (12%), *Streptococcus* species (12%), *E. coli* (8%), *Bacteroides* species (6%). However, other studies still show coagulase-negative *Staphylococci* as the most common organism ( Magill et al., 2018, Baier and Linke, 2016). Among these pathogens, antimicrobial resistance is a serious problem ( Jernigan et al., 2020). Risk factors for CLABSI may be divided into host and catheter factors. Host factors include immunocompromised statuses such as chronic illness, neutropenia, malnutrition, parenteral nutrition, extremes of ages, and bone marrow transplantations. Catheter factors include prolonged hospitalization before catheterization, prolonged time of catheterization, multi-lumen CVC, type of catheter material, multiple CVC, urgent insertion, and lack of sterile barriers or breaks in the aseptic technique. There exists some debate about whether femoral CVC carries an increased risk of CLABSI as compared to subclavian or jugular site ( Baier et al., 2020).

**Catheter-Associated Urinary Tract Infection (CAUTI):** CAUTI is a urinary tract infection that occurs in the setting of an indwelling urinary catheter, which may be inserted for numerous medical indications. Approximately 15 to 25% of hospitalized patients in the United States have a urinary catheter. CAUTI can be classified as extraluminal or intraluminal. Extraluminal infections occur when bacteria track along the extraluminal surface of the catheter and enter from the urethral meatus to the bladder. Intraluminal infection arises when there is urinary stasis, usually due to blocked drainage or ascending infection from the intraluminal side of a contaminated catheter. Bacterial and fungal pathogens typically use biofilm formation to facilitate growth and spread along with the indwelling device (Hooton et al., 2010). Fecal and skin microflora generally are the culprit

pathogens. Numerous studies have listed *E. coli* as the most common CAUTI pathogen, followed by *Klebsiella pneumoniae/oxytoca*, *Enterococcus* species, *Pseudomonas aeruginosa*, and *Candida* species ( Greissman et al., 2018, Suetens and Latour, 2018, Weiner, 2016) Complications of CAUTI include involvement of the upper urinary tract, sepsis, and bacteremia. The most critical risk factor for CAUTI is the duration of catheterization. Operative or insertion protocol, such as nonadherence to aseptic techniques, is another modifiable risk factor. Patient characteristics that predispose to increased risk are female sex, paraplegia, cerebrovascular disease, older age, diabetes mellitus, history of UTI in the preceding year, and recent antibiotic use within 90 days ( Letica-Kriegel et al., 2013).

**Skin and Soft Tissue Infection (SSI):** SSI occurs in 2-5% of patients undergoing surgery and usually manifest within 30 days of surgery or 90 days of implanted devices (Anderson et al., 2014). The infection depth and location determine the type of SSI: superficial SSI involves only the skin and subcutaneous tissues; deep SSI involves the muscle or fascia, and organ or space-specific SSI occupy the anatomic vicinity of surgery. The patient's skin, gastrointestinal tract, and female genital tract serve as a reservoir of the healthy flora that may contaminate the surgical site depending on the location of the surgery. Procedure-related risk factors include the duration of surgery, wound class, hypothermia and hypovolemia during surgery, hypoxemia, the urgency of surgery, more than one intervention/surgery, necessity for blood transfusion, and the type of prosthesis implanted. The most critical risk factor is the duration of operation due to the time that the tissue is exposed to the environment leading to an increased chance of contamination ( Mukagendaneza et al., 2019). The wound class is also an important consideration, dirty, contaminated, and clean-

contaminated wounds have the greatest risk compared to clean wounds (Mioton et al., 2013). Post-operative risk factors include the presence of wound drains, poor wound hygiene, and postoperative length of stay (Gibbons et al., 2011). Patient-related risk factors include immunosuppression, tobacco use, obesity, hyperglycemia, malnutrition, joint disease, and increasing age. Common SSI pathogens are *E. coli*, *S. aureus*, *Klebsiella* species, *Enterobacter* species, *Enterococcus* species, *Streptococcus* species, Coagulase-negative *Staphylococcus*. Exogenous sources of microorganisms from surgical instrumentation, environment, and operator are less common sources and usually occur in clusters of infections (Concannon et al., 2018, Harelimana and Muvunyi, 2019, Patel, 2016).

**Pneumonia:** Hospital-acquired pneumonia is pneumonia that develops after 48 hours of admission. Ventilator-associated pneumonia develops after 48 hours of endotracheal intubation. Approximately 5 to 15% of mechanically ventilated patients develop VAP (Howell et al., 2014). Patients develop HAP as a result of aspiration, inhalation of contaminated aerosols, bacterial translocation, and via hematogenous spread. Pathogens commonly associated with HAP and VAP include *S. aureus*, *P. aeruginosa*, *Candida* species, *Klebsiella oxytoca* and *pneumoniae*, *Streptococcus* species, and *Enterobacter* species. Multi-drug resistant organisms are commonly seen in VAP. Host susceptibility depends on local factors, such as underlying lung disease, or systemic factors, such as immunosuppression, neutropenia, age greater than 70, dysphagia, and recent abdominal or thoracic surgery (Komiya et al., 2015). Mechanical ventilation, sedation, supine positioning, poor oral care, physical deconditioning, and reintubation are risk factors for VAP (Kózka et al., 2020). Risk factors for developing HAP or VAP with multi-drug resistant organisms are prior IV antibiotic use within the last 90 days, need for

ventilatory support, septic shock at the time of VAP, acute respiratory distress syndrome preceding VAP, more than five days of hospitalization before VAP onset and need for acute renal replacement therapy (Kumar et al., 2017).

**Clostridioides difficile Infection (CDI):** *C. difficile* is the single most common organism encountered in HAI. CDI causes antibiotic-associated diarrhea and colitis. Colonization of the intestinal tract occurs by fecal-oral transmission and also through aerosolization of spores (Roberts et al., 2008). *C. difficile* produces toxins that act on intestinal epithelial cells leading to tissue injury and result in diarrhea. The most critical risk factor for healthcare-facility onset *C. difficile* infection (HO-CDI) is antibiotic use and environmental contamination, both of which are modifiable risk factors. Other frequently seen risk factors include increasing age, hospitalization, multiple comorbidities, use of gastric acid-suppressing medications, and immunosuppression (Bourgault et al., 2011).

#### **Symptoms of Nosocomial Infections:**

For a HAI, the infection must occur up to 48 hours after hospital admission, up to 3 days after discharge, up to 30 days after an operation, in a healthcare facility when someone was admitted for reasons other than the infection. Symptoms of HAIs will vary by type. The most common types of HAIs are urinary tract infections (UTIs), surgical site infections, gastroenteritis, meningitis and pneumonia. The symptoms for these infections may include discharge from a wound, fever, cough, shortness of breathing, burning with urination or difficulty urinating, headache, and nausea, vomiting, diarrhea. People who develop new symptoms during their stay may also experience pain and irritation at the infection site. Many will experience visible symptoms (Graham Rogers., 2017).

**Transmission:** In-dwelling catheters have recently been identified with hospital acquired infections. To deal with this complication procedure are used, called intravascular antimicrobial lock therapy that can reduce infections that are unexposed to blood-borne antibiotics (Justo et al., 2014) Introducing antibiotics, including ethanol, into the catheter (without flushing it into the bloodstream) reduces the formation of biofilms (Akbari et la., 2015).

#### **Main routes of transmission:**

**Contact transmission:** The most important and frequent mode of transmission of nosocomial infections is by direct contact.

**Droplet transmission:** Transmission occurs when droplets containing microbes from the infected person are propelled a short distance through the air and deposited on the patient's body; droplets are generated from the source person mainly by coughing, sneezing, and talking, and during the performance of certain procedures, such as bronchoscopy.

**Airborne transmission:** Dissemination can be either airborne droplet nuclei (small-particle residue 5 µm or smaller in size of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors; therefore, special air-handling and ventilation are required to prevent airborne transmission. Microorganisms transmitted by airborne transmission include Legionella, Mycobacterium tuberculosis and the rubeola and varicella viruses.

**Common vehicle transmission:** This applies to microorganisms transmitted to the host by

contaminated items, such as food, water, medications, devices, and equipment.

**Vector borne transmission:** This occurs when vectors such as mosquitoes, flies, rats, and other vermin transmit microorganisms.

**Contact transmission is divided into two subgroups: direct-contact transmission and indirect-contact transmission:**

**Direct-contact transmission:** This involves a direct body surface-to-body surface contact and physical transfer of microorganisms between a susceptible host and an infected or colonized person, such as when a person turns a patient, gives a patient a bath, or performs other patient-care activities that require direct personal contact. Direct-contact transmission also can occur between two patients, with one serving as the source of the infectious microorganisms and the other as a susceptible host.

**Indirect-contact transmission:** This involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, such as contaminated instruments, needles, or dressings, or contaminated gloves that are not changed between patients. In addition, the improper use of saline flush syringes, vials, and bags has been implicated in disease transmission in the US, even when healthcare workers had access to gloves, disposable needles, intravenous devices, and flushes (Jain et al.,2005).

#### **Prevention:**

Controlling nosocomial infection is to implement QA/QC measures to the health care sectors, and evidence-based management can be a feasible approach. For those with ventilator-associated or hospital-acquired pneumonia, controlling and monitoring hospital indoor air quality needs to be on agenda in management ( Leung et al., 2006). whereas for nosocomial rotavirus infection, a hand hygiene



protocol has to be enforced ( Chan et al., 2007, Traub-Dargatz, 2006, Katz, 2004).

**Sanitation:** Hospitals have sanitation protocols regarding uniforms, equipment sterilization, washing, and other preventive measures. Thorough hand washing and/or use of alcohol rubs by all medical personnel before and after each patient contact is one of the most effective ways to combat nosocomial infections ( McBryde et al., 2004). More careful use of antimicrobial agents, such as antibiotics, is also considered vital ( Lautenbach E., 2001). As many hospital-acquired infections caused by bacteria such as methicillin-resistant *Staphylococcus aureus*, methicillin-susceptible *Staphylococcus aureus*, and *Clostridium difficile* are caused by a breach of these protocols, it is common that affected patients make medical negligence claims against the hospital in question. Sanitizing surfaces is part of nosocomial infection in health care environments. Modern sanitizing methods such as Non-flammable Alcohol Vapor in Carbon Dioxide systems have been effective against gastroenteritis, methicillin-resistant *Staphylococcus aureus*, and influenza agents. Use of hydrogen peroxide vapor has been clinically proven to reduce infection rates and risk of acquisition. Hydrogen peroxide is effective against endospore-forming bacteria, such as *Clostridium difficile*, where alcohol has been shown to be ineffective ( Otter et al., 2009) Ultraviolet cleaning devices may also be used to disinfect the rooms of patients infected with *Clostridium difficile* or methicillin-resistant *Staphylococcus aureus* after discharge ( Healthcare Research and Quality., 2014). Despite sanitation protocol, patients cannot be entirely isolated from infectious agents. Furthermore, patients are often prescribed antibiotics and other antimicrobial drugs to help treat illness; this may increase the selection pressure for the emergence of resistant strains ( Kolár et al., 2001).

**Sterilization:** Sterilization goes further than just sanitizing. It kills all microorganisms on equipment and surfaces through exposure to chemicals, ionizing radiation, dry heat, or steam under pressure ( Gibraltar., 2013).

**Isolation:** Isolation is the implementation of isolating precautions designed to prevent transmission of microorganisms by common routes in hospitals. (See Universal precautions and Transmission-based precautions.) Because agent and host factors are more difficult to control, interruption of transfer of microorganisms is directed primarily at transmission for example isolation of infectious cases in special hospitals and isolation of patient with infected wounds in special rooms also isolation of joint transplantation patients on specific rooms.

**Handwashing:** Handwashing frequently is called the single most important measure to reduce the risks of transmitting skin microorganisms from one person to another or from one site to another on the same patient. Washing hands as promptly and thoroughly as possible between patient contacts and after contact with blood, body fluids, secretions, excretions, and equipment or articles contaminated by them is an important component of infection control and isolation precautions. The spread of nosocomial infections, among immunocompromised patients is connected with health care workers' hand contamination in almost 40% of cases, and is a challenging problem in the modern hospitals. The best way for workers to overcome this problem is conducting correct hand-hygiene procedures; this is why the WHO launched in 2005 the GLOBAL Patient Safety Challenge (WHO Guidelines on Hand Hygiene in Health Care.,2009).

Two categories of micro-organisms can be present on health care workers' hands: transient flora and resident flora. The first is represented by the micro-organisms taken by workers from the environment, and the bacteria in it are capable of surviving on the human skin and sometimes to grow.

The second group is represented by the permanent micro-organisms living on the skin surface (on the stratum corneum or immediately under it). They are capable of surviving on the human skin and to grow freely on it. They have low pathogenicity and infection rate, and they create a kind of protection from the colonization from other more pathogenic bacteria. The microbes comprising the resident flora are: *Staphylococcus epidermidis*, *Staphylococcus hominis*, and *Micrococcus*, *Propionibacterium*, *Corynebacterium*, *Dermobacterium*, and *Pitosporum* spp., while transient organisms are *Staphylococcus aureus*, and *Klebsiella pneumoniae*, and *Acinetobacter*, *Enterobacter* and *Candida* spp. The goal of hand hygiene is to eliminate the transient flora with a careful and proper performance of hand washing, using different kinds of soap, (normal and antiseptic), and alcohol-based gels. The main problems found in the practice of hand hygiene is connected with the lack of available sinks and time-consuming performance of hand washing. An easy way to resolve this problem could be the use of alcohol-based hand rubs, because of faster application compared to correct hand-washing ( Hugonnet et al., 2002).

Improving patient hand washing has also been shown to reduce the rate of nosocomial infection. Patients who are bed-bound often do not have as much access to clean their hands at mealtimes or after touching surfaces or handling waste such as tissues. By reinforcing the importance of handwashing and providing sanitizing gel or wipes within reach of the bed, nurses were directly able to reduce infection rates. A study published in 2017 demonstrated this by improving patient education on both proper hand-washing procedure and important times to use sanitizer and successfully reduced the rate of enterococci and *Staphylococcus aureus* ( Haverstick et al., 2017). All visitors must follow the same procedures as hospital staff to adequately control the

spread of infections. Moreover, multidrug-resistant infections can leave the hospital and become part of the community flora if steps are not taken to stop this transmission. It is unclear whether or not nail polish or rings affected surgical wound infection rates ( Arrowsmith et al., 2014).

**Gloves:** In addition to hand washing, gloves play an important role in reducing the risks of transmission of microorganisms. Gloves are worn for three important reasons in hospitals. First, they are worn to provide a protective barrier for personnel, preventing large scale contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and non-intact skin. In the United States, the Occupational Safety and Health Administration has mandated wearing gloves to reduce the risk of bloodborne pathogen infections. Second, gloves are worn to reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient-care procedures that involve touching a patient's mucous membranes and nonintact skin. Third, they are worn to reduce the likelihood that the hands of personnel contaminated with micro-organisms from a patient or a fomite can transmit those micro-organisms to another patient. In this situation, gloves must be changed between patient contacts, and hands should be washed after gloves are removed (Occupational Exposure to Bloodborne Pathogens., 2011).

**Antimicrobial surfaces:** Micro-organisms are known to survive on inanimate 'touch' surfaces for extended periods of time this can be especially troublesome in hospital environments where patients with immunodeficiencies are at enhanced risk for contracting nosocomial infections (Wilks et al., 2005). Touch surfaces commonly found in hospital rooms, such as bed rails, call buttons, touch plates, chairs, door handles, light switches, grab rails, intravenous

poles, dispensers (alcohol gel, paper towel, soap), dressing trolleys, and counter and table tops are known to be contaminated with *Staphylococcus*, methicillin-resistant *Staphylococcus aureus* (one of the most virulent strains of antibiotic-resistant bacteria) and vancomycin-resistant *Enterococcus* (U.S. Department of Defense-funded clinical trials.,2008). Objects in closest proximity to patients have the highest levels of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus*. This is why touch surfaces in hospital rooms can serve as sources, or reservoirs, for the spread of bacteria from the hands of healthcare workers and visitors to patients. A number of compounds can decrease the risk of bacteria growing on surfaces including: copper, silver, and germicides (Weber et al., 2013). There have been a number of studies evaluating the use of no-touch cleaning systems particularly the use of ultraviolet C devices. One review was inconclusive due to lack of, or of poor quality evidence (Health Technology Assessment Series., 2018) Other reviews have found some evidence, and growing evidence of their effectiveness (Weber et al ,2016).

### **Impact of nosocomial infections:**

Hospital-acquired infections add to functional disability and emotional stress of the patient and may, in some cases, lead to disabling conditions that reduce the quality of life. Nosocomial infections are also one of the leading causes of death (Ponce-de-Leon S., 1991). The economic costs are considerable (Plowman et al.,1999, Wenzel, 1995). length of stay for infected patients is the greatest contributor to cost (Pittet et al., 1994, Kirkland et al,1999, Wakefield et al, 1988). One study (Coella et al.,1993). showed that the overall increase in the duration of hospitalization for patients with surgical wound infections was 8.2 days, ranging from 3 days for gynaecology to 9.9 for general surgery and 19.8 for orthopaedic surgery. Prolonged stay not only increases direct costs to patients or

payers but also indirect costs due to lost work. The increased use of drugs, the need for isolation, and the use of additional laboratory and other diagnostic studies also contribute to costs. Hospital-acquired infections add to the imbalance between resource allocation for primary and secondary health care by diverting scarce funds to the management of potentially preventable conditions. The advancing age of patients admitted to health care settings, the greater prevalence of chronic diseases among admitted patients, and the increased use of diagnostic and therapeutic procedures which affect the host defences will provide continuing pressure on nosocomial infections in the future. Organisms causing nosocomial infections can be transmitted to the community through discharged patients, staff, and visitors. If organisms are multiresistant, they may cause significant disease in the community.

### **previous studies on incidence of hospital infection among delivery women with caesarean section in hospitals:**

There are a lot of projects have studies hospital infection among delivery women with caesarean section in hospitals. In one of these studies showed that the rate of surgical site infections (SSI) following cesarean section is approximately 18.8% in Pinang, considering the large number of women undergoing cesarean section in Malaysia. These infections are likely to incur substantial additional health care costs. Significant independent risk factors for SSI were as follows: higher BMI, increase in the amount of blood loss during surgery, breech baby presentation, intrathecal analgesia, spinal anesthesia, and the duration of hospital stay. The risk factors identified in this study are important in terms of the potential review of practice and subsequent reduction in SSI. Post-cesarean SSI commonly complicates CS in our unit. Strategies for the prevention of this morbidity in CS patients must aim to control mother's weight

during pregnancy and reduce intraoperative blood loss. Patients should be made aware of the risk of SSI, particularly where there is a high risk due to the type of anesthesia and analgesia or known patient risk factors. This will allow patients to make better informed decisions about whether to proceed with surgery in maternal request cesarean. More studies regarding effect of anesthesia and analgesia type as possible contributing factors to the development of SSI after cesarean section are required to be conducted. In addition, effort should be made to reduce length of hospital stay after cesarean section. Overall strategies that reduce CS rate will lower this morbidity and its sequelae ( Hillan et al.,1995).

In another study in 2007 has found that hypertensive disorders of pregnancy, contaminated wound, multiple vaginal examinations, operations carried out by an intern or junior doctor and prolonged duration of the surgical procedure (longer than 60 minutes) have been found to be independent factors which increase the risk of SSI at Bugando Medical Centre. Identifying high-risk patients who require intensive postoperative care is critical in order to reduce the incidence of SSIs. This can be achieved if independent risk factors for SSI are well understood within the given clinical setting ( Betrán et al., 2007).

Moreover, postoperative wound infection commonly complicates CS in our unit. This is mostly caused by *S. aureus* sensitive to cephalosporins and quinolones. Strategies for prevention of this morbidity in CS patient must target prolonged labor from un booked emergencies, training of surgeons to improve their skills, reduce intraoperative blood loss and long operating time. Overall strategies that reduce CS rate will lower this morbidity and its sequelae (Opoien et al., 2007).

In study has been done by Blumenfeld in 2015 has found that surgical site infection (SSI) following cesarean delivery was noted in 4.4% patients and it is a major cause of burden of disease both for the

patients and the healthcare system in terms of the morbidity, and economic costs. Multidisciplinary team approach has proven effective for decreasing the incidence to minimal level. Reduction in incidence of SSI may be achieved by use of peri operative antibiotics, correction of anemia, use of proper surgical techniques and minimizing the duration of surgery. Pre-operative and post LSCS antibiotic policy should depend on types of bacteria isolated by culture and their resistance mechanism. This may effectively contribute in decreasing SSI after LSCS (Blumenfeld et al., 2015).

In view of the increasing rates of CS being performed without a clear medical indication, new practice protocols should be implemented to reduce the rate of cesarean deliveries as CS surgery has a 5–20 times higher risk of post-partum infection as compared to vaginal deliveries. this study demonstrates that most SSI following CS are detected only after patient's discharge from the hospital. Emergency CS and improper antibiotic prophylaxis are important risk factors in the development of SSI, and given the proliferation of MDR organisms there is an urgent need to implement revised prophylactic antibiotic policy as part of antimicrobial stewardship to reduce infection rates. Further research evaluating all possible risk factors is important for a better understanding of the causes and evolution of SSI post-CS (Iyoke et al., 2014).

A retrospective cohort study was conducted to determine the incidence of post-caesarean infections in a Canadian community teaching hospital using computer algorithms designed for the diagnosis of nosocomial infections. Inferential chart review was done on 1335 women delivered by lower-segment caesarean section (793 primary and 542 secondary) at the Calgary General Hospital between January 1985 and April 1988. The overall infection rates were 42•1 and 46•1% for women delivered by primary and secondary caesarean section, respectively. Incisional

surgical wound infection accounted for the largest proportion of post-caesarean infections found. Women delivered by primary caesarean section had significantly higher rates of endometritis, deep surgical wound infection and bacteraemia than those delivered by secondary section. All types of post-caesarean infection, except asymptomatic bacteriuria, caused the duration of the post-partum hospital stay to be significantly increased ( Ledger et al., 1986).

Even though the rate of CS procedures consistently rose in the study period, the rate of wound infections remained consistent. The rate of CS wound infections was 2.66% between 2001 and 2012. The most common pathogens observed were *S. aureus*, *P. aeruginosa* and *E. coli*, which is in agreement with the results of other studies. The most sensitive antibiotics were aminoglycoside and cephalosporin. Obesity, diabetes, prolonged labour with PROM and wound haematoma were the main contributory risk factors responsible for PCS wound infections ( Ledger et al., 1986).

The need to reduce SSI is currently receiving considerable attention and requires more research. Reducing the rate of SSI will help to reduce the unnecessary morbidity and associated socioeconomic consequences for the patient and her family. Recommendations include addressing modifiable risks factors in the preconception period, ensuring a sterile environment, aseptic surgeries, meticulous haemostatic techniques and the use of antimicrobial prophylaxis to reduce the incidence of infection. Additionally, an organised system of wound surveillance and reporting may help to reduce the wound infection rate to an attainable minimum ( Nwankwo et al., 2012).

Out of a total of 4650 childbirths occurred over the two-year study period (Jan 2016–Dec 2017) at AAH, 807 (17.4%) women had caesarean sections. Of these 807, a total of 796 (98.6%) women had no SSI, and 17 (2.1%) women developed SSIs according to

the primary definition. Out of these 17 cases, 3 (0.38%) patients were excluded as their caesarean procedures were performed elsewhere, and further 3 (0.38%) post-caesarean SSIs were excluded as the infection was originated from another source (specifically from community acquired pneumonia). It was found that 11 (100.0%) women were diagnosed post-discharge, within 30 days after the operation date, and none (0.0%) were detected during the hospital stay. Of these, nine (81.8%) were diagnosed as superficial SSIs and two (18.2%) developed deep SSI infections( Abdel Jalilet al., 2017).

CS rates have reached their highest levels until now accounting for half of all deliveries in some countries. With this, SSIs are increasing and there is an increased cost burden on the healthcare systems as well as personally to mothers and their families. The first step is to quantify this burden for the first time and estimate the magnitude of the incidence of SSI following CS. This systematic review and meta-analysis will influence policy, practice and future research and empower stakeholders including nurses in the operating theatre to patients in the community. Variations in definitions and diagnostic criteria for SSI have made it difficult for the health authorities in different health systems to benchmark each other and variations in the reporting of SSIs exist as a result. In the future, a standard definition of SSI globally would help to minimise this problem (Betran et al., 2007).

Three independent risk factors are significantly increasing the chance for SSIs after CS. All the three of them are modifiable to a certain extent. Reduction of BMI should be addressed from the early childhood onwards and unnecessary pre-operative hospital stay, and overcrowding should be discouraged. In public sector Hospitals, this may be a challenge for the caregivers. Another factor worth mentioning is the relationship between hypertensive disorders and prolonged hospital stay (Confounder). Proper guidelines to avoid prolonged stay and proper

management of HDP are the need of the era. Even though the statistical significance was not achieved in the final model, all the modifiable factors attained significance at the individual level also are to be

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