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Health Care Associated Infections

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An infection that can be acquired in the hospital or other clinical settings is known as a health care associated infection. It is a major cause of morbidity and mortality among hospitalized patients. It is also one of the factors that contribute to the rising cost of hospital care. According to the CDC, around 1.7 million health care associated infections occur globally each year, which contributes to around 99,000 deaths. Some of these infections are surgical site infections, bloodstream infections, and urinary tract infections. Healthcare related infection can include uncomfortable urination, fever, vomiting, breathing difficulties, skin redness, and discharge from surgical sites. These diseases are transmitted by a variety of means, including damaged skin, mucous membranes, and respiratory pathways. Microbial agents like viruses, bacteria, parasites, and fungi, environmental factors like crowded conditions, patient factors like age, immune status, underlying disease, and diagnostic procedures like endoscopy, catheterization, mechanical ventilation, as well as other surgical procedures, are among the risk factors that predispose one to health care associated infection. Utilizing the relevant specimens, these infections can be identified in the laboratory utilizing microscopy, culture, and serological based tests. Personal hygiene, frequent hand washing, sterilization, disinfection, and proper waste disposal can all help avoid illnesses that are related to healthcare. It is thought that hospital-acquired infections can be controlled and mostly eliminated if they are dealt with methodically and properly, making hospitals safer and more efficient.

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1. INTRODUCTION

A patient who was admitted to the hospital for a reason unrelated to the infection is said to have contracted a "health care associated infection," also known as a "hospital- acquired infection" or "nosocomial infection." It is a disease that is contracted in a hospital or another type of healthcare facility [1]. It is an illness that develops in a patient who was not already sick or incubating it when they were admitted to a hospital or other healthcare facility [2]. Additionally, it can be acquired outside of hospitals, such as in a nursing home, rehabilitation center, outpatient clinic, diagnostic lab, or other therapeutic settings [1].

Facilities that range from well-equipped clinics and cutting-edge university hospitals to front-line units with only the most basic amenities are used to deliver patient care. Despite improvements in hospital treatment and public health, diseases continue to spread among hospitalized patients and can even harm hospital employees. There are numerous factors that increase the risk of infection in hospitalized patients, including decreased immunity in the patients themselves, an increase in the number of invasive medical procedures, the spread of drug-resistant bacteria among crowded hospital populations, and subpar infection control procedures. The word can be simply understood as implying that the infection was acquired after admission because there is typically no indication that it was incubating or present when the patient joined the healthcare facility [3]

2. TYPES OF HEALTH CARE ASSOCIATED INFECTIONS

2.1 Infections of the Urinary Tract

Most nosocomial infections are caused by this one, and 80% of them are linked to the use of an indwelling bladder catheter. The urinary catheter is a tube used to collect urine that is placed into the bladder. Patients who struggle with bladder control or emptying benefit from it [4]. Every year, almost 150 million people get a urinary tract infection [5]. Salvatore *et al*. reported that they are more prevalent inn women than the men [6]. Urinary tract infections may be brought on by pathogens that are transmitted through the perineum or a contaminated urinary catheter. Microbiological parameters are typically used to define infections: quantitative urine culture that is positive (≥105 microorganisms/ml, with a maximum of 2 isolated microbial species) [5]. The bacteria responsible arise from the gut flora, either normal (*Escherichia coli*) or acquired in hospital (multi resistant *Klebsiella*) [7].

2.2 Surgical Site Infections

Depending on the procedure and patient's underlying condition, the frequency of surgical site infections ranges from 0.5 percent to 15 percent [8]. The key clinical components of the definition include purulent discharge around the lesion, pus at the drain insertion site, and cellulitis that is spreading from the wound [9]. Deep infections of organs or organ spaces are distinguished from infections of the surgical incision (whether above or below the aponeurosis) [9]. The infection is typically contracted during the actual procedure; either exogenously (from the air, medical equipment, surgeons, and other staff), internally from the flora on the patient's skin or in the surgical site, or very rarely from blood used during the procedure [9]. Depending on the nature and location of the surgery, as well as the antimicrobials the patient took, the infecting bacteria can vary. The biggest risk factor is how polluted the area is during the process (clean, clean-contaminated, contaminated, dirty), which depends mostly on how long the operation takes and how the patient is feeling overall [10] Virulence of the microorganisms, concurrent infection at other sites, usage of preoperative shaving, the presence of foreign bodies like drains, and the experience of the surgical team are other considerations [10].

2.3 Hospital Acquired Pneumonia

Pneumonia contracted at a hospital can affect a variety of patient populations. The rate of pneumonia in intensive care units, where ventilator-dependent patients make up the majority, is 3% per day. Ventilator-associated pneumonia has a high case-fatality rate, however because of the high patient comorbidity, it is challenging to pinpoint the related risk [11]. Microorganisms can be endogenous (from the digestive system, nose, or throat), exogenous (typically via contaminated respiratory equipment), or both. They can colonize the stomach, upper airways, bronchi, and cause illness in the lungs (pneumonia) [12]. Diagnosis is more specific when quantitative micro biological samples are obtained using specialized protected bronchoscopy methods [13]. Known risk factors for infection include the type and duration of ventilation, the quality of respiratory care, severity of the patient’s condition (organ failure), and previous use of antibiotics [14].

Patients who experience seizures or a loss of consciousness are at risk for nosocomial infections, in addition to ventilator-associated pneumonia, even if they are not intubated [15]. In addition to influenza and subsequent bacterial pneumonia, viral bronchiolitis (respiratory syncytial virus, RSV) is frequently seen in pediatric wards [16]. *Aspergillus pneumonia* and legionella spp. can develop in people with severe immunosuppression [17].

2.4 Hospital Acquired Bacteremia

About 5% of nosocomial infections are these illnesses, however for specific bacteria, the case-fatality rate is over 50%, which is a high rate [18]. Incidence is rising, especially for certain species like Candida spp. and multi-resistant coagulase-negative *Staphylococcus* [19]. It's possible for an intravascular device's skin entry site or the catheter's subcutaneous path to become infected (tunnel infection). Without an obvious exterior illness, bacteria colonizing the catheter inside the channel may cause bacteremia. The cause of infection is either the transitory or permanent cutaneous flora [20]. The duration of catheterization, asepsis level upon insertion and ongoing catheter care are the key risk factors.

2.5 Other Nosocomial Infections

These are the four most frequent and important nosocomial infections, but there are many other potential sites of infection. For example: Skin and soft tissue infections: open sores (ulcers, burns and bedsores) encourage bacterial colonization and may lead to systemic infection [21]. The most frequent nosocomial infection in children is gastroenteritis, where the rotavirus is the main pathogen; in developed nations, *Clostridium difficile* is the main cause of nosocomial gastroenteritis in adults [22], infections of the eye and conjunctiva as well as sinusitis and other gastrointestinal illnesses [23]. Endometritis and other infections of the reproductive organs may follow after childbirth [24].

3. ROUTES OF TRANSMISSION

3.1 Contact Transmission

The most essential and common way for nosocomial diseases to spread is by direct contact, which involves touching another person's body directly, or through indirect contact, which involves coming into contact with a contaminated object such contaminated needles or tools [25].

3.2 Droplet Transmission

Droplets are produced from the source individual mostly by coughing, sneezing, and talking, as well as when performing some operations, including bronchoscopy, and transmission happens when these droplets are propelled a short distance through the air and land on the patient's body [26].

3.3 Airborne Transmission

Airborne droplet nuclei, which are microscopic particles of evaporated droplets harboring bacteria that linger in the air for a long time, or dust particles containing the infectious agent can both spread disease. In order to prevent airborne transmission, special air handling and ventilation are needed. This is because microorganisms carried in this way can be widely dispersed 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 [27]. *Legionella*, *Mycobacterium tuberculosis*, the rubeola and varicella viruses, as well as other microorganisms can be spread through the air [28].

3.4 Common Vehicle Transmission

This holds true for germs that are transferred to the host through tainted substances like food, water, drugs, gadgets, and equipment [29].

3.5 Vector Borne Transmission

Infections known as vector-borne diseases are those that are spread through the bite of an infected species of arthropod, such as a mosquito, tick, triatomine bug, sandfly, or blackfly [30].

4. RISK FACTORS INFLUENCING THE DEVELOPMENT OF HEALTHCARE ASSOCIATED INFECTIONS

The situation in a hospital is different from that in other types of institutions in a number of ways, including the fact that the majority of infections acquired there are brought on by microbes that are typically found in the general population and which typically cause disease in less severe forms than they do in hospital patients [31]. As a result, exposure to the bacterium is rarely the primary factor influencing the development of clinical disease. The frequency and kind of infections are influenced by different combinations of the four primary variables [32].

4.1 The Microbial Agent

During hospitalization, the patient is exposed to a wide range of microorganisms. Clinical disease does not always occur as a direct result of patient contact with a bacterium. The kind and incidence of nosocomial infections are affected by several factors [33]. The risk that exposure will result in infection is somewhat influenced by the traits of the microorganisms, such as intrinsic virulence, resistance to antimicrobial agents, and quantity (inoculum) of infectious material [34]. Nosocomial infections can be brought on by a wide range of bacteria, viruses, fungi, and parasites. The patient's own flora or a bacterium that was brought into the hospital from another patient (cross-infection) can both result in infections (endogenous infection). Some organisms can be acquired from inanimate objects or materials that have recently been contaminated by human activity (environmental infection) [35].

Prior to the widespread use of basic hygiene techniques and antibiotics in medicine, the majority of hospital infections were brought on by pathogens that originated externally (such as those that cause food- and airborne illnesses, gas gangrene, tetanus, etc.) or were brought on by microorganisms that weren't part of the patients' normal gut flora (e.g. diphtheria, tuberculosis) [36]. The use of antibiotics to treat bacterial infections has made a significant dent in the mortality rate for numerous infectious diseases [37]. Today, the majority of infections acquired in hospitals are brought on by germs that are widespread in the general community, where they rarely or never cause disease compared to hospital patients (*Staphylococcus aureus*, coagulase-negative *staphylococci, enterococci, Enterobacteriaceae*) [2].

4.2 Patient Susceptibility

Age, immunological status, underlying disease, and diagnostic and therapeutic measures are significant patient characteristics that can affect the development of an infection [38]. A diminished resistance to infection is linked to the extremes of life, such as infancy and old age. [38]. Patients who have a chronic illness, such as cancerous tumors, leukemia, diabetes mellitus, renal failure, or AIDS, are more likely to contract infections from opportunistic microorganisms. [39,40]. The latter are illnesses caused by organisms that are typically harmless, such as bacteria found in a person's natural bacterial flora, but can turn pathogenic when the body's immune system is weakened [40]. Mucous membrane and skin injuries avoid the body's self-defenses. Malnutrition is also a risk [41]. The risk of infection is increased by numerous contemporary diagnostic and therapeutic procedures, including biopsies, endoscopic examinations, catheterization, intubation/ventilation, suction, and surgical procedures [42]. Direct introduction of contaminated items or substances into tissues is also possible. These sites include the lower respiratory tract and the urinary system, which are typically sterile.

4.3 Environmental Factors

Infected people and people who are more likely to contract infection congregate in healthcare facilities. Infectious people are both produced and accumulated in hospitals. Patients and staff may contract illnesses from hospitalized patients who have infections or are carriers of harmful microbes [43]. Hospitalized patients who contract an infection are another source of infection [3]. Nosocomial infections are a result of a number of factors, including crowded hospital environments, frequent patient transfers between units, and the concentration of patients who are particularly vulnerable to infection in one location (such as newborn newborns, burn patients, or intensive care) [21]. Microbial flora can contaminate tools, materials, and other items that come into contact with patients' vulnerable body areas [44]. Additionally, new illnesses caused by bacteria, including aquatic bacteria (atypical mycobacteria), viruses, and parasites, are still being discovered.

4.4 Drug Resistant Bacteria

Antimicrobial medicines are given to many patients. Antibiotics encourage the establishment of multidrug-resistant bacterial strains by promoting the selection and interchange of genetic resistance elements. While susceptible strains of the normal human flora are reduced, resistant strains endure and may spread across the hospital [45]. The main factor influencing resistance is the extensive use of antimicrobials for treatment or prophylaxis (including topical) [46]. Due to resistance, antimicrobial agents sometimes lose their effectiveness. Bacteria that are resistant to an antimicrobial agent eventually appear as a result of widespread usage of the antibiotic and may spread in the healthcare environment. Most or all of the antimicrobials that were once effective are today ineffective against many strains of tuberculosis, *staphylococci, enterococci*, and *pneumococci*. In many hospitals, multi-resistant *Klebsiella* and *Pseudomonas aeruginosa* are common [47]. This trouble is especially crucial in growing nations wherein extra high-priced second-line anti-biotics won't be to be had or affordable.

5. PREVENTION AND CONTROL OF HEALTHCARE ASSOCIATED INFECTIONS

Control measures aim to stop transmission channels, strengthen host defenses, prevent the selection of hospital strains of organisms, and safeguard infection sites [48,49]. Evidence-based management can be a practical strategy for reducing nosocomial infections by implementing Quality assurance and Quality control methods across the healthcare industry [49]. Controlling and monitoring hospital indoor air quality must be on the management agenda for patients with ventilator-associated pneumonia or hospital-acquired pneumonia, whereas a hand hygiene strategy must be implemented for nosocomial rotavirus infection. The hospital's infection control committee is in charge of codifying infection prevention procedures, and the microbiologist must be ready to advise the committee on all significant issues where choices must be made [50].

5.1 Personal Hygiene

Every employee must practice decent personal hygiene. Short, clean nails are required. Wearing false nails is not advised. Hair must be pinned up or kept short. Beards and mustaches need to be maintained well-groomed and short [51].

5.2 Clothing

Staff members may typically dress casually or in their own uniforms when wearing a white coat. In specialized locations like a burn unit or intensive care unit, the working attire must be constructed of a material that is simple to clean and disinfect. A tidy outfit should ideally be worn every day [51].

5.3 Shoes

Staff must wear specialized cover shoes that are easier to clean in aseptic units and operation rooms [51].

5.4 Masks

Cotton wool, gauze, or paper masks are useless. Paper masks with synthetic filtering materials are a good deterrent to bacteria. Masks are crucial for patient safety, immunocompromised patient care, and bodily cavity puncture. Staff must wear masks when caring for patients who have airborne illnesses, etc., for their own safety [51].

5.5 Gloves

Gloves are crucial in lowering the hazards of microbial transmission in addition to hand cleaning.

In hospitals, gloves are used for three crucial reasons. First and foremost, they serve as a barrier of protection for staff, preventing widespread contamination of hands from blood, bodily fluids, secretions, excretions, mucous membranes, and non-intact skin. The Occupational Safety and Health Administration has made wearing gloves mandatory in the US in order to lower the risk of blood-borne pathogen infections. Second, gloves are used to lessen the possibility that pathogens on staff hands will be transferred to patients during invasive or other patient-care procedures that entail touching the mucous membranes and non-intact skin of a patient [51]. Thirdly, they are worn to lessen the possibility that staff members' hands, which may have been contaminated with a patient's or a fomite's microorganisms, may spread those microorganisms to another patient. In this circumstance, it is necessary to switch gloves between patient interactions, and gloves must always be removed before washing hands.

5.6 Antimicrobial Surfaces

Microorganisms have been observed to persist for a long time on inanimate 'touch' surfaces.

This can be particularly problematic in healthcare settings as immunocompromised people are more likely to get nosocomial infections. Various types of intensive care units are where most hospitalized patients with hospital acquired infections are kept (ICUs) [52]. Bed rails, call buttons, touch plates, chairs, door handles, light switches, grab rails, intravenous poles, dispensers (alcohol gel, paper towel, soap), dressing trolleys, counter and table tops, and grab rails are examples of touch surfaces frequently found in hospital rooms. These surfaces are known to be contaminated with *Staphylococcus*, methicillin-resistant *Staphylococcus aureus* (one of the most virulent strains of antibiotic-resistant bacteria), and the largest concentrations of methicillin-resistant *Staphylococcus aureus* are found in objects adjacent to patients and vancomycin-resistant *Enterococcus* [53]. A number of substances, such as copper, silver, and germicides, can reduce the likelihood of bacteria developing on surfaces [54]. Numerous studies have been conducted to assess the use of no-touch cleaning methods, especially the usage of ultraviolet C devices [55].

5.7 Handwashing

The risk of spreading skin bacteria from one person to another or from one spot on a patient to another is said to be reduced to the greatest extent by frequent hand-washing. An important part of infection control and isolation measures is washing hands as soon as possible and thoroughly after coming into touch with blood, body fluids, secretions, excretions, and equipment or items that have been contaminated by them [56]. In over 40% of cases, the spread of nosocomial infections among immunocompromised patients is attributed to healthcare personnel' contaminated hands. This is a difficult issue in contemporary hospitals. Health care professionals may have transitory flora and resident flora microorganisms on their hands. The first is represented by the microorganisms that employees collect from the environment; the bacteria in it are able to live and occasionally grow on human skin. The persistent microbes that reside on, in, or just under the stratum corneum of the skin make up the second category. They have the ability to live and develop unhindered on human skin [57]. They are less infectious and hazardous, and they operate as a kind of barrier against the colonization of other, more dangerous bacteria. *Staphylococcus epidermidis, Staphylococcus hominis, Micrococcus, Propionibacterium, Corynebacterium, Dermobacterium, and Pittosporum spp*. are the microbes that make up the resident flora, and *Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter, Enterobacter, and Candida spp*. are the transient organisms. With thorough and proper hand washing, the use of different types of soap (both regular and antiseptic), and alcohol-based gels, it is possible to eradicate transient flora. The shortage of available sinks and the labor-intensive process of performing hand washing are the main issues encountered in the practice of hand hygiene. Because they can be applied more quickly than proper hand washing, alcohol-based hand rubs may be a simple solution to this issue [56].

5.8 Isolation

Implementing isolation measures in hospitals is one way to stop the spread of germs through common channels [58]. Because agent and host factors are more challenging to manage, efforts to stop the spread of microorganisms focus mostly on isolation of infectious cases in designated hospitals, patients with infected wounds in designated rooms, and recipients of joint transplants in designated rooms.

5.9 Sterilization

The elimination of all microbes is sterilization. More than just sanitizing is accomplished. It eliminates all microorganisms from surfaces and equipment by using chemicals like formaldehyde and ethylene oxide, ionizing radiation, dry heat at 160°C or 170°C for 120 or 60 minutes, or steam under pressure at 121°C for 15 to 30 minutes in an autoclave [59].

5.10 Sanitation

Regarding uniforms, equipment sterilization, cleaning, and other preventive measures, hospitals have sanitation guidelines. One of the best strategies to prevent nosocomial infections is for all medical staff to thoroughly wash their hands before and after each patient interaction and/or to rub their hands in alcohol. It is also thought to be crucial to utilize antimicrobial medicines like antibiotics more cautiously [60]. Because a breach of these protocols frequently results in hospital-acquired infections from bacteria like methicillin-resistant *Staphylococcus aureus*, methicillin-susceptible *Staphylococcus aureus*, and *Clostridium difficile*, affected patients frequently file medical malpractice lawsuits against the hospital in question. Methicillin-resistant *Staphylococcus aureus*, influenza, and gastroenteritis have all been successfully treated using modern sanitizing techniques such Non-flammable Alcohol Vapor in Carbon Dioxide systems. Clinical studies have demonstrated that using hydrogen peroxide vapor lowers the risk of illness and infection rates [52]. Alcohol has been demonstrated to be useless against endospore-forming bacteria like *Clostridium difficile*, whereas hydrogen peroxide is. After discharge, patients with methicillin-resistant Staphylococcus aureus or *Clostridium difficile* infections may additionally have their rooms cleaned with ultraviolet cleaning equipment.

Patients cannot be completely isolated from infectious agents despite cleaning procedures. Additionally, doctors frequently prescribe antibiotics and other antimicrobial medications to patients in order to treat their illnesses; this may boost the selection pressure for the evolution of resistant strains of bacteria [61].

6. LABORATORY DIAGNOSIS

The understanding of clinical microbiology techniques is assumed, although particular techniques employed in the investigation of hospital infections as well as for purposes of surveillance and monitoring are taken into consideration in considerable depth.

7. METHOD

7.1 Specimens Collection and Transport

Hospital employees may become infected when collecting and transporting specimens from patients. Unsafe specimen collection poses a risk to lab personnel. Blood collectors should be advised to avoid forcing blood through needles and, in some circumstances, to use gloves [62,63]. All samples must be contained in impervious containers, although these containers may not contain the laboratory request forms. All specimens should be sorted in a specific laboratory area as they arrive at the lab [64]. The containers into which patient samples are collected are often provided by the laboratory; in any event, the microbiologist must ensure that they are acceptable, sterile, and do not pose a risk to laboratory personnel. They ought to be big enough to hold waste, particularly excrement and sputum, without polluting the outside. Containers must be leak-proof. Screw-capped containers with a strong liner are ideal; plastic "snap-on" lids are hazardous to open [65]. The relative importance of preventing delays when transferring samples to the lab can be partially avoided by using transport media or, in some situations, by chilling. Stuart-type transport medium are often effective for the preservation of the majority of germs on swabs from wounds and mucous membranes and are advised for the majority of uses. If the highest yield of non-sporing Gram-negative anaerobes is to be achieved, very quick transfer to the laboratory is in any case required; alternatively, pre-reduced media can be seeded at the bedside. Blood cultures can be drawn directly into medium bottles or into tubes that contain sodium polyanethl sulphonate [65]. The importance of the results is strongly tied to the care exercised in collecting samples and the circumstances under which they are transported to the laboratory. Cultures in urine must be semiquantitative. Catherization to acquire a urine sample for routine diagnostic purposes is currently inappropriate; suprapubic puncture may be utilized in some circumstances, but the most typical routine procedure is some type of "clean catch" or "mid-stream" sampling. The laboratory should receive samples within an hour or so of collection; if this is not possible, samples should be quickly chilled and delivered in batches every several hours. It is recommended to employ an instantaneous culture, such as the "dip-slide," if the travel period is expected to be more than one hour [65].

7.2 Isolation and Identification of Pathogens

For some classes of organism, such as some bacterial pathogens like *S. aureus*, the groupable -hemolytic streptococci, pneumococci, and enterococci, the pathogenic clostridia, *Corynebacterium diphtheriae*, the enterobacteria, the species, and the common serotypes of *Salmonella and Shigella*, precise identification is more crucial. It's particularly important to be aware of the *Escherichia coli* serotypes *P. aeruginosa, P. cepacia, and F. meningosepticum*, which are frequently linked to infantile enteritis [66]. Even though many of these may not be viable to provide locally, some facilities for the identification of viral diseases are necessary. The service for identifying patients and carriers of the hepatitis B virus will be continuously used and should be as decentralized as possible [67]. Now taking on practical significance is the quick electron microscopic identification of viruses in the feces in cases of infantile diarrhea. Smallpox, vaccinia, and influenza diagnostic services must be occasionally yet easily accessible, and they are advantageous for other viral diseases. For the diagnosis of systemic mycoses, the services of a professional mycological laboratory are greatly desired.

A large portion of the diagnosis of bacterial infection will be done on general-purpose, non-selective media, but this will only be effective if there is access to knowledgeable "front-line" technical workers. It is necessary to have a dependable system for anaerobic cultivation. Whether the isolation of non-sporing Gram-negative anaerobes can be accomplished best using a good "traditional" anaerobic culture. Microscopic studies are frequently very helpful in making a quick presumptive diagnosis: meningitis is suspected in cerebrospinal fluid, and gas gangrene is suspected in wound exudate. A part of the appropriate specimens must be placed in a preservation solution that some laboratories supply as soon as it has been collected.

Numerous brand-new approaches are now being developed or tested in addition to more established quick diagnosis techniques like direct microscopy, and some of them will probably soon become standard practice in laboratories.

8. CONCLUSION

Finally, this study reveals that hospitals can be made safer and more efficient by controlling and mostly preventing healthcare-associated infections through hand cleanliness, environmental hygiene, screening, and surveillance.

9. RECOMMENDATION

By having efficient control programs and computer-assisted epidemiological surveillance for monitoring these illnesses, healthcare associated infections can be kept under control. This should be treated as a worldwide initiative with major involvement from developing nations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rosenthal VD, Bijie H, Maki DG, Mehta Y, Apisarnthanarak A, Medeiros EA, Leblebicioglu H, Fisher D, Álvarez-Moreno C, Khader IA, et al. INICC members. International Nosocomial Infection Control Consortium (INICC) report, data summary of 36 countries, for 2004-2009. Am J Infect Control. 2012;40(5):396-407.
   DOI: 10.1016/j.ajic.2011.05.020. Epub 2011 Sep 10. PMID: 21908073.
2. Stubblefield H, Rogers G. What are nosocomial infections?; 2017.
   Available:https://www.healthline.com/health/hospital-acquired-nosocomial-infections Retrieved June 26, 2022.
3. Monegro AF, Muppidi V, Regunath H. Hospital Acquired Infections. [Updated 2022 May 2]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
   Available:https://www.ncbi.nlm.nih.gov/books/NBK441857/
4. Raka L, Zoutman G, Mulliqi S, Krasniqi I, Dedushaj N, Raka. Prevalence of nosocomial infections in high-risk units in clinical center. Infection Control Hospital Epidemiology. 2014;27(4):421-423.
5. Flores-mireles AL, Walker JN, Caparon M. Hultgren SJ. Urinary tract infections. Nature Reviews. Microbiology. 2015; 13(15):269-284.
6. Salvatore S, Cattoni E, Siesto G, Serati M, Torella M. Urinary tract infections in women. European Journal of Obstetrics, Gynecology, and Reproductive Biology. 2011;156(5):131-136.
7. MacGill M, Sethi S. What are the gut microbiota and human microbiome?; 2018. Available:https://www.medicalnewstoday.com/articles/307998 Retrieved June 26, 2022
8. Lakoh S, Yi L, Sevalie S, Guo X, Adekanmbi Smalle OI, Williams N, Barrie U, Koroma C, Zhao Y, Kamara NM, Cummings-John C, Jiba FD, Namanaga SE, Deen B, Zhang J, Maruta A, Kallon C, Liu P, Wurie RH, Kanu SJ, Deen FG, Samai M, Sahr F, Firima E. Incidence and risk factors of surgical site infections and

related antibiotic resistance in Freetown, Sierra Leone: a prospective cohort study. Antimicrob Resist Infect Control. 2022;11: 39.
DOI:https://doi.org/10.1186/s13756-022-01078-y
9. Centers for Disease Control and Prevention (CDC) (2010). Surgical Site Infection (SSI).
Available:https://www.cdc.gov/hai/ssi/ssi.html
Retrieved June 26, 2022
10. Fentiman R. What are the biggest causes of surgical site infections and how do you prevent them?; 2020.
Available:https://inivos.com/blog/surgical-site-infections/ Retrieved June 26, 2022
11. Michetti CP, Fakhry SM, Ferguson PL, Cook A, Moore F, Gross R. Ventilator-associated pneumonia rates at major trauma centers compared with a national benchmark. The Journal of Trauma and Acute Care Surgery. 2012;72(5):1165-1173.
12. Htoutou Sedláková M, Pudová V, Kolář M. Bakteriální původci nozokomiálních pneumonií - multicentrická stidie v Ceské republice. [Bacterial pathogens causing hospital-acquired pneumonia - a multicenter study in the Czech Republic]. Klin Mikrobiol Infekc Lek. 2015;21(1):10-4. Czech. PMID: 26098488.
13. Sanjay S. Hospital-Acquired Pneumonia. MSD Manual; 2020.
Available:https://www.msdmanuals.com/professional/pulmonary-disorders/pneumonia/hospital-acquired-pneumonia. Retrieved June 26, 2022
14. Virginia AS. Factors related to the risk for hospital-acquired pneumonia. pulmonology adviser; 2022.
Available:https://www.pulmonologyadvisor.com/home/topics/pneumonia/factors-related-to-risk-for-hospital-acquired-pneumonia/
15. Wu D, Wu C, Zhang S, Zhong Y. Risk factors of ventilator-associated pneumonia in critically iii patients. Frontiers in Pharmacology. 2019;10:482.
DOI:https://doi.org/10.3389/fphar.2019.00482.
16. Thorburn K, Harigopal S, Reddy V, Taylor N, van Saene HK. High incidence of pulmonary bacterial co-infection in children with severe respiratory syncytial virus (RSV) bronchiolitis. Thorax. 2006; 61(7):611–615.
DOI:https://doi.org/10.1136/thx.2005.048397
17. Aleem MS, Sexton R, Akella J. Pneumonia In An Immunocompromised Patient. [Updated 2022 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-.
Available:https://www.ncbi.nlm.nih.gov/books/NBK557843/
Retrieved June 26, 2022.
18. Scherbaum M, Kösters K, Mürbeth RE, Ngoa UA, Kremsner PG, Lell B, Alabi A. Incidence, pathogens and resistance patterns of nosocomial infections at a rural hospital in Gabon. BMC Infectious Diseases. 2014;14:124.
DOI:https://doi.org/10.1186/1471-2334-14-124
19. Pappas P, Lionakis M, Arendrup MC, Ostrosky-Zeichner L, Bart Jan Kullberg BJ. Invasive candidiasis. Nat Rev Dis Primers. 2018;4:18026.
DOI:https://doi.org/10.1038/nrdp.2018.26
20. Ullman AJ, Cooke ML, Mitchell M, Lin F, Long DA. Dressings and securement devices for central venous catheters. The Cochrane Database of systemic reviews. 2015;34(9):110-367.
21. Sikora A, Zahra F. Nosocomial Infections. [Updated 2022 Feb 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
Available:https://www.ncbi.nlm.nih.gov/books/NBK559312/
Accessed June 26, 2022
22. Parashar UD, Nelson EA, Kang G. Diagnosis, management, and prevention of rotavirus gastroenteritis in children. BMJ (Clinical research ed. 2013;347:f7204.
DOI:https://doi.org/10.1136/bmj.f7204
23. Azari AA, Barney NP. Conjunctivitis: a systematic review of diagnosis and treatment. JAMA. 2013;310(16):1721–1729.
DOI:https://doi.org/10.1001/jama.2013.280318
24. Taylor M, Pillarisetty LS. Endometritis. [Updated 2022 May 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
Available:https://www.ncbi.nlm.nih.gov/books/NBK553124/
25. Jain S, Persaud D, Perl T. Nosocomial Infection. Emerging Infection Distribution. 2013;11(7):1097-1099.
26. Ibrahimi OA, Sharon V, Eisen DB. Surgical-site infections and routes of

bacterial transfer: which ones are most plausible? Dermatol Surg. 2011; 37(12):1709-20.
DOI: 10.1111/j.1524-4725.2011.02183.x. Epub 2011 Oct 14. PMID: 22092583.

27. Noguchi C, Koseki H, Horiuchi H, Yonekura A, Tomita M, Higuchi T, Sunagawa S, Osaki S. Factors contributing to airborne particle dispersal in the operating room. BMC Surg. 2017;17:78.
DOI:https://doi.org/10.1186/s12893-017-0275-1

28. Ather B, Mirza TM, Edemekong PF. Airborne precautions. [Updated 2022 Mar 18]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-.
Available:https://www.ncbi.nlm.nih.gov/books/NBK531468/

29. Wayne WL. Transmission of infectious disease. Boston University School of Public Health; 2016.
Available:https://sphweb.bumc.bu.edu/otlt/mph-modules/ph/ph709_transmission/PH709_Transmission5.html
Retrieved June 27, 2022

30. Semenza JC, Menne B. Climate change and infectious diseases in Europe. Lancet ID. 2009;9:365-75.
Available:https://www.ecdc.europa.eu/en/climate-change/climate-change-europe/vector-borne-diseases
Accessed June 27, 2022

31. Datta P, Rani H, Chauhan R, Gombar S, Chander J. Health-care-associated infections: Risk factors and epidemiology from an intensive care unit in Northern India. Indian Journal of Anaesthesia. 2014;58(1):30–35.
DOI:https://doi.org/10.4103/0019-5049.126785

32. Alfonso-Sanchez JL, Martinez IM, Martín-Moreno JM, González RS, Botía F. Analyzing the risk factors influencing surgical site infections: the site of environmental factors. Canadian journal of surgery. Journal Canadien de Chirurgie. 2017;60(3):155–161.
DOI:https://doi.org/10.1503/cjs.017916

33. Alp E, Elmali F, Ersoy S, Kucuk C, Doganay M. Incidence and risk factors of surgical site infection in general surgery in a developing country. Surg Today; 2014;. (4):685-9.
DOI: 10.1007/s00595-013-0705-3. Epub 2013 Sep 3. PMID: 24000102.

34. Litwin A, Fedorowicz O, Duszynska W. Characteristics of Microbial Factors of Healthcare-Associated Infections Including Multidrug-Resistant Pathogens and Antibiotic Consumption at the University Intensive Care Unit in Poland in the Years 2011-2018. International Journal of Environmental Research and Public Health. 2020;17(19):6943.
DOI:https://doi.org/10.3390/ijerph17196943

35. Bonadonna L, Briancesco R, Coccia AM. Analysis of microorganisms in hospital environments and potential risks. Indoor Air Quality in Healthcare Facilities. 2017; 53–62.
DOI:https://doi.org/10.1007/978-3-319-49160-8_5

36. World Health Organization (WHO). Prevention of hospital-acquired infections a practical guide 2nd edition; 2002.
Available:http://apps.who.int/iris/bitstream/handle/10665/67350/WHO_CDS_CSR_EPH_2002.12.pdf;jsessionid=68800C57AC58FA2AAD8957D412B2D4BF?sequence=1
Accessed June 27, 2022

37. Almagor J, Temkin E, Benenson I, Fallach N, Carmeli Y. DRIVE-AB consortium The impact of antibiotic use on transmission of resistant bacteria in hospitals: Insights from an agent-based model. PloS one. 2018;13(5):e0197111.
DOI:https://doi.org/10.1371/journal.pone.0197111

38. Haque M, Sartelli M, McKimm J, Abu Bakar M. Health care-associated infections - an overview. Infection and Drug Resistance. 2018;11:2321–2333.
DOI:https://doi.org/10.2147/IDR.S177247

39. Deeks SG, Lewin SR, Havlir DV. The end of AIDS: HIV infection as a chronic disease. Lancet (London, England). 2013;382(9903):1525–1533.
DOI:https://doi.org/10.1016/S0140-6736(13)61809-7

40. Dropulic LK, Lederman HM. Overview of Infections in the Immunocompromised Host. Microbiology Spectrum. 2016; 4(4):10.1128/microbiolspec.DMIH2-0026-2016.
DOI:https://doi.org/10.1128/microbiolspec.DMIH2-0026-2016

41. Katona P, Katona-Apte J. The interaction between nutrition and infection. Clinical Infectious Diseases. 2008;46(10):1582–1588.
DOI:https://doi.org/10.1086/587658

42. Inderdeep SW, Rajiv MB. Manual of operating room discipline and protocol. Jaypee Brothers; 2012.
ISBN: 978-93-5025-963-4
Available:https://books.google.com.ng/books?id=-iz_AwAAQBAJ&pg=PA269&lpg=PA269&dq=Many+modern+diagnostic+and+therapeutic+procedures,+such+as+biopsies,+endoscopic+examinations,+catheterization,+intubation/ventilation+and+suction+and+surgical+procedures+increase+the+risk+of+infection&source=bl&ots=rg6KQWd5AX&sig=ACfU3U2Tb28xYfS5TeeYVE3DeHakU319CQ&hl=en&sa=X&ved=2ahUKEwiYltP1zM34AhUGxhoKHUjqD6EQ6AF6BAgCEAM#v=onepage&q=Many%20modern%20diagnostic%20and%20therapeutic%20procedures%2C%20such%20as%20biopsies%2C%20endoscopic%20examinations%2C%20catheterization%2C%20intubation%2Fventilation%20and%20suction%20and%20surgical%20procedures%20increase%20the%20risk%20of%20infection&f=false Retrieved June 27, 2022
43. Centers for Disease Control and Prevention (CDC). Healthcare Environmental Infection Prevention and Control; 2020.
Available:https://www.cdc.gov/hai/prevent/environment/index.html
Accessed June 27, 2022
44. Wilkinson Blvd Charlotte. New solutions to reduce health care-acquired infections. Powerful efficacy with low toxicity. Pure chlorine dioxide from MTC; 2022. Available:https://transformsanitize.com/wp-content/uploads/2020/03/Acute-Care-insert.pdf
Accessed June 27, 2022
45. Davies J, Davies D. Origins and evolution of antibiotic resistance. Microbiology and Molecular Biology Reviews: MMBR. 2010; 74(3):417–433.
DOI:https://doi.org/10.1128/MMBR.00016-10
46. Institute of Medicine (US) Forum on emerging infections; Knobler, S. L, Lemon, S. M. & Najafi M. editors. The Resistance Phenomenon in Microbes and Infectious disease vectors: Implications for human health and strategies for containment: workshop summary. Washington (DC): National Academies Press (US). 2003;5. Factors Contributing to the Emergence of Resistance.
Available:https://www.ncbi.nlm.nih.gov/books/NBK97126/
47. Fair RJ, Tor Y. Antibiotics and bacterial resistance in the 21st century. Perspectives in Medicinal Chemistry. 2014;6:25–64.
DOI:https://doi.org/10.4137/PMC.S14459
48. Collins AS. 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). 2008 Apr.;Chapter 41.
Available:https://www.ncbi.nlm.nih.gov/books/NBK2683/
49. Better Health. Preventing healthcare associated infection (HAI); 2019.
Available:https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/infections-in-hospital-reduce-the-risk
Accessed June 27, 2022
50. Mehta Y, Gupta A, Todi S, Myatra S, Samaddar DP, Patil V, Bhattacharya P. K, Ramasubban S. Guidelines for prevention of hospital acquired infections. Indian J Crit Care Med. 2014;18(3):149-63.
DOI: 10.4103/0972-5229.128705. PMID: 24701065; PMCID: PMC3963198.
51. WHO guidelines on hand hygiene in health care: A summary; 2014.
Available:http://www.whqlibdoc.who.int/hq/2009/WHO_IER_PSP_2009.07_eng.pdf . [Ref list]
Retrieved June 27, 2022
52. CDC. Guidelines for environmental infection control in health care facilities; 2020.
Available:http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf
Retrieved June 27, 2022
53. McBryde ES, Bradley LC, Whitby M, McElwain DL. An investigation. An investigation of contact transmission of methicillin-resistant *Staphylococcus aureus*. Journal of Hospital Infection. 2010;58(2):104-108.
54. Weber D, Rutala WA. Self-disinfecting surfaces. American Journal of Infection Control. 2013;41(5):31-35.
55. Steve Reinecke. Evaluating a 'no-touch' UVC Radiation Device on High Touch Surfaces; 2019.
Available:https://infectioncontrol.tips/2019/06/26/evaluating-a-no-touch-uvc/
Accessed June 27, 2022

56. Dykewicz CA, Jaffe HW, Kaplan JE. Guidelines for preventing opportunistic infections among hematopoietic stem cell transplant recipients; recommendations of CDC, the Infectious Disease Society of America, and the American Society of Blood and Marrow Transplantation; 2000. Available:https://stacks.cdc.gov/view/cdc/13465
Accessed June 28, 2022
57. Pratt RJ. The Epic project: Developing national evidence-based guidelines for preventing health care associated infections. Journal of Hospital Infections. 2017;47(4):53-54.
58. Haverstick S, Goodrich C, Freeman R, James S. Patients hand washing reducing Hospital acquired Infections. Critical Care Nurse. 2017;37(3):112-120.
59. CDC. Sterilization. Guideline for disinfection and sterilization in healthcare facilities. 2016;2008.
Available:https://www.cdc.gov/infectioncontrol/guidelines/disinfection/sterilization/index.html Accessed June 28, 2022
60. Leung M, Chan AH. Control and management of hospital indoor air quality. Medical Science Monitoring. 2019; 12(3):17-23.
61. Kolar M, Urbanek K, Latal T. Antibiotic selective pressure and development of bacterial resistance. International Journal of Antimicrobial Agents. 2001;17(15):357-363
62. McElvania E, Singh K. Specimen collection, transport, and processing: Bacteriology. In: Manual of Clinical Microbiology, 13th ed, Carroll K. C, Pfaller M. A. (Eds):American Society for Microbiology, Washington DC. 2019;302.
63. Miller JM, Binnicker MJ, Campbell S, Carroll KC, Chapin KC, Gilligan PH, Gonzalez MD, Jerris RC, Kehl SC, Patel R, Pritt BS, Richter SS, Robinson-Dunn B, Schwartzman JD, Snyder JW, Telford S. 3rd, Theel ES, Thomson RB. Jr, Weinstein MP, Yao JD. A guide to utilization of the microbiology laboratory for diagnosis of infectious diseases: 2018 Update by the Infectious Diseases Society of America and the American Society for Microbiology. Clin Infect Dis. 2018;31;67(6):e1-e94.
DOI: 10.1093/cid/ciy381. PMID: 29955859; PMCID: PMC7108105
64. CDC. Chapter 5: Collection and Transport of Clinical Specimens; 2016.
Available:https://www.cdc.gov/meningitis/lab-manual/chpt05-collect-transport-specimens.html
65. Carey RB, Bhattacharyya S, Kehl SC, Matukas LM, Pentella MA, Salfinger M, Schuetz AN. Practical guidance for clinical microbiology laboratories: implementing a quality management system in the medical microbiology laboratory. Clin Microbiol Rev. 2018; 2;31(3):e00062-17.
DOI: 10.1128/CMR.00062-17. PMID: 29720490; PMCID: PMC6056841.
66. Kasa G, Tegegne B, Tadesse B. Isolation and identification of major pathogenic bacteria from clinical mastitic cows in Asella Town, Ethiopia. Veterinary Medicine International. 2020;2020, Article ID 6656755, 6:2020.
DOI:https://doi.org/10.1155/2020/6656755
67. Dorsey MB, Harry BG. Rotaviruses; 2017.
Available:http://www.antimicrobe.org/v18.asp Accessed June 28, 2022

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