Hospital-Associated Infections: Epidemiological Trends, Diagnostic Approaches, and Evidence-Based Prevention Strategies: A Narrative Review Study

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ABSTRACT

Hospital-associated infections (HAIs) are still an important issue in the healthcare environment as they can make it harder for patients to get better, lengthen hospital stays, make treatment more expensive and cause antimicrobial resistance. Despite the improvements in medical treatment, the prevention of these infections remains difficult with the use of invasive procedures, vulnerable populations, contamination of the environment and the spread of resistant microorganisms. This narrative review explores epidemiology trends, most common types of HAIs, common pathogens and factors that facilitate the development and transmission of HAIs. It also reviews diagnostic strategies such as conventional microbiological culture, antimicrobial susceptibility testing, molecular and rapid diagnostic (RD) technologies that facilitate the identification of the pathogen in time. The review also discusses prevention and control evidence-based practices, including hand hygiene, personal protective equipment, environmental cleaning, sterilization, safe use of medical devices, antimicrobial stewardship and hospital surveillance programmers. Importance of early diagnosis, appropriate antimicrobial use, training of healthcare workers and consistent implementation of infection prevention guidelines are highlighted. Current issues such as resource scarcity, lack of surveillance and the emergence of multidrug resistant organisms are also taken into account in the review. To ensure progress in the future, increasing access to diagnostics, enhanced digital surveillance, innovative infection control measures and continued institutional focus on patient safety are needed. The combination of these strategies can help lower preventable infections, aid in making treatment decisions and enhance the quality of health care provision.

Keywords: Hospital associated infections, Health care associated infections, Antimicrobial resistance, Diagnostic methods, Infection prevention and control, and Patient safety.

1. INTRODUCTION

Hospital-associated infections (HAIs) also called healthcare-associated infections, are an infection that develops in a patient during medical care in a hospital or other healthcare facility that was not present or incubating at the time of admission. Such infections continue to be a significant patient safety and healthcare quality threat as they can make the recovery process longer, complicate hospital stays, drive up expenses for treatment, and cause illness and death. HAIs can occur in various clinical situations and include surgical site infections, central line–associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), and hospital-acquired pneumonia (HAP). HAIs are a continuing challenge in healthcare globally and are linked to poor patient outcomes and the development of antimicrobial resistance (AMR) (World Health Organization (WHO), 2024).

The risk of HAIs is different from country to country and from facility to facility, depending on the patient, resources at that patient's bedside, patient infection surveillance, and implementation of infection prevention strategies. In high income countries, about 7 of every 100 patients develop at least one HAI during a hospital stay, and in low- and middle-income countries, it is estimated that 15 of every 100 patients develop at least one HAI while in a hospital setting. These differences reflect the importance of enhanced IPC programmes, especially in facilities that suffer from overcrowding, poor infrastructure, the lack of diagnostic facilities, or of trained health care personnel, that could impact the quality of care. In addition to their acute clinical implications, HAIs also impose extra burden on the

health care system and can drive the selection and spread of multidrug resistant microorganisms (MDRM) (World Health Organization, 2024).

Several factors are interrelated in the development of HAIs such as patient health status, the nature of medical procedures, the environment of the hospital and the practices followed by the health care workers. Older adults and critically ill patients, as well as newborns, immunocompromised people and patients with chronic diseases are more susceptible to infections. Most of the time, microorganisms can find their way into the body through the use of invasive medical devices like urinary catheters, central venous lines and mechanical ventilators. In the same way, surgical procedures, unnecessary hospital stays, using inappropriate antibiotics, poor hand washing and inadequate cleaning or sterilisation of medical equipment can make people more susceptible to infection. Microorganisms can be spread by contaminated hands, equipment, surfaces or contact with a susceptible person who is infected. To minimize such risks and ensure healthcare safety, it is crucial to consistently follow infection prevention practices, as highlighted by the Centers for Disease Control and Prevention (CDC, 2026).

The added dimension of antimicrobial resistance in the management of HAIs. Treatment may be more difficult if the microorganisms that cause the infection are resistant to the commonly used antimicrobials, resulting in more prolonged illness, more expensive health care utilization and worse clinical outcomes. The WHO (2024) emphasizes the interdependency of HAIs with antimicrobial resistance, and the need to incorporate IPC and following antimicrobial usage. This means that effective management isn't simply about managing a confirmed infection, but also the prompt identification of the infection, accurate laboratory diagnosis, surveillance and regular implementation of evidence-based preventative measures.

In this context, the purpose of the present narrative review is to give an overview of the epidemiological trends, the most relevant pathogens and main risk factors of hospital associated infections. It also explores traditional and new diagnostic methods, focusing on early detection and identification of antimicrobial resistance. In addition, evidence-based prevention and control measures are also explored such as hand hygiene, environmental cleaning, medical device safety, antimicrobial stewardship and hospital surveillance programmes. This review aims to summarize the available literature and present the latest public health recommendations to identify practical strategies for lowering the incidence of HAIs and improving patient safety in health care facilities.

2. EPIDEMIOLOGY AND TYPES OF HOSPITAL-ASSOCIATED INFECTIONS

2.1. Global and Regional Prevalence of Hospital-Associated Infections

Hospital-associated infections (HAIs) are a persisting public health problem and occur at different frequencies and in different locations in different countries, healthcare facilities and patient groups. Variability in infection prevention practice, hospital structure, antimicrobial use, lab capacity and surveillance systems affect the reported burden. In 2022–2023 a point-prevalence survey was conducted by the European Centre for Disease Prevention and Control (ECDC) which gathered data from acute-care hospitals in Europe and in the participating Western Balkan countries, thus generating valuable evidence on the distribution of HAIs and antimicrobial use. According to the Centers for Disease Control and Prevention (CDC, 2026), between 2016 and 2023, the proportion of hospitalized patients with at least one HAI ranged between 2.0 and 2.7% of the total number of hospitalizations that year, with an estimated 518,000 infections occurring in acute-care hospitals in 2023. The figures illustrate that HAIs continue to be a problem even in a well-established healthcare system, such as a surveillance programme.

The situation may be more challenging in areas where access to appropriate infection prevention tools, diagnostic testing, competent staff, and medical supplies is restricted. However, caution should be exercised when using the results of the studies for country-to-country comparisons as the studies vary in case definition, method of surveillance, sampling time, and patient population. It is therefore crucial that regional assessments are carried out to discover if there is a consistent infection pattern; to identify high risk clinical environments; and to allocate resources to the most effective infections preventive measures. Surveillance and standardized reporting is needed to be able to understand local epidemiology and to assess progress over time.

2.2. Common Types of Hospital-Associated Infections

Depending on the patient's condition, the microorganisms involved and the medical procedures performed, HAI may impact various organs and body systems.

Type of infection

Postoperative infection around the surgical wound or affected tissue in the surgical site (Surgical site infection [SSI]). These risk factors include contaminated surgical site, prolonged surgery and poor perioperative infection control.

Catheter-associated urinary tract infections (CAUTIs): Associated with urinary catheterization, especially when catheterization is prolonged, or care provided is inadequate.

HAP: Pneumonia that develops while a person is in the hospital and can include VAP. Special concern is given to patients who are very sick or are on mechanical ventilation.

Bloodstream infections: It may develop from contaminated vascular catheters or invasive procedures or from other infection sites and become serious and widespread.

Clostridioides difficile infection (CDI): It results in antibiotic associated diarrhoea and colitis. Disruption of normal intestinal microbiota, exposure to contaminated health care settings, may be associated with transmission (ECDC, 2024; CDC, 2024).

The ECDC (2024) survey of acute-care hospitals in Europe showed that the top two categories of HAIs were pneumonia and lower respiratory tract infections (29.3%). The most common types of infections were urinary tract infections (19.2%), surgical site infections (16.1%), bloodstream infections (11.9%) and gastrointestinal infections (9.5%). 5.9% of all reported HAIs were due to C. difficile. The data in this study show the wide range of clinical manifestation for HAIs and the need for specific prevention strategies for different types of HAIs.

2.3. High risk patients and hospital departments.

Patient risk, complexity of treatment and exposure to invasive procedures all play a role in the risk of HAI. Patients in intensive care units (ICUs) are especially vulnerable as they might be on mechanical ventilation, central venous catheter, urinary catheter, and extended life support. Surgical wards are at risk of wound contamination and complications after surgery; neonatal wards are responsible for children who have underdeveloped or weak immune systems, and oncology wards are responsible for children with cancer. Those in haematology, transplant, burn-care and long-term acute-care units also warrant special consideration, as they may have complex medical needs or longer stays in health care settings.

Risk factors on the patient level are advanced age, prematurity, severe illness, diabetes, cancer, immunosuppression, malnutrition and prolonged hospitalisation. Regular transfers between wards, multiple antibiotic courses and multiple invasive devices may further place individuals at risk. The ECDC (2024) survey shows that, to ensure an accurate understanding of HAI prevalence, patient characteristics and differences in hospital settings should also be taken into consideration. Recognizing high-risk populations can inform healthcare providers to focus on these populations for surveillance, diagnostic testing, and preventive interventions.

2.4. Emerging Pathogens and Antimicrobial Resistance Trends

Epidemiology of HAIs is further complicated by emergence and spread of antimicrobial resistant microorganisms. Methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus (VRE), carbapenem-resistant Klebsiella pneumoniae, resistant Acinetobacter baumannii and Pseudomonas aeruginosa are some of the important pathogens. These organisms can survive in healthcare settings, infect the vulnerable patient and cause infections that are hard to treat. The Gram-negative bacteria are of special interest since some strains may be resistant to treatment. The World Health Organization's (WHO, 2024) revised list of bacterial priority pathogens includes several resistant pathogens as significant public health threats, and underscores the need to develop better surveillance tools, discover new treatments, and find effective prevention strategies.

AR can arise and spread in a number of ways, such as through inappropriate antibiotic use, insufficient infection control measures, patient-to-patient transmission and movement of colonized or infected persons from one healthcare facility to another. If resistant pathogens invade the bloodstream,

they can cause bloodstream infections and pneumonia, UTI, and surgical site infection, making treatment more challenging and complicating patient outcomes. Also, variation in pathogens in circulation and/or HAIs, which may occur with changes in healthcare-associated respiratory infection, can modify HAIs over time. The survey by ECDC (2024) also showed the role of COVID-19 disease associated with health care in the reported burden of respiratory infections, highlighting the importance of viral infections in health care epidemiology.

Surveillance should therefore include not only the type and prevalence of infections, but also the organism(s) which cause the infection and their susceptibility to antimicrobial agents. By integrating these microbiological data with clinical information, hospitals can better detect new threats, discern transmission dynamics and provide proper treatment. The integrated approach will serve as the basis for the diagnostic and prevention strategies described in the following sections.

3. PATHOGENS AND RISK FACTORS ASSOCIATED WITH HOSPITAL-ASSOCIATED INFECTIONS

3.1. Common bacterial, viral, fungal and other infectious agents

HAIs are the result of infection with many different types of microorganisms, such as bacteria, viruses, fungi and, less frequently, other infectious organisms. The pathogens causing the infections are depending on the type of infection, clinical condition of patient, procedures performed and/or infection control measures taken in the healthcare facility. Some microorganisms are acquired from the patient's normal microbial flora and others are spread via contaminated medical equipment, by the hands of health care workers, by surfaces in the environment or by contact with other people who are infected (Centers for Disease Control and Prevention [CDC], 2024a).

One of the most common causes of HAIs is the presence of bacteria. These include Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii and Enterococcus species. These can lead to bloodstream infection, pneumonia, urinary tract infection and surgical site infection. They are clinically important based on virulence, site of infection, host immunity and susceptibility to antimicrobial agents. Microbial persistence may be further promoted through the formation of biofilms on catheters, implants, and other medical devices, and may contribute to making some infections harder to cure (CDC, 2024a).

Respiratory and contact precautions may be inadequate in healthcare settings where viral pathogens can be spread, especially with close contact of patients with healthcare workers. Some viruses that can cause outbreaks and transmission in healthcare settings are influenza viruses, respiratory syncytial virus (RSV), SARS-CoV-2, and norovirus. In patients with deep fungal infections (e.g. Candida spp and Aspergillus spp), exposure to prolonged intensive care unit stays or underlying conditions that predispose to such infections are important. In certain clinical and/or epidemiological situations, parasites and prions are less likely to be relevant. The identification of this diversity is significant because some microorganisms are diagnosed with different methods and have different infection control measures (CDC, 2024b).

3.2. Role of Multidrug-Resistant Organisms

Multi-drug resistant organisms (MDROs): these are organisms that have become resistant to a number of antimicrobial agents and therefore are harder to treat. Examples of these are methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus (VRE), extended-spectrum beta-lactamase-producing Enterobacterales and carbapenem-resistant Klebsiella pneumoniae and Acinetobacter baumannii in the hospital environment. The organisms are a special concern in intensive care units and other environments where patients are very sick, have had invasive procedures or are being treated with antimicrobials for a long time (CDC 2024c).

There are multiple factors that contribute to the spread of MDROs, such as inappropriate use of antimicrobials, inadequate hand hygiene, contaminated equipment, inadequate cleaning of the environment, and movement of patients who are colonized or infected with MDROs from one healthcare environment to another. Selective pressure from exposure to antimicrobials can favour the emergence of antimicrobial resistant microorganisms and lapses in infection control practices can allow

the transmission of antimicrobial resistant microorganisms between patients. Resistant organisms also can live in the healthcare environment, allowing for additional exposures (CDC, 2024c).

MDRO infections can make it more difficult to treat the infection, require intensive antimicrobial treatment or result in extended hospitalizations and worse clinical outcomes. Colonization (not necessarily an active infection) can be a reservoir for the spread of an infection. Thus, MDRO management should be complemented with and depend on testing for microbiology, antimicrobial susceptibility testing, monitoring and implementation of infection prevention measures.

3.3. Patient-Related Risk Factors

Risk factors associated with patients are factors or medical conditions that decrease the body's resistance to infection. Age should be taken into account as a factor as all newborn babies will have underdeveloped immune systems, and older adults may have a compromised immune system and more chronic disease. Other people with chronic diseases, such as diabetes, cancer, kidney disease, severe respiratory disease or other long-term condition, may also be at higher risk of complications, especially if they need frequent hospital trips or complicated treatment (CDC, 2023).

A weakening of the immune system due to disease, chemotherapy, organ transplantation or immunosuppressive drug therapy can also make individuals even more susceptible to opportunistic organisms. Other factors can also be involved, such as malnutrition, diminished wound healing, decreased mobility and critical illness, which all can affect normal protective mechanisms. Chen et al. (2023) conducted a systematic review and meta-analysis of over 1.2 million patients in Chinese general hospitals who were hospitalized and identified associations between HAIs and a range of factors such as older age, invasive procedures, chronic diseases, immunosuppression and longer hospital stays. Whether the level of these relationships varies from one healthcare facility to another, the results show that the risk of HAI is often due to a combination of patient susceptibility and hospital treatment related exposures.

Being able to identify patients at increased risk enables health care providers to use the right preventive measures, to keep a closer eye on clinical changes and to investigate possible infections quickly. Each person's risk of infection should be assessed individually as the age of the person and presence of a chronic disease is not enough to predict if there is or isn't a risk of infection.

3.4. Healthcare-Related Risk Factors

Healthcare related risk factors are related to the medical interventions, treatment methods, environmental factors and organization of patient care. Bypassing the body's natural protective barriers is possible when invasive devices enter the bladder, blood vessels, or lungs, such as urinary and central venous catheters and endotracheal tubes, which may create areas for microorganisms to attach and develop a biofilm. Risk can be higher if they are left in place for longer than recommended, or if insertion, handling and maintenance practices do not follow recommended infection prevention practices (CDC, 2023).

Long hospital stays also allow more time to be spent in the hospital where infectious agents and invasive interventions might be present. Other threats include poor hand hygiene, failure to reprocess reusable instruments, lack of cleaning of patient-care equipment, lack of adherence to aseptic technique, overcrowding, and lack of resources for water, sanitation, ventilation, and/or infection control. Different microorganisms can be spread by contact with people, contaminated hands, shared items, respiratory particles, or contaminated environmental surfaces (CDC, 2023). These factors often are linked and interdependent. A critically ill patient might need to be ventilated mechanically, and remain in the intensive care unit for extended periods of time, which will expose the patient to more invasive devices and opportunities for contact with health care associated pathogens. The best way to prevent infection is to implement a coordinated program of appropriate device use, continual evaluation of ongoing clinical need, hand washing, cleaning the environment, training of staff and ensuring adherence with infection control protocols.

4. DIAGNOSTIC APPROACHES FOR HOSPITAL-ASSOCIATED INFECTIONS

4.1. Medical signs, symptoms and patient evaluation.

A thorough clinical evaluation is the first step in the diagnosis of hospital-associated infections (HAIs) and involves an examination of symptoms, medical history, underlying diseases, recent procedures, and invasive medical devices. Symptoms include fever, chills, rapid breathing, cough, difficulty breathing, pain or redness at a surgical site, unusual drainage from the surgical site, or changes in a patient's overall condition. In some cases, however, the appearance might differ according to the site of infection and the immune status of the patient. Older children, newborns and those with underlying immune deficiencies can have an infection without a fever or the usual signs and symptoms.

Most HAIs can't be confirmed by clinical findings alone, since there are other non-infectious conditions that have similar symptoms. For instance, the fever could be caused by the reaction to the medications and the decline in the respiratory system could be due to fluids accumulation or other complications. Miller et al. (2024) point out that the choice of diagnostic tests depends on the suspected infection, clinical presentation and quality of specimen collected. Sensitive and judicious initial evaluation is thus important in making decisions about appropriate laboratory testing and in minimizing unnecessary testing and misinterpretation.

4.2. Conventional Microbiological Culture and Antimicrobial Susceptibility Testing

Conventional microbiological culture is still a valid method for the identification of pathogens causing HAIs. Samples can contain urine, blood, and any other body fluids and tissues involved in the suspected infection, such as respiratory secretions or wound material. Samples are collected with the use of the proper aseptic technique and are transported to the lab in a manner that will ensure the preservation of the microorganisms of interest. After proper incubation in media, the growth of the microbes can be studied and identified by biochemical tests, automated identification system or other laboratory methods.

After a clinically significant organism has been recovered, antimicrobial susceptibility testing (AST) can be used to find out which antimicrobial agents are likely to be effective. This information will help you treat the person in a focused manner and can help identify resistance, which may rule out the use of some drugs. Culture can be a very useful diagnostic tool, but it is subject to the critical importance of specimen selection, collection and transport. The test results may be influenced by previous antimicrobial treatment, insufficient specimen size, contamination, and delayed specimens. Miller et al. (2024) suggest selecting microbiological tests based on the suspected infection and should interpret the results along with clinical findings.

Culture-based methods are important because they are able to recover viable microorganisms and allow getting isolates for susceptibility testing. However, they may take longer to identify organisms and to evaluate resistance and may not be the best choice as a single diagnostic method if quick decisions need to be made.

4.3. Molecular Diagnostic Techniques including PCR

Advances in molecular diagnostic techniques have led to the ability to detect infectious agents by searching for specific genetic material from bacteria, viruses, fungi and other pathogens. Selected DNA sequences can be amplified using polymerase chain reaction (PCR), and RNA targets detected after the conversion to complementary DNA (cDNA) using reverse-transcription PCR (RT-PCR). These methods can detect the presence of pathogens directly from an appropriate clinical specimen or specific organisms within positive cultures, depending on the type of assay. They are especially helpful when there is a need to make a quick diagnosis or if standard culture is less sensitive due to previous antimicrobial treatment.

Multiplex PCR panels may be used to detect multiple pathogens in a single test which may be useful in the study of infections with similar clinical presentations. Some molecule tests are also able to identify a specific gene linked to antimicrobial resistance. However, it is not always possible to establish that a viable organism is causing an active infection, simply by detecting genetic material. The results should be correlated with clinical data, specimen quality and other laboratory tests. Miller et al. (2024)

highlight the importance of choosing the molecular test based on the suspected infection and the diagnostic question asked.

4.4. The RDM Method and New Technologies

The goal of rapid diagnostics is to reduce the time needed for the identification of pathogens and to aid decisions in treatment. These techniques encompass antigen detection, selected immunoassays, nucleic acid amplification tests and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). The MALDI-TOF MS approach relies on the analysis of protein fingerprints, which is mostly performed with cultured isolates or suitable positive-culture material, to identify microorganisms. Some platforms are able to detect more than one pathogen or selected resistance markers in one test.

Wolk et al. (2025) conducted a systematic review and meta-analysis of evidence on rapid diagnostic tests for bloodstream infections and advised for using these tests in conjunction with meaningful communication of actionable results to healthcare professionals. Early diagnosis can help assist with quicker adjustment of antimicrobial treatment, including when to change to more directed treatment if necessary. The authors also highlighted the fact that there are some evidence gaps on certain clinical outcomes, especially with regard to the need for prompt clinical interventions based on the results of rapid tests.

New diagnostic technologies include automated microbiology platforms, advanced sequencing technologies and fully integrated systems that integrate pathogen identification with resistance-marker detection. While these methods have a number of advantages, their availability, cost, technical requirements, and capacity to detect clinically relevant organisms are variable. Therefore, they should be used in addition to, and not in place of, existing diagnostic procedures.

4.5. Importance of Early Diagnosis and Accurate Pathogen Identification.

Prompt and accurate diagnosis is vital for the management of HAIs since delay can cause the appropriate treatment and infection control measures to be delayed. Early recognition enables clinicians to choose appropriate antimicrobial treatment, identify the presence of resistant organisms and prevent overuse of broad-spectrum antibiotics. It also allows for timely decisions to be made about isolation precautions, monitoring of patients and investigations of possible spread within the hospital.

The reliability of the diagnostic result is dependent on the entirety of the testing process, from the selection and collection of the correct specimen to the analysis and interpretation of the test results, as well as the communication of the test results. A positive result should be interpreted based on the clinical situation given that there may be contamination, colonization or remaining genetic material in the test that can affect interpretation. On the other hand, a negative result is not definitely negative, as might be expected, because of poor specimen quality or failure of the test to include the pathogen. Miller et al. (2024) and Wolk et al. (2025) emphasize the need to select tests appropriately and for good communication between the clinical and laboratory teams. In general, the best approach to diagnosis involves a clinical evaluation and the use of the most appropriate conventional and molecular tests. Combining quick results with antimicrobial stewardship and infection prevention programmes can enhance clinical decision-making, aid in targeted treatment and bolster the overall response to hospital-associated infections.

5. EVIDENCE-BASED PREVENTION AND CONTROL STRATEGIES

There is a need for a coordinated strategy involving healthcare staff, hospital administration, microbiology laboratories, environmental services and patients to prevent hospital-associated infections (HAIs). An effective IPC programme involves using standard hygiene measures, a combination of procedure-related measures, the right use of antimicrobials, ongoing monitoring and regular training of staff. The Centers for Disease Control and Prevention (CDC, 2024a) recommend that these practices be maintained at all health care locations and be facilitated by sufficient resources, clearly established policies, and tracking of compliance.

5.1. Hand Hygiene & Personal Protective Equipment

Hand hygiene is one of the most important preventive measures to minimize the spread of infectious microorganisms in the healthcare industry. These are the times at which hands should be washed by healthcare workers: before coming into contact with the patient, before conducting an aseptic procedure, after exposure to body fluids, after touching the patient and after touching the patient's environment. Alcohol based hand rubs are recommended to use when hands are not visibly soiled and soap and water to use when hands are visibly soiled and when specified by pathogen-specific guidance. Hand hygiene facilities, supplies, and staff education are effective interventions to promote adherence to hand hygiene (World Health Organization [WHO], 2009).

In addition to creating a barrier to exposure to infectious agents, personal protective equipment (PPE) may be worn, such as gloves, gowns, masks, eye protection and respirators if necessary. PPE should be selected based on the procedure being performed, the suspected or known pathogen(s) and the level of exposure anticipated. Gloves are not a substitute for hand hygiene and PPE must be removed in a safe manner to prevent contamination of hands, clothing or the environment. Standard precautions, combined with any added contact, droplet or airborne precautions as needed, can decrease the likelihood of transmission from patients to healthcare workers (CDC, 2024a).

5.2. Sterilization, Disinfection, and Environmental Cleaning

For the reduction of microbial contamination in healthcare facilities, proper sterilization, disinfection and environmental cleaning are essential. While the process of disinfection can kill many or most pathogenic microorganisms on inanimate surfaces, using a specific method and product, the process of sterilization eliminates all viable microbial life, including microbial spores. The proper procedure will vary based on the end use of the equipment, the material involved and level of infection risk. Any reusable equipment should be reprocessed to the level necessary for a specific job, and critical medical instrument such as those that enter into sterile tissues and/or the bloodstream should undergo sterilization.

The aim of environmental cleaning is to target areas of the building where patients come into contact with the environment, areas where surfaces are often touched, shared equipment and areas where contamination is likely to occur. Staff responsible for cleaning should adhere to the standard procedures, use the appropriate products, at the appropriate concentrations and follow the contact times. Special care should be taken for surfaces and medical equipment shared by more than one person in isolation rooms. The CDC (2024b) suggests incorporating environmental services into infection prevention programs, training staff on cleaning and disinfecting, standardizing cleaning procedures, and keeping track of cleaning and disinfecting efforts. These measures help minimize the risk of the environment becoming a source of transmission, and make healthcare facilities safer.

5.3. Infection Prevention Bundles for surgical procedures, ventilators and catheters.

Infection prevention bundles are bundles of evidence-based practices that are bundled together to lower infections related to a procedure or medical device. They are effective when they are consistently applied, staff are held accountable and they are evaluated regularly for clinical outcomes. Prevention of CAUTIs starts with the idea of trying to avoid using a urinary catheter where possible and only keeping it in place when there is a clinical need. If insertion is required, the healthcare worker should use aseptic technique and sterile equipment, keep the drainage system closed and allow the urine to flow. Appropriate indications for the use of a catheter, aseptic insertion, maintenance of the catheter, and removal when no longer necessary are emphasized in the CDC's CAUTI guideline (CDC, 2009a).

Ventilator-associated pneumonia: These include early identification of patients eligible for early extubation from mechanical ventilation, oral care, maintaining the head of the bed raised when clinically appropriate and minimizing unnecessary exposure to invasive mechanical ventilation. Ventilator care practices should be as per the latest evidence based guidelines and should be customized for the individual patient. Appropriate hand hygiene and handling respiratory equipment procedures should also be followed by staff.

Preventing surgical site infections: A multi-faceted approach before, during and after surgery will

be needed. Appropriate preoperative skin preparation, timely administration of indicated antimicrobial prophylaxis, maintenance of appropriate temperature and glucose management, the aseptic surgical technique and suitable postoperative wound care. One of the CDC's surgical site infection guideline recommendations is to prevent surgical site infections (SSI) related to surgical procedures (Berríos-Torres et al., 2017). The right elements obtained in the bundle should be suitable for the procedure and patient population. Hospitals should keep records of compliance, audit infection rates, and delve into non-compliance to identify areas for improvement.

5.4. Resistance Monitoring and Management Programmes (RMP)

The practice of antimicrobial stewardship programmes encourages the correct choice, dose, route and duration of antimicrobial treatment. They are meant to optimize the outcome of treatment and minimize unnecessary antimicrobial use and selection and dissemination of antimicrobial resistance. Some of the important activities include reviewing antibiotics prescription, obtaining the right microbiological samples, reducing the prescription based on the antibiotic susceptibility results, and re-evaluating the therapy when the patients condition changes. Cooperation between clinical and infectious disease specialists and hospital pharmacists and microbiologists can facilitate rational prescribing. Structured hospital stewardship interventions such as prospective audit and feedback and preauthorization of selected antimicrobial agents (where appropriate) are recommended by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America (Barlam et al., 2016). Stewardship should not only build on infection prevention and control measures, but complement them.

Surveillance programmes give information on incidence of infections, pathogens that cause infections, antimicrobial resistance of pathogens and changes in transmission patterns. Case definitions and data on a patient-by-patient basis can be provided to hospitals to track a variety of infections including catheter-associated urinary tract infections (CAUTI), bloodstream infections and surgical site infections (SSI). These data are analyzed regularly to help identify outbreaks, and to evaluate the impact of preventive measures and focus resources on most at-risk areas. Combining data from surveillance with antimicrobial stewardship enables the healthcare setting to better address the development of antimicrobial resistance and shift in antimicrobial use patterns.

5.5. Infection control guidelines and training of healthcare workers.

To ensure that infection prevention measures are understood and applied correctly, it is important to educate healthcare workers. Hand hygiene should be taught, the use of appropriate personal protective equipment (PPE), aseptic procedures, safe injection practices, the care of infection prevention devices, environmental cleaning, specimen collection and the identification of potential infection outbreaks should all be addressed. New appointments, experienced staff and refresher training should be designed to meet the responsibility of the person involved and refresher training can be aimed at addressing the needs identified during audit and/or changes in clinical guidance. Institutional leadership, adequate materials, easy-to-find written protocols and clear accountability for infection prevention activities are also important for successful implementation. WHO (2016) mentions some key elements of successful infection prevention and control programmes, including: organizational structure, education and training, surveillance, multimodal improvement strategies, monitoring and feedback, staffing, and the built environment.

Structured observations, audits, and outcomes of infections should be used to gauge hospital employee adherence. Feedback should be timely, constructive and provide opportunities to improve and be based on more than just punishment. Engagement of patient and/or carer in appropriate hygiene education will further reinforce prevention measures. Finally, a sustained culture of patient safety, sustained by evidence-based policies and continuous quality improvement, is needed to decrease the occurrence of preventable HAIs.

6. CONCLUSION AND FUTURE PROSPECTS

Hospital-associated infections (HAIs) continue to be a problem for health care quality and safety

as they can result in additional morbidity, increased length of stay, higher treatment costs, and facilitate the development of antimicrobial resistance. The risk of HAIs is related to many factors, which are interdependent: patients' vulnerability, invasiveness of the procedure, hospital and healthcare environment, pathogen characteristics, and the uniformity of infection prevention measures. The most significant clinical issues associated with infections include surgical site infections, catheter associated urinary tract infections, hospital-acquired pneumonia, bloodstream infections and Clostridioides difficile infections, and these need to be targeted for prevention and management. While the World Health Organization (WHO, 2022) highlights that IPC programmes are key for the reduction of avoidable infections and improving the safety and quality of healthcare, it also notes that they need to be implemented effectively.

An early diagnosis and correct identification of the causal organism is a key element of good HAI management. The conventional microbiological culture and antimicrobial susceptibility testing is still needed to identify microorganisms and counsel treatment and molecular assays and rapid diagnostic technologies can be useful in selected clinical scenarios to provide earlier result. The interpretation of the diagnostic findings, however, should also be done in the light of the clinical assessment, to ensure that the correct treatment is administered and avoid unnecessary antibiotic use. Good prevention means frequent hand washing, wearing the right kind of protection equipment, cleaning the environment, sterilising and disinfecting, safe medical-device practices and evidence-based bundles of practice. Appropriate prescribing, early detection of trends in transmission and quick action against resistant organisms are further optimized by antimicrobial stewardship and ongoing surveillance.

Although diagnostic techniques and infection control policies have improved, there are still several challenges, especially in health care facilities where resources are limited, staffing is inadequate, overcrowding is present, there is poor surveillance, and access to laboratory services is limited. As resistance to antimicrobial agents becomes a growing concern, infection prevention is now more important than ever since there may be limited options for treating some microorganisms. Other factors may also affect comparisons between hospitals and regions, such as variations in the surveillance definitions and reporting practices. These problems need to be solved through long-term investment in health system infrastructure, training of health care workers, strengthening laboratory capacity and a national and institutional program for controlling infection.

Improved access to rapid and accurate diagnostics, improved digital surveillance systems and leveraging real-time data to detect unusual infection patterns and potential outbreaks should be pursued in the future. The use of AI and data analysis could facilitate the understanding of surveillance data and enable early risk identification, yet the quality and responsible use of the data will be relevant to its effectiveness. Innovative technologies for environmental decontamination, new medical-device design, and useful interventions that are feasible in resource-poor areas should also be explored in further studies. Improving IPC is a priority to lower HAC as emphasized by WHO (2024). In conclusion, the most effective way to reduce HAIs and to improve patient outcomes is to implement all of the above: early diagnosis, responsible use of antimicrobials, evidence-based prevention strategies and ongoing quality enhancement efforts.

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