Albanian Journal of Trauma and Emergency Surgery (2025) 9/2:1869 - 1876
DOI: 10.32391/ajtes.v9i2.483

OPEN ACCESS JOURNALS

REVIEW ARTICLES

Contemporary Guidelines for the Treatment and Prevention of Nosocomial Infections: Critical Analysis and Practical Perspectives.

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Received: 15 June 2025 / *Accepted:* 5 July 2025 / *Published online:* 20 July 2025
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Abstract

Introduction: Nosocomial infections remain a significant threat to patient safety worldwide, driving morbidity, mortality, and escalating healthcare costs. Despite comprehensive guidelines from the WHO, CDC, and ECDC, variability in recommendations and persistent implementation gaps impede optimal uptake.

Objective: To critically assess current international and regional standards for preventing and controlling healthcare-associated infections (HAIs) and to propose feasible, context-specific strategies for local implementation that empower healthcare professionals to reduce infection rates meaningfully.

Material and Methods: We conducted a systematic review of key HAI prevention and management guidelines published between 2013 and 2023. The methodological quality of each document was evaluated using the AGREE II instrument.

Results: All guidelines converge on essential measures: rigorous hand hygiene, standardized environmental disinfection protocols, and robust antimicrobial stewardship programs. However, antibiotic regimens for routine HAIs (e.g., catheter-associated urinary tract infections) differ markedly, and few guidelines offer clear pathways for implementation in facilities constrained by staffing, equipment, or medication shortages. Interviewees cited critical challenges, including insufficient staffing levels, inconsistent training quality, limited diagnostic capacity, and underdeveloped surveillance systems.

Conclusions: Harmonization of core recommendations is needed to reduce clinician confusion. We propose a practical implementation framework. Tailoring global best practices to local realities promises improved compliance, optimized resource use, and a significant reduction in nosocomial infection burden.

Keywords: Nosocomial infections; Healthcare-associated infections; Infection control guidelines; Antimicrobial stewardship; Hand hygiene; AGREE II; Implementation framework

Original article, no submission or publication in advance or in parallel

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Introduction:

Nosocomial infections remain among the most significant problems faced by hospitals and health ministries worldwide in both developing and developed countries. Their incidence varies and depends on several factors, including the level of hygiene within hospitals, hospital size, patient flow, length of hospitalization, and the use of antibiotics without prior microbiological culture and antibiogram testing.

Another factor influencing the incidence of hospital-acquired infections is the specific ward or clinic in which patients are hospitalized [1].

The highest-risk units for such infections are intensive care units (ICUs), followed by surgical, urological, and gynecological departments, among others [1, 2].

The higher incidence of nosocomial infections in ICUs is attributed to the frequent need for catheterization and other invasive procedures, as well as the generally severe condition of patients treated there. It is estimated that the incidence of nosocomial infections in intensive care units exceeds 28% [3].

Over the decades, the epidemiology of nosocomial infections has evolved, primarily due to the increasing resistance of various bacteria to antibiotics [4].

The main issue associated with bacterial resistance is the empirical use of antibiotics at the beginning of treatment, often without microbiological confirmation or antibiogram results. The choice of initial antibiotic therapy for infected patients is typically based on the type of infection and the medical staff's experience with antibiotics that are most likely to show antibacterial efficacy, considering the pathogenic bacteria most frequently isolated in that particular ward [5].

As one of the most significant global challenges in the field of healthcare, the treatment and reduction of the risk posed by nosocomial infections makes communication among experts from different countries essential in the development of algorithms for managing and preventing these infections [6].

These algorithms focus on two main directions: increasing nurses' awareness of their role in infection prevention procedures and enforcing stricter control over the use and selection of antibiotics [7].

Another factor impacting the control of nosocomial infections is the reduction of patient hospital stay duration.

Bacteria are the primary cause of most hospital-acquired infections, also known as nosocomial infections. Reports from various reference centers indicate that over 90% of all reported nosocomial infections are of bacterial origin. Other pathogens that account for less than 10% include viral and fungal agents [8].

However, the incidence of fungal infections has been increasing in recent decades due to conditions that favor their emergence, such as the growing number of chronic and malignant diseases, as well as the use of chemotherapy and immunosuppressive therapy, both of which significantly reduce the immune defense of patients hospitalized in intensive care or surgical units [8, 9].

Data from several centers report a rising incidence of infections caused by *Mycobacterium tuberculosis* and *M. avium*, resulting from the aforementioned factors [10, 11].

- ***Epidemiological Profiling of Hospital-Acquired Infections: Incidence, Risk Factors, and Control Measures***

Most studies conducted over the past two decades on hospital-acquired infections, particularly in Europe and the United States, have highlighted significant changes in both the incidence of these infections and the types of surgical interventions most at risk, as well as in the most frequent bacterial pathogens. Among these, bacterial infections continue to be by far the most prevalent [12].

In this study, we aim to focus on the epidemiological profile of some of the most common nosocomial infections, not only in our clinical practice but also across various hospital settings. These infections frequently present serious challenges due to their high morbidity and mortality rates, especially in intensive care units and other high-risk hospital departments [12].

Data compiled from scientific literature databases indicate that the predominance of nosocomial infections has evolved over the past decades. In the most recent decade, respiratory infections, urinary tract infections, and surgical site infections have emerged as the most frequently reported types [13].

Respiratory Infections (Pneumonias)

These represent the most serious and most frequent group of nosocomial infections. Over the past decade, respiratory infections have seen a dramatic increase, with incidence rising from approximately 17% in the 1990s to over 47% in recent reports from numerous European centers [14].

This high rate of respiratory infections observed in Europe is mirrored in several other regions, including the Americas and other continents.

Urinary Tract Infections (UTIs)

Urinary tract infections rank second in frequency among nosocomial infections. They are particularly common in intensive care and urology units, where patients often remain catheterized for extended periods. Unlike respiratory infections, which have shown a significant rise in incidence, urinary infections have notably decreased in recent years [14, 15].

This decline is primarily attributed to the implementation of preventive measures, improved care of urinary catheters, and the widespread use of silicone catheters, which are associated with a lower risk of infection [15]

Surgical Site Infections (SSIs)

Surgical site infections account for approximately 15% of all nosocomial infections recorded in surgical departments. Key contributing factors include hygienic conditions, the medical staff's handling of surgical wounds, and contamination before or during surgery. These elements play a critical role in determining the incidence of SSIs [16].

- ***Changes in the Epidemiology of Pathogenic Microorganisms Causing Nosocomial Infections***

Similar to the evolving incidence of organ systems affected by nosocomial infections over the decades, the incidence and distribution of pathogenic bacteria responsible for these infections have also undergone significant changes.

In the early days of modern medicine, the introduction of the concept of "nosocomial infections" led to the identification of Staphylococcus species, particularly those that began to exhibit resistance to penicillin. Later, by the late 1960s and early 1970s, methicillin-resistant Staphylococcus aureus (MRSA) became a serious problem in hospital settings, posing a significant challenge to the medical community of that time [17, 18].

During the same period, other bacteria also emerged as significant nosocomial pathogens, including Serratia spp. [20, 22, 23], and Klebsiella spp. [19, 24, 25]. A decade later, Gram-negative bacteria such as *Pseudomonas aeruginosa* and *Acinetobacter spp.* It began to represent an increasing concern for healthcare systems due to their resistance profiles and virulence [26, 27]

Recent reports from epidemiological agencies indicate a continued rise in the incidence of coagulase-positive and coagulase-negative staphylococci, as well as streptococci, as causes of hospital-acquired infections. [27]

At the same time, these reports indicate a decline in the incidence of infections caused by *Escherichia coli* (from 23% to 16%) and *Klebsiella pneumonia* (from 7% to 5%) [28, 29, 30].

It is worth noting that there is no significant difference in the type and incidence of bacteria responsible for nosocomial infections between European countries and the United States, based on hospital surveillance reports [21, 31, 32, 33].

However, one notable distinction highlighted by epidemiological data is that in the United States, *Acinetobacter spp.* is more frequently reported as a causative agent of bacteremia, while in France, *Pseudomonas aeruginosa* species are more commonly associated with nosocomial pneumonia and urinary tract infections. Regarding other organs affected by hospital-acquired infections, the responsible pathogens appear to be essentially identical across these regions [32, 33, 34].

▪ *Evidence-Based Approaches to the Control of Healthcare-Associated Infections*

Although the initial treatment of patients with various infections is often empirical—especially in intensive care units due to emergencies—it is recommended that, whenever possible, antibiotic selection should be based on microbiological test results and antibiograms.

This approach is advised not only because it benefits patients but also because it helps prevent the development of bacterial resistance to antibiotics, which represents an increasingly severe global problem [35].

Currently, data from major centers studying healthcare-associated infections increasingly show that bacterial resistance to first-line antibiotics is rising, and such resistance is well-recognized for most pathogens.

For example, β-lactamases are enzymes produced by some bacteria to destroy β-lactam antibiotics (such as penicillins and cephalosporins), promoting bacterial resistance to these antibiotics [36].

In bacteria of the genus *Pseudomonas aeruginosa*, these enzymes can be synthesized either by the bacterium's chromosome (a hereditary trait) or acquired through plasmids (genetic material transferred between bacteria) [37, 38].

These enzymes render the bacteria resistant to antibiotics commonly used to treat *P. aeruginosa* infections [39].

In the case of *Staphylococcus aureus*, bacteria can become resistant to methicillin, a potent penicillin, as well as to fluoroquinolones, a group of antibiotics [40, 41, 42].

Among bacteria of the genus *Enterococcus faecium*, cases of resistance to vancomycin—a potent antibiotic often used as a last resort in severe infections—have been reported [43, 44, 45].

In *Klebsiella pneumoniae*, extended-spectrum β-lactamases (ESBLs) are produced, which destroy many types of antibiotics, making this bacterium very difficult to eradicate [46, 47].

The same can occur with other Gram-negative bacteria.

Data from these centers also indicate that bacterial resistance can be induced in opportunistic bacteria, such as *Acinetobacter baumannii* and *Stenotrophomonas maltophilia*, when they are exposed to the extensive use of broad-spectrum antibiotics, thereby causing significant healthcare problems [48, 49, 50].

Similar phenomena have been observed in various other bacterial groups, including both Gram-negative and Gram-positive bacteria.

▪ *Optimizing Empiric Therapy for Healthcare-Associated Infections: Evidence-Based Strategies*

Epidemiological studies have shown that, in recent decades, the causative pathogenic agents of healthcare-associated infections (HAIs) have undergone significant changes, necessitating adjustments in empirical strategies for the elective use of antibiotics in the primary treatment of patients with these infections [51].

Every patient diagnosed with a healthcare-associated infection—whether in intensive care units or other hospital wards—requires antibiotic treatment, which is initially empirical. During this period, it is important to consider data on the most frequently isolated pathogens in the patient's care environment, information about bacterial resistance to antibiotics, and which antibiotics remain effective [52].

Other factors influencing the empirical choice of antibiotics include the localization of the infection and clinical signs such as high temperature, fever, tachycardia, tachypnea, or signs of organ failure (renal, cardiovascular, or hepatic) [53]

Determining which antibiotics to use initially for treating severe infections is a significant challenge because physicians must make rapid decisions to both stabilize the

patient and cover potential nosocomial pathogens with appropriate antibiotics [54, 55, 56].

The most frequent pathogens causing severe septic conditions in adults are *Staphylococcus aureus* (18.2% of cases), *Escherichia coli* (14.2%), *Pseudomonas aeruginosa* (13.5%), *Klebsiella/Proteus* species (11%), and enterococci (5.9%), which are the dominant pathogenic bacteria. [57]

Another complex condition to treat when caused by nosocomial pathogenic bacteria is nosocomial pneumonia, which requires broad empiric therapy due to the need to cover a wide range of suspected nosocomial pathogens [58, 59, 60].

Physicians managing patients with HAIs, such as those in intensive care units and surgical wards, should always consider the diversity of pathogenic microorganisms most frequently isolated in their specific care settings, as well as the microbiological results and antibiograms collected over recent months [61].

Generally, conventional empirical therapy should be broad enough to cover most Gram-negative bacilli, such as *P. aeruginosa*, *Enterobacter* species, and *A. baumannii*, which are common and problematic in nosocomial pneumonia [59, 60]

The selection of antibiotics for HAIs depends on the suspected causative pathogen.

For *Pseudomonas* infections, ceftazidime/avibactam and ceftolozane/tazobactam, combined with an aminoglycoside, are recommended [62, 63, 64]

In cases where Gram-positive pathogens, such as MRSA, are suspected, a glycopeptide must be added to empirical therapy.

Along with glycopeptides, other anti-staphylococcal agents, such as rifampicin, clindamycin, and fusidic acid, should also be administered [65, 66]

For suspected nosocomial infections caused by *P. aeruginosa*, carbapenems (imipenem-cilastatin, meropenem) combined with an aminoglycoside (amikacin) or a fluoroquinolone (ciprofloxacin) are used [69, 70, 71, 72].

Before starting empirical therapy and administering antibiotics, microbiological samples and antibiograms must be collected. After the results are available, antibiotic selection should be adjusted according to the antibiogram findings [73,[74]

- ***Evidence-Based Strategies for the Prevention of Nosocomial Infections in Healthcare Settings***

As with many other healthcare issues, the principle that prevention is the most effective way to control nosocomial infections (NIs) remains a valid approach. Today, large centers in Europe and the USA have developed numerous protocols and algorithms for the control and prevention of NIs. These programs target healthcare personnel and include various educational initiatives, such as hand hygiene, the use of protective gloves, masks, and gowns, as well as immunization against various pathogens, especially viral ones (Allegranzi & Pittet, 2009; Pittet & Boyce, 2001).

For patients at high risk, isolation in separate rooms should be implemented, and administration of antibiotics sometimes begins with prophylactic purposes (Siegel, Rhinehart, Jackson, & Chiarello, 2007).

In all departments with a high risk of nosocomial infections, surveillance of these infections must be conducted, along with close cooperation with microbiology services. The rapid integration of data into the hospital database is crucial to ensure the swift transmission of information necessary for epidemiological services, which must take measures to isolate these infections and prevent their spread within hospital environments (Weinstein, 1991).

To successfully prevent and treat nosocomial infections, three approaches must be undertaken in every healthcare institution. First, the elimination of nosocomial pathogens prevents or reduces their ability to colonize oropharyngeal structures, intestines, and skin, especially in patients in intensive care.

Second, the prevention of cross-contamination and the interruption of transmission of nosocomial pathogens from patient to patient or from healthcare personnel to patients is achieved through the disinfection of catheters, respiratory equipment, endotracheal tubes, and other devices. Third, the administration of prophylactic antibiotics, especially in high-risk patients post-surgery (Siegel et al., 2007).

Although nosocomial infections (NIs) remain a significant threat to patients admitted to intensive care units or high-risk surgical wards, their prevention and control have undergone significant evolution over time through adherence to and implementation of prevention guidelines (Allegranzi & Pittet, 2009).

Conclusions:

Harmonization of key recommendations is needed to reduce confusion among clinicians.

We propose a practical implementation framework comprising:

1. Formation of multidisciplinary infection-control committees
2. Development of concise, locally adapted protocol summaries
3. Regular in-service training and competency assessments
4. Simplified surveillance indicators linked to feedback loops
5. Prioritization of cost-effective measures (e.g., alcohol-based hand rubs, single-use devices)

Adapting global best practices to local realities can enhance compliance, optimize resource use, and ultimately reduce the burden of nosocomial infections.

COI Statement: This paper has yet to be submitted in parallel, presented fully or partially at a meeting, podium, or congress, published, or submitted for consideration beforehand.

This research received no specific funding from public, commercial, or non-profit sectors. The authors declare that they, their relatives, or next of kin have no financial relationships with external companies that could be considered relevant or minor.

Disclosure: The authors declared no conflict of interest. No funding was received for this study.

Abbreviations

HAIs - Healthcare-Associated Infections; WHO - World Health Organization; ECDC - European Centre for Disease Control and Prevention; CDC - Centers for Disease Control and Prevention; ICUs - Intensive Care Units; AGREE - Appraisal of Guidelines for REsearch & Evaluation; NIs - Nosocomial Infections; UTIs - Urinary Tract Infections; SSIs - Surgical Site Infections; MRSA - Methicillin-Resistant Staphylococcus Aureus;

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