Open Access Research Journal of
Life Sciences
Journals home page: https://oarjpublication/journals/oarjls/
ISSN: 2783-025X (Online)

(REVIEW ARTICLE)

Hospital-acquired bacterial infections: Epidemiology and control interventions

Inas Ahmed Zaynal *

Department of Biology, College of Education for Pure Science, University of Kirkuk-Iraq.

Open Access Research Journal of Life Sciences, 2026, 11(01), 051-057

Publication history: Received on 05 February 2026; revised on 12 March 2026; accepted on 14 March 2026

Article DOI: https://doi.org/10.53022/oarjls.2026.11.1.0012

Abstract

Nosocomial infections or hospital-acquired infections (HAIs) are one of the biggest health burdens around the globe related to higher morbidity, mortality, and healthcare expenses. Most HAIs are caused by bacterial pathogens especially in intensive care units and high-risk patients. The increased incidence of antimicrobial resistance also makes treatment and control of infection an even bigger struggle. The review gives a full account of the epidemiology, the key causative pathogens, the risk factors, the dynamics of transmission, and evidence-based prevention and control measures. It is necessary to enhance infection prevention initiatives, antimicrobial stewardship, surveillance, and international cooperation to reduce the consequences of HAIs on the global level.

Keywords: Hospital; Bacterial; HAIs; Level

1. Introduction

Nosocomial infections are also known as hospital-acquired infections (HAIs), and they are illnesses that arise at least 48 hours or more following the admission of the patient in the hospital and have not been present or incubating at the moment the patient was admitted [1]. They are among the most serious negative occurrences linked to the provision of healthcare in the global arena. HAIs have an impact on millions of patients annually and they are generally known as vital harbingers of healthcare quality, patient safety and system performance. Their level of occurrence indicates human-factor intricacy between susceptible hosts, invasive medical care procedures, medical care environments and microorganisms [2].

Although the number of diagnostic techniques and antimicrobial treatment, sterilization measures and infection control procedures had significant progress, HAIs are still present, and in certain facilities, they grow in size. The healthcare sector has increasingly become complex, and the use of invasive treatments like mechanical ventilation, central venous catheterization, urinary catheterization, dialysis, and major surgical interventions has increased [3]. Alongside the fact that these technologies save lives, they also violate natural host defences and provide points of entry to opportunistic pathogens. Particularly susceptible to infection are also critically ill patients, neonates, elderly persons, transplant recipients, oncology patients, and persons undergoing immunosuppressive treatment [4].

HAIs epidemiology is determined by several inseparable factors, among which are microbial virulence, antimicrobial resistance trends, adherence of healthcare workers to infection control protocols, hospital facilities, and antimicrobial usage habits [5]. The most common HAIs are caused by bacterial pathogens, but Gram-negative organisms are becoming increasingly prevalent in most locations because of the increasing levels of antimicrobial resistance. The growth of multidrug-resistant (MDR) organisms has greatly complicated the treatment strategies as well as aggravated clinical outcomes. The production of extended-spectrum β-lactamase, production of carbapenemase, production of methicillin, and production of vancomycin have led to the decreased efficacy of most of the first-line treatments [6].

HAIs are a significant burden to the world, and the burden is disproportionately high among low- and middle-income countries (LMICs). There are limited resources, overcrowding, lack of infection control infrastructure, and limited

* Corresponding author: Inas Ahmed Zaynal

access to sophisticated diagnostics, which increases the chances of contracting infections in these countries [7]. But HAIs do not occur in resource-limited environments only, but high-income health care systems are also endemic in their transmission, and experience occasional outbreaks of resistant organisms. In very specialized medical facilities, the density of the vulnerable population and high intensity of invasive services contribute to the creation of conducive environments in which pathogen spread may occur [8].

HAIs cause a financial burden to healthcare systems economically because of the long-term hospitalization, more intensive care equipment, extra diagnostic tests, and the use of expensive antimicrobial medication. Long-term disability, loss of productivity, and burden on the society are considered indirect costs. Regarding the sphere of public health, HAIs lead to the rise in the number of antimicrobial use, which contributes to the development and spread of resistance [9].

The increasing awareness of antimicrobial resistance as a healthcare problem of global concern has only increased the significance of preventing and controlling HAIs. The international organizations and national health agencies focus on surveillance, antimicrobial stewardship, prevention of infections programs and investment in research as key pillars of healthcare-associated infections. Vast knowledge on the epidemiology, transmission and prevention of HAIs is thus necessary to enhance patient safety and sustainable healthcare delivery [10].

Figure 1 Hospital-Acquired bacterial infections (HALs)

This review will provide a critical analysis of hospital-acquired bacterial infections, epidemiology, key causative agents, risk factors, resistance trends, and the evidence-based control practices. By combining the current scientific facts with the perceptions of the general population regarding health, the present paper will help clinicians, microbiologists, policymakers and scientists to address one of the most significant challenges in modern healthcare [11].

2. Epidemiology of Hospital-Acquired Bacterial Infections

2.1. Global Burden

Globally, HAIs affect an estimated 5–15% of hospitalized patients, with higher rates reported in intensive care units. Mortality attributable to HAIs is substantial, especially in vulnerable populations such as neonates, elderly patients, and immunocompromised individuals. Healthcare-associated bloodstream infections and ventilator-associated pneumonia contribute significantly to hospital mortality rates [12].

Surveillance data reveal regional variability influenced by infection control practices, antimicrobial use, healthcare infrastructure, and socioeconomic factors. Developing countries often report higher prevalence rates due to overcrowding, limited resources, and inadequate infection control measures [13].

2.2. Common Bacterial Pathogens

The most frequently isolated bacterial pathogens in HAIs include [14]:

- *Staphylococcus aureus (*including MRSA strains*)*
- *Escherichia coli*
- *Klebsiella pneumoniae*
- *Pseudomonas aeruginosa*
- *Acinetobacter baumannii*

Gram-negative bacteria have gained increasing importance due to rising antimicrobial resistance, particularly carbapenem resistance. Methicillin-resistant *S. aureus* (MRSA) remains a major cause of surgical site infections and bloodstream infections. Polymicrobial infections are also common, especially in surgical and trauma patients [15].

2.3. Types of Hospital-Acquired Infections

Major categories of HAIs include [16]:

- Ventilator-Associated Pneumonia (VAP) – Occurs in mechanically ventilated patients and is associated with high mortality.
- Central Line-Associated Bloodstream Infections (CLABSI) – Linked to intravascular catheter use.
- Catheter-Associated Urinary Tract Infections (CAUTI) – Among the most common HAIs globally.
- Surgical Site Infections (SSI) – Occur postoperatively and increase hospital stay and costs.

Each category has distinct risk factors and prevention strategies.

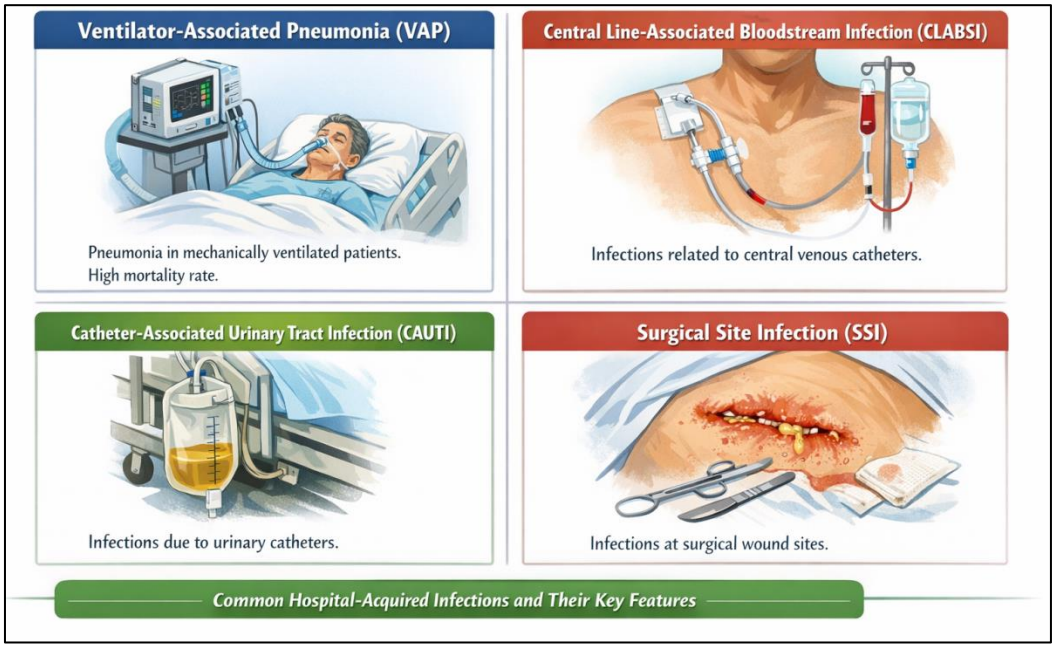

Figure 2 Types of hospital-aquired infections

3. Risk Factors and Transmission Dynamics

3.1. Patient-Related Factors

Patient variables are determinant in the occurrence of hospital-acquired infections (HAIs). Old age correlates with immunosenescence that decreases the ability of the innate and adaptive immune responses. The opportunistic pathogens are especially dangerous to immunosuppressed people, chemotherapy and corticosteroid users. Host defense mechanisms are further compromised by such chronic comorbidities like diabetes mellitus and malignancies. Also, the long stay in hospitals means cumulative exposure of resistant microorganisms in the healthcare facility [17].

3.2. Healthcare-Related Factors

There are medical practices that play a great role in the spread of infectious agents in hospitals. Direct points of entry of pathogens are offered by the use of invasive medical equipment, which includes central venous catheters and mechanical ventilators. The exposure to broad-spectrum antibiotics introduces selective pressure that favors the appearance of resistant strains. Lack of compliance with hand hygiene measures is one of the major causes of cross-transmission. Wards are also overcrowded and there is a scarcity of resources to control infections that further weaken preventive measures [18].

3.3. Modes of Transmission

Transmission of bacteria within a healthcare setting happens in a number of major ways. The most frequent way of transmission is direct contact especially through the hands of the medical personnel. Indirect transmission is by contamination of surfaces, medical equipment or items of common use. Airborne dissemination can be carried out with certain pathogens in certain conditions, although less often. These channels of transmission need a good understanding to apply specific measures aimed at controlling the infection [19].

4. Antimicrobial Resistance in HAIs

The problem of antimicrobial resistance (AMR) is a major problem in the management of hospital-acquired infections. Multidrug-resistant organisms (MDROs) restrict treatment choices and are linked to high morbidity and mortality. Of particular concern are MRSA (methicillin-resistant Staphylococcus aureus), ESBL-producing (extended-spectrum β-lactamase) and carbapenem-resistant Enterobacterales. Misuse or overuse of antibiotics speeds up the process of resistance development by the mechanism of selective pressure. In addition, resistance genes carried in plasmids promote rapid horizontal gene transfer in healthcare settings [20].

5. Infection Control Strategies

5.1. Standard Precautions

The basis of infection prevention in healthcare facilities is standard precautions. The strict compliance with the hand hygiene has been identified as the most effective preventive measure. Proper usage of personal protective equipment (PPE) helps to eliminate the risk of direct exposure to infectious agents. Bloodborne diseases are prevented by safe injection. Frequent cleaning and disinfection of the environments help reduce the infection of microbes in the patient care units [21].

5.2. Transmission-Based Precautions

The precautions applied in transmission of patients who are infected or colonized with highly transmissible or resistant organisms are those that are implemented as transmission-based precautions. Contact precautions involve the use of gloves and gowns in order to avoid the spread of pathogens. The isolation/cohorting of colonized patients aids in the outbreak control in healthcare facilities. Specialized medical equipment will minimize chances of cross-contamination. Regular use of the measures is effective in breaking transmission chains [22].

5.3. Device-Associated Infection Prevention Bundles

Evidence based prevention bundles have proven to be highly effective in preventing device related infections. Central line sterile insertion technique has a great reduction in blood stream infection rates. Eliminating unwarranted device exposure happens through the daily evaluation of the need of the catheter. Head of bed elevation decreases the chances of ventilator-associated pneumonia (VAP). Before invasive surgeries, skin should be properly antisepticized to reduce the risk of colonization with local microbes and infection [23].

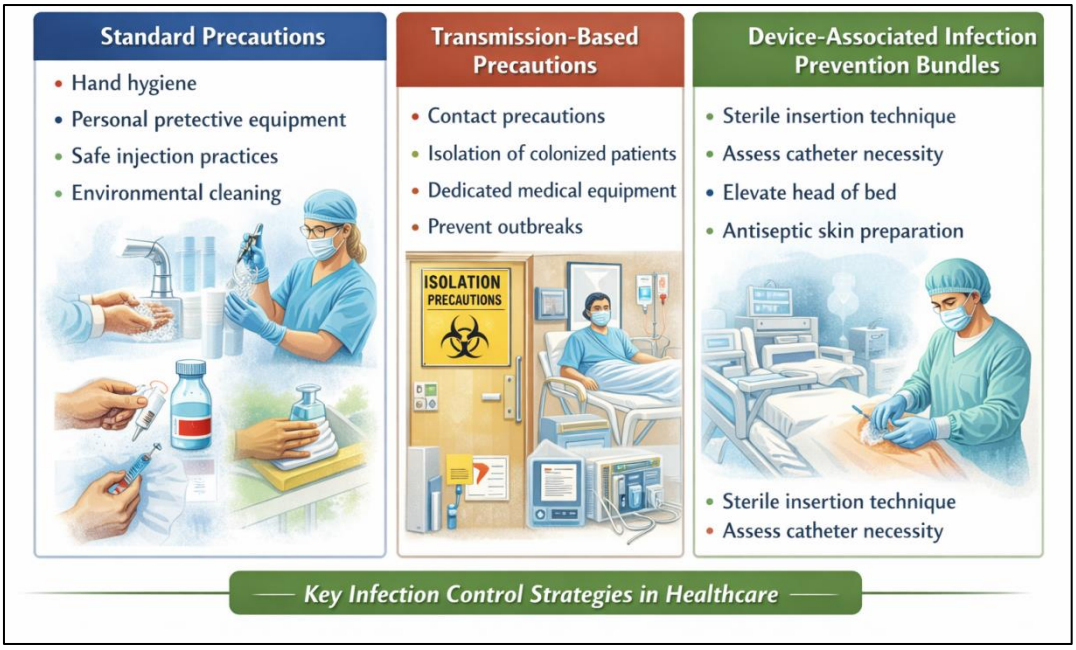

Figure 3 Infection control strategies

6. Antimicrobial Stewardship Programs (ASPs)

Antimicrobial stewardship initiatives are developed to enhance the clinical outcomes and optimize the use of antibiotics. The policy of restricting availability to high-risk antimicrobials restricts the inappropriate use of antimicrobials. Prescribing is improved by the prospective audit and feedback mechanisms. Microbiological-based de-escalation of therapy minimizes unwarranted broad-spectrum coverage. Dose optimization provides therapeutic efficacy with little toxicity and development of resistance [24].

7. Surveillance and Reporting Systems

The surveillance systems need to be continuous so that early detection and trend analysis can be done. Regular data gathering allows to track the infection rates and patterns of resistance. To reduce the spread of infections in the hospital, hospital infection control committees interpret surveillance data to initiate remedial interventions. The national reporting systems facilitate the benchmarking and policy making. Evidence-based decision making enhances prevention and distribution of resources [25].

8. Emerging Technologies and Future Directions

The use of innovative technologies is changing the approach to infection prevention and control. Quick solutions Rapid molecular diagnostics make it possible to detect resistant pathogens early and direct treatment. AID tools can help with prediction and analysis of outbreaks as well as dynamics of transmission. Antimicrobial surfaces coating decreases the pollution of the environment in the high-risk areas. Also, vaccination regimens and bacteriophage therapy are some of the promising future cure measures of resistant infections [26].

9. Economic and Public Health Impact

HAIs cause immense financial problems to the healthcare system. Long-term hospitalization and other interventions are also bound to raise direct medical expenses. Extreme complications can result in long-term disability and mortality. The indirect costs are loss of productivity and financial burden on the society. Prevention programs are economical to invest in and boost the overall patient safety outcomes [27].

10. Conclusion

Bacterial infections that are hospital-acquired continue to be a significant problem with the worldwide health care systems. The interaction of invasive medical approaches, antimicrobial resistance, and shortcomings of the healthcare infrastructure makes them persistent. The key elements of reducing the burden of HAI include comprehensive infection prevention programs, antimicrobial stewardship programs, effective surveillance, and international cooperation. It will require sustainable investments in research and building health care capacity to guarantee the control of the long term and better results of patients.

References

[1] Chakraverty, R., & Kundu, A. K. (2025). Introduction to nosocomial infection. In *Hospital-Acquired Infections in Intensive Care Unit and their Management: The Indian Perspective* (pp. 1-12). Singapore: Springer Nature Singapore.

[2] Basak, D., Arrighi, S., Darwiche, Y., & Deb, S. (2021). Comparison of anticancer drug toxicities: paradigm shift in adverse effect profile. *Life*, *12*(1), 48.

[3] Alatawi, A. D., Hetta, H. F., Ali, M. A. S., Ramadan, Y. N., Alaqyli, A. B., Alansari, W. K., ... & Algammal, A. M. (2025). Diagnostic innovations to combat antibiotic resistance in critical care: tools for targeted therapy and stewardship. *Diagnostics*, *15*(17), 2244.

[4] Faizan, A. L. I., Ahmed, A., Maqsood, S., Fatima, M., Hussain, M., Rehman, S. U., & SAFDAR, M. (2024). The never-ending battle: strategies for infectious disease control in the face of emerging pathogens. *Curr Stud Health Life Sci*, *240*, 240-264.

[5] Sandu, A. M., Chifiriuc, M. C., Vrancianu, C. O., Cristian, R. E., Alistar, C. F., Constantin, M., ... & Tantu, M. M. (2025). Healthcare-associated infections: the role of microbial and environmental factors in infection control—a narrative review. *Infectious Diseases and Therapy*, *14*(5), 933-971.

[6] Scaglione, G., Perego, M., Colaneri, M., Genovese, C., Brivio, F., Covizzi, A., ... & Palomba, E. (2024). Understanding the burden of antibiotic resistance: a decade of carbapenem-resistant Gram-negative bacterial infections in Italian intensive care units. *Frontiers in microbiology*, *15*, 1405390.

[7] Odoom, A., Tetteh-Quarcoo, P. B., & Donkor, E. S. (2025). Prevalence of hospital-acquired infections in low-and middle-income countries: Systematic review and meta-analysis. *Asia Pacific Journal of Public Health*, *37*(5), 448-466.

[8] Abalkhail, A., & Marzouk, E. (2025). Healthcare-associated infections: an overview of global strategies and challenges in minimizing infection transmission. *Cellular and molecular biology (Noisy-le-Grand, France)*, *71*(10), 7-16.

[9] Gidey, K., Gidey, M. T., Hailu, B. Y., Gebreamlak, Z. B., & Niriayo, Y. L. (2023). Clinical and economic burden of healthcare-associated infections: A prospective cohort study. *Plos one*, *18*(2), e0282141.

[10] World Health Organization. (2024). *Global strategy on infection prevention and control*. World Health Organization.

[11] Chakraverty, R., & Kundu, A. K. (2025). Current management algorithms of hospital-acquired infections. In *Hospital-Acquired Infections in Intensive Care Unit and their Management: The Indian Perspective* (pp. 21-37). Singapore: Springer Nature Singapore.

[12] Javed, U., Merchant, S., Nizar, N., Amin, N., & Batool, F. (2025). Investigating the Impact of HAIs on Patient Outcomes including Morbidity, Mortality, and Length of Stay in ICU in a Tertiary Care Hospital in Karachi. *Pakistan Journal of Medical & Cardiological Review*, *4*(3), 1523-1535.

[13] Li, W., Huang, T., Liu, C., Wushouer, H., Yang, X., Wang, R., ... & Yang, L. (2025). Changing climate and socioeconomic factors contribute to global antimicrobial resistance. *Nature Medicine*, *31*(6), 1798-1808.

[14] Abban, M. K., Ayerakwa, E. A., Mosi, L., & Isawumi, A. (2023). The burden of hospital acquired infections and antimicrobial resistance. *Heliyon*, *9*(10).

[15] Mancuso, G., De Gaetano, S., Midiri, A., Zummo, S., & Biondo, C. (2023). The challenge of overcoming antibiotic resistance in carbapenem-resistant gram-negative bacteria:"Attack on Titan". *Microorganisms*, *11*(8), 1912.

[16] Shulakova, N. I., Tutelyan, A. V., Maleev, V. V., & Akimkin, V. G. (2023). Risks of HAIs: problems and pitfalls. *Health Risk Anal*, *2023*, 104-114.

[17] Hasona, I. F., Awad, A., Younis, G., & Mohamed, W. F. (2026). A One Health Perspective on Proteus mirabilis: The Interaction of Virulence and Antimicrobial Resistance Across Human and Animal Reservoirs. *Microorganisms*, *14*(2), 444.

[18] Chakraverty, R., & Kundu, A. K. (2025). *Hospital-acquired infections in intensive care unit and their management: the Indian perspective*. Springer Nature.

[19] Pandey, N. (2024). Bacterial pathogenesis. *Microbes of Medical Importance [Internet]. Iterative International Publishers, Selfypage Developers Pvt Ltd*, 3-28.

[20] Wang, X., Liu, Y., Ding, Y., Li, M., Gao, Y., & Li, T. (2025). Disease spectrum of patients with hospital-acquired multidrug-resistant organism infections in the intensive care unit: a retrospective study. *Frontiers in Microbiology*, *16*, 1568615.

[21] Festa, M. G. (2025). The Standard Precautions and Behavior About Transmission-Based Precautions Isolation Techniques and Room Placement. In *Principles of Nursing Infection Prevention Control: Introduction and global context of Infection Prevention and Control (Volume 1)* (pp. 93-108). Cham: Springer Nature Switzerland.

[22] Festa, M. G. (2025). The Standard Precautions and Behavior About Transmission-Based Precautions Isolation Techniques and Room Placement. In *Principles of Nursing Infection Prevention Control: Introduction and global context of Infection Prevention and Control (Volume 1)* (pp. 93-108). Cham: Springer Nature Switzerland.

[23] Awad, S. (2024). *THE IMPACT OF THE PROTOCOL CENTRAL LINE BUNDLE CARE ON CATHETER RELATED BLOOD STREAM INFECTION* (Doctoral dissertation, Faculty of Graduate Studies THE IMPACT OF THE PROTOCOL CENTRAL LINE BUNDLE CARE ON CATHETER RELATED BLOOD STREAM INFECTION By Safaa Awad Supervisor Dr. Aidah Alkaissi This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Critical Care Nursing, Faculty of Graduate Studies, An-Najah National University).

[24] Pulia, M. S. (2024). Optimizing Antimicrobial Stewardship in the. *Infectious Disease Emergencies, An Issue of Emergency Medicine Clinics of North America, E-Book: Infectious Disease Emergencies, An Issue of Emergency Medicine Clinics of North America, E-Book*, *42*(2), 443.

[25] Ingelbeen, B., van Kleef, E., Mbala, P., Danis, K., Macicame, I., Hens, N., ... & van der Sande, M. A. (2025). Embedding risk monitoring in infectious disease surveillance for timely and effective outbreak prevention and control. *BMJ global health*, *10*(2).

[26] Alatawi, A. D., Hetta, H. F., Ali, M. A. S., Ramadan, Y. N., Alaqyli, A. B., Alansari, W. K., ... & Algammal, A. M. (2025). Diagnostic innovations to combat antibiotic resistance in critical care: tools for targeted therapy and stewardship. *Diagnostics*, *15*(17), 2244.

[27] Abban, M. K., Ayerakwa, E. A., Mosi, L., & Isawumi, A. (2023). The burden of hospital acquired infections and antimicrobial resistance. *Heliyon*, *9*(10).