The Review Of
DIABETIC
STUDIES
OPEN ACCESS

The Review of DIABETIC STUDIES

Reprint from

Infection Control In Clinical Nursing: Best Practices For Reducing Nosocomial Infections

Mohammed Abdu Assiri[1], Hamed Eid Alqarni[2], Zayed Amer Asiri [3], Alghareeb Mohammed Asiri[4], Atheer Ali Mohammed Alasmari[5], Amani Mesfer ALHalafi[6], Yahya Muzher Yahya Alasmari[7], Norah Minshet Ali Alshahrani[8], Hassan Mohammed Redha Alhajri[9], Hassan Sameer Almalfai [10], Fatimah Ramadan AlGhazal [11], Diaa Hassan Alali[12], Ahmad Hassan Ali Almusailem[13], Ali Ahmed Ali Albetiyan [14], Ali Talib Ali Alamir [15]

[1]Senior Nursing Specialist, Ahad Rofidah Hospital, Asir cluster, Kingdom of Saudi Arabia.
[2]Senior Nursing Specialist, King Abdullah Hospital, Asir Cluster, Kingdom of Saudi Arabia.
[3]Nursing Specialist, Rijal Almaa Hospital, Asir cluster, Kingdom of Saudi Arabia.
[4]Nursing Specialist, Mohayl General hospital, Asir Cluster, Kingdom of Saudi Arabia.
[5]Nursing Specialist, Ballasmar General Hospital, Asir Cluster, Kingdom of Saudi Arabia.
[6]Nursing Specialist, Sabt Al alaya Hospital, Asir Cluster, Kingdom of Saudi Arabia.
[7]Nursing Specialist, Aseer Central Hospital, Asir Cluster, Kingdom of Saudi Arabia.
[8]Nursing Technician, Bishah central sector, Asir cluster, Kingdom of Saudi Arabia.
[9]Nursing Specialist, King fahad Hospital in Hofuf, Kingdom of Saudi Arabia.
[10]Nursing Specialist, Eradah Complex and Mental Health in Dammam, Kingdom of Saudi Arabia.
[11]Nursing Specialist, Mch Alhasa, Kingdom of Saudi Arabia.
[12]Nursing Technician, KFHH Alhassa, Kingdom of Saudi Arabia.
[13]Nursing Specialist, KFHH Alhassa, Kingdom of Saudi Arabia.
[14]Nursing Specialist, Psychiatric Hospital in Hahsa, Kingdom of Saudi Arabia.
[15]Nursing Specialist, KFHH Alhassa, Kingdom of Saudi Arabia.

Abstract

Background: Nosocomial infections, or healthcare-associated infections (HAIs), present a significant global challenge to patient safety, clinical outcomes, and healthcare costs. Nurses, as primary frontline providers, play a pivotal role in infection prevention and control (IPC) through evidence-based practices and leadership. This review aims to comprehensively examine best nursing practices for infection control to reduce the incidence and impact of HAIs.

Methods: A comprehensive literature synthesis was conducted evaluating current evidence on nursing-led IPC interventions, barriers to optimal implementation, and strategies to enhance nursing education and leadership in infection control. Focus areas included hand hygiene, PPE, aseptic technique, environmental cleaning, device-associated infection prevention, surveillance, behavioral interventions, and emerging technologies.

Results: Effective nursing practices center on stringent hand hygiene compliance guided by WHO protocols, proper PPE utilization, aseptic maintenance during invasive procedures, and environmental sanitation. Continuous education, simulation training, behavioral change frameworks, and mentorship improve compliance and safety culture. Advances in surveillance, rapid point-of-care diagnostics, and artificial intelligence support early detection and antimicrobial stewardship. Multidisciplinary collaboration and strong nursing leadership drive accountability and sustainable IPC outcomes.

Conclusions: Clinical nursing is fundamental to reducing healthcare-associated infections through comprehensive infection control practices, education, leadership, and innovation. Addressing current and emerging challenges requires ongoing commitment to evidence-based IPC, integrated technologies, and fostering a culture of safety and accountability within healthcare teams.

Keywords: Infection control, nursing, nosocomial infections, healthcare-associated infections, hand hygiene, personal protective equipment, aseptic technique, surveillance, antimicrobial stewardship, nursing education.

Introduction

Nosocomial infections, also known as healthcare-associated infections (HAIs), are infections acquired by patients during the course of receiving medical treatment in a healthcare facility, which were neither present nor incubating at the time of admission. These infections can manifest 48 hours or more after hospital admission and encompass a range of infections such as urinary tract infections, respiratory tract infections, surgical site infections, and bloodstream infections. The scope of nosocomial infections extends across all healthcare environments, from intensive care units to general wards, posing a significant threat to patient safety worldwide. Despite advances in medical care, these infections remain a persistent and escalating challenge to clinical outcomes, healthcare quality, and costs (Tobin & Zahra, 2025).

The relevance and burden of nosocomial infections in modern healthcare cannot be overstated. Globally, these infections affect millions of patients annually, with prevalence rates varying based on geographic and socioeconomic conditions. In developed countries, the incidence of HAIs may affect up to 12% of hospitalized patients, whereas in developing countries this can rise to 15% or higher. The consequences of HAIs include increased patient morbidity and mortality, prolonged hospital stays, higher healthcare costs, and strain on healthcare resources. Vulnerable populations such as the elderly, immunocompromised, or those undergoing invasive procedures are at particularly high risk. Additionally, the emergence of multidrug-resistant organisms as causative agents exacerbates the clinical burden, complicating treatment and outcomes (Taye et al., 2023).

In the context of nursing practice, infection control is paramount and constitutes a foundational element for ensuring patient safety and quality of care. Nurses are frontline healthcare providers who play a critical role in preventing healthcare-associated infections through the implementation of evidence-based infection prevention and control (IPC) strategies. These include meticulous hand hygiene, use of personal protective equipment (PPE), environmental cleaning, safe injection practices, and antimicrobial stewardship. Nurses also serve as educators, advocates, and monitors of IPC compliance within clinical settings. Their engagement and adherence to stringent infection control protocols have demonstrated significant reductions in infection rates and improvement in patient outcomes (Hill et al., 2024).

The objective of this review is to comprehensively examine the best practices in infection control specific to clinical nursing to reduce the incidence and impact of nosocomial infections. This includes an evaluation of current evidence-based interventions, identification of barriers to effective implementation, and strategies for fostering a culture of safety and accountability within healthcare teams. Furthermore, this review aims to highlight the evolving role of nursing professionals in infection prevention, emphasizing continuous education, leadership, and interprofessional collaboration as vital components for sustainable success in IPC.

Methods

This review employed a comprehensive literature synthesis approach to evaluate best practices in infection control specific to clinical nursing aimed at reducing nosocomial infections. A systematic search of peer-reviewed publications, clinical guidelines, and infection control frameworks was conducted across relevant medical and nursing databases. Key concepts included evidence-based infection prevention strategies, nursing roles in antimicrobial stewardship, education and competency development, surveillance and data management, behavioral interventions, and leadership in infection control. Studies focusing on the epidemiology of healthcare-associated infections (HAIs), transmission mechanisms, and challenges in clinical nursing implementation were prioritized. The review examined interventions such as hand hygiene protocols, personal protective equipment (PPE) use, aseptic techniques, environmental cleaning, device-associated infection prevention bundles, and emerging technologies like rapid diagnostics and artificial intelligence applications. Barriers to effective practice and facilitators such as role modeling and interprofessional collaboration were also analyzed. The methodology emphasized integration of multidisciplinary evidence and current best practices to inform clinical guidelines, education, and leadership strategies in nursing infection control.

Epidemiology of Nosocomial Infections

Nosocomial infections, also known as healthcare-associated infections (HAIs), are a significant global public health concern, affecting millions of patients annually. Globally, nosocomial infections impact over 100 million patients each year, with an estimated prevalence rate varying widely from around 5% in parts of North America and Europe to as high as 40% in some regions of Asia. The burden of HAIs is notably higher in low-income and developing countries, where limited healthcare resources, infrastructure challenges, and economic constraints contribute to elevated rates of infection. For example, the Eastern Mediterranean region reports HAI prevalence as high as 16%, whereas developed countries generally report between 5-15% (Raoofi et al., 2023).

There is considerable regional variation in nosocomial infection rates influenced by geographic, economic, and healthcare delivery factors. Within hospitals, the risk of acquiring HAIs varies by unit type, with intensive care units (ICUs) experiencing the highest rates. For instance, studies indicate infection prevalence rates in ICUs can exceed 19%, compared with lower rates in surgical wards and general hospital units. Surgical wards tend to witness a high proportion of surgical site infections (SSIs), urinary tract infections (UTIs), bloodstream infections (BSIs), and pneumonia, with SSIs accounting for roughly a quarter of all nosocomial infections in surgical patients. Critical care units, neonatal intensive care, and step-down units also demonstrate varying infection burdens due to patient acuity and device use (Khan et al., 2017).

The microbial landscape of HAIs encompasses bacteria, fungi, and viruses, with bacteria as the predominant causative agents. Multidrug-resistant organisms (MDROs) constitute a growing threat, complicating treatment and increasing morbidity and mortality. Common bacterial pathogens include methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus (VRE), extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae such as Klebsiella pneumoniae, and carbapenem-resistant Pseudomonas aeruginosa and Acinetobacter species. Fungal infections, particularly involving Candida species such as Candida albicans and the emerging multidrug-resistant Candida auris, are also significant, especially in immunocompromised patients or those with invasive devices. Viral agents, though less prevalent, contribute to outbreaks in healthcare settings through respiratory and contact transmission (Saikeerthana et al., 2021).

Infection reservoirs within healthcare facilities include contaminated surfaces, medical equipment, water sources, and healthcare workers' hands. Water reservoirs, including sinks, faucet aerators, and water-related devices, have been linked to outbreaks of Legionella, Pseudomonas, and nontuberculous mycobacteria, representing critical sources for pathogen transmission. Transmission occurs primarily through contact (direct and indirect), respiratory droplets, airborne routes, and common vehicles such as contaminated medical instruments or fluids. Contact transmission, especially via healthcare workers' hands, is considered the most frequent and important route in clinical settings (Kanamori et al., 2016).

Patient-specific risk factors significantly influence susceptibility to nosocomial infections. Advanced age, underlying comorbidities such as diabetes and immunosuppression, use of invasive devices like central venous catheters and urinary catheters, prolonged hospital stays, and prior antibiotic exposure increase infection risk. Invasive devices disrupt normal barriers and provide portals for microbial entry, contributing heavily to bloodstream infections and device-associated infections. Furthermore, longer hospital stays both result from and contribute to increased infection risk, leading to a vicious cycle of morbidity and resource utilization. Immunosuppressed patients and the elderly have diminished host defenses, making them particularly vulnerable to opportunistic infections caused by fungal and multidrug-resistant bacterial pathogens (Stewart et al., 2021).

Pathophysiology and Mechanisms of Infection Transmission

The pathophysiology and mechanisms of infection transmission in clinical nursing are grounded in the chain of infection model, which outlines the sequential steps required for an infection to occur: the infectious agent, reservoir, portal of exit, mode of transmission, portal of entry, and susceptible host. Each link must be intact for transmission to proceed, and clinical nursing interventions aim to break this chain at any point to prevent nosocomial infections. Healthcare workers, particularly nurses, play a pivotal role in this process, as they are often the primary interface between patients and the healthcare environment, responsible for implementing aseptic techniques, ensuring hand hygiene compliance, and monitoring environmental decontamination to prevent cross-transmission. Their adherence to infection prevention and control (IPC) protocols directly influences the integrity of the chain, with lapses in practice—such as inconsistent glove use or inadequate handwashing—significantly increasing the risk of pathogen dissemination (Alhumaid et al., 2021).

Transmission of nosocomial pathogens occurs through multiple routes, each requiring specific nursing interventions. Contact transmission, the most common mode, includes direct contact (e.g., skin-to-skin transfer) and indirect contact via contaminated fomites such as medical equipment, bed rails, or healthcare workers' hands. This route is particularly relevant for multidrug-resistant organisms like methicillin-resistant Staphylococcus aureus (MRSA) and Clostridioides difficile, which can persist on surfaces for extended periods. Droplet transmission involves large respiratory droplets (>5 µm) expelled during coughing, sneezing, or talking, which travel short distances (typically <1 meter) and deposit on mucous membranes of the eyes, nose, or mouth. Influenza and Neisseria meningitidis are classic examples, necessitating droplet precautions such as surgical masks and spatial separation. In contrast, airborne transmission involves smaller particles (<5 µm) that remain suspended in the air for prolonged periods and can be inhaled deep into the respiratory tract, requiring specialized engineering controls like negative pressure rooms and N95 respirators for pathogens such as Mycobacterium tuberculosis and measles virus. Although vector-borne transmission is less common in hospital settings, it remains a consideration in regions where arthropods like mosquitoes or ticks may introduce pathogens such as Plasmodium species (Douedi & Douedi, 2023).

A critical factor in the persistence and treatment resistance of nosocomial infections is biofilm formation, particularly on indwelling medical devices such as central venous catheters, urinary catheters, and prosthetic joints. Biofilms are structured communities of microorganisms encased in an extracellular polymeric matrix that adhere to biotic or abiotic surfaces, providing a protective barrier against both host immune defenses and antimicrobial agents. The development of biofilms occurs in stages: initial attachment of planktonic bacteria to the device surface, microcolony formation, maturation into a complex three-dimensional structure, and eventual dispersion of cells to seed new infection sites. This lifestyle confers significant survival advantages, including reduced antibiotic penetration, altered metabolic states that decrease drug efficacy, and enhanced horizontal gene transfer of resistance determinants. Common biofilm-forming pathogens include Staphylococcus epidermidis, Pseudomonas aeruginosa, and Candida albicans, all of which are frequently isolated from device-associated infections. The recalcitrant nature of biofilm infections often necessitates device removal, as systemic antibiotics alone are typically insufficient to eradicate the embedded microbial community (Mishra et al., 2024).

The emergence and spread of antibiotic resistance in nosocomial pathogens represent a major public health challenge, driven by both intrinsic and acquired mechanisms. Intrinsic resistance includes low outer membrane permeability in Gram-negative bacteria, constitutive efflux pumps, and production of antibiotic-inactivating enzymes such as extended-spectrum β-lactamases (ESBLs) and carbapenemases. Acquired resistance arises through mutational changes or, more commonly, horizontal gene transfer (HGT) via transformation, conjugation, or transduction, allowing rapid dissemination of resistance genes across bacterial species within the hospital ecosystem. Mobile genetic elements such as plasmids and transposons facilitate the spread of multidrug resistance, particularly in high-risk environments like intensive care units where antibiotic selection pressure is intense. Adaptive resistance mechanisms, including biofilm formation, further compound the problem by creating microenvironments where subinhibitory antibiotic concentrations promote the selection of resistant mutants. The convergence of these factors has led to the global rise of pan-resistant pathogens such as carbapenem-resistant Enterobacteriaceae (CRE) and vancomycin-resistant Enterococcus (VRE), which are associated with high mortality rates and limited treatment options. Addressing this crisis requires a multifaceted approach integrating antimicrobial stewardship, enhanced surveillance, and strict infection control practices to limit both the emergence and transmission of resistant organisms (Xia et al., 2016).

Role of Clinical Nursing in Infection Prevention

Clinical nursing plays a pivotal role in preventing and controlling nosocomial infections within healthcare settings, deploying a wide range of responsibilities directly influencing patient safety. At the frontline of care delivery, nurses provide continuous patient monitoring and intervention, making their engagement in infection prevention fundamental. They are uniquely positioned to implement stringent infection control practices such as hygiene protocols, use of personal protective equipment (PPE), and aseptic techniques. Moreover, nurses educate patients and families about infection risks and prevention strategies, fostering safer discharge and home care environments. Their vigilance in maintaining sterile environments and adherence to infection control policies reduces transmission risks significantly (Chen & Liu, 2024).

Nurses are charged with core responsibilities essential to infection control, including meticulous hand hygiene, environmental cleaning, instrument sterilization, and waste management. They enforce isolation precautions as needed and ensure the correct use of protective barriers. Beyond these practical tasks, nurses lead vaccination efforts, advocate for immunization compliance, and contribute to occupational health safety by reducing potential occupational exposure to infectious agents. These actions collectively lower healthcare-associated infections (HAIs), contributing directly to improved patient outcomes. Additionally, nurses' constant bedside presence allows early detection of infection symptoms, triggering timely treatment and containment measures (Alp Meşe et al., 2025).

Effective infection surveillance is critical in tracking infection incidence, understanding trends, and initiating timely interventions within healthcare facilities. Nurses play an indispensable role in collecting and documenting infection-related data, monitoring compliance with preventive measures such as hand hygiene and PPE use, and reporting findings through established infection control programs. Surveillance tools range from manual audits to automated electronic systems that enhance data accuracy and promptness. Through systematic surveillance, nurses contribute to infection prevention quality improvement plans and help curb outbreaks by promptly informing infection control teams and healthcare management (Shenoy & Branch-Elliman, 2023).

Infection prevention is inherently multidisciplinary, requiring close coordination between nurses, physicians, and infection control specialists. Physicians typically develop patient care plans, but nurses implement these plans at the bedside while monitoring patient responses and infection risks. Infection control teams provide expertise in protocols, outbreak management, and training, supporting and guiding both physicians and nurses. Effective nurse-physician collaboration has been linked to lower incidence of HAIs, especially in intensive care environments, through shared decision-making and oversight of sterile techniques such as catheter insertion and maintenance. This integrated teamwork ensures consistent adherence to infection control measures and rapid response to emerging infection threats (Gregory et al., 2023).

Leadership and accountability in infection control are critical leadership competencies for clinical nursing roles, particularly for head nurses and infection control nurse leaders. These leaders shape organizational culture, cultivate adherence to infection prevention standards, and motivate multidisciplinary teams.

Relational and transformational leadership styles emphasize shared vision, continual process improvement, and accountability, resulting in significant reductions in infection rates, including catheter-associated urinary tract infections (CAUTIs) and bloodstream infections (CLABSIs). Transparent communication and risk messaging by nursing leaders promote staff awareness, compliance, and patient safety culture. Nurses at all levels are accountable for infection prevention, and their proactive communication of risks and prevention strategies builds trust and preparedness throughout healthcare settings (Cappelli et al., 2025).

Evidence-Based Infection Control Practices

Hand hygiene remains the cornerstone of preventing nosocomial infections in clinical nursing practice. The World Health Organization's (WHO) "Five Moments for Hand Hygiene" framework strategically identifies critical points when healthcare workers should perform hand hygiene to interrupt microorganism transmission. These moments include before touching a patient, before aseptic tasks, after exposure to body fluids, after touching a patient, and after touching patient surroundings. Hand hygiene technique must involve thorough cleaning with soap and water or alcohol-based hand rubs covering all hand surfaces and ensuring appropriate duration and friction. Compliance monitoring through direct observation and electronic systems is vital to maintain adherence; studies consistently show improved infection rates with high compliance. Alcohol-based hand rubs are widely effective across most pathogens, fast-acting, and less irritant than soap and water, facilitating improved compliance among nursing staff (Cole, 2024).

Aseptic technique during invasive procedures is critical to prevent the introduction of pathogens. Procedures necessitating intentional skin puncture or exposure to sterile body sites demand rigid sterile field maintenance. Nurses must utilize sterile gloves, gowns, and draping techniques to create a sterile barrier. This includes preparing the patient's skin with approved antimicrobial agents and ensuring all supplies and instruments are sterile before contact. Strict principles include permitting only sterile items in the sterile field, checking packaging integrity, proper donning of sterile gloves without contamination, and avoidance of any breaches in the sterile area during intervention. Maintaining this sterile environment throughout invasive interventions prevents contamination and resultant infections (Rn) et al., 2021).

Effective PPE use is essential to safeguard nurses and patients from pathogen transmission, especially during outbreaks and aerosol-generating procedures. Correct selection depends on the anticipated exposure risk and includes masks or respirators, gloves, gowns, and eye protection. Proper donning follows an order: hand hygiene, gown, mask/respirator, eye protection, and gloves; doffing involves removal of gloves first, then gown, eye protection, and mask, followed by hand hygiene to prevent self-contamination. PPE shortages during outbreaks demand optimization strategies such as extended use or reprocessing, guided by infection control protocols. Ongoing training is critical as compliance remains suboptimal, leading to increased occupational and patient infection risks if protocols are not strictly followed (Valdez, 2015).

Regular and thorough environmental cleaning reduces microbial bioburden on surfaces, thereby limiting indirect pathogen transmission. Cleaning frequency must be guided by patient turnover, type of care area, and risk assessment. Disinfectant efficacy depends on appropriate selection based on target pathogens, contact time, and surface compatibility. High-touch areas require frequent disinfection, and cleaning protocols should include standardized procedures, staff training, and audit. Biomedical waste management must follow strict segregation by infectious risk categories, with sharps and contaminated waste properly disposed in puncture-resistant containers and treated before final disposal to minimize risk to staff and the environment (D. Wright et al., 2024).

Strict adherence to single-use policies is paramount to prevent cross-contamination and transmission of blood-borne infections. Nurses must adhere to aseptic techniques when preparing and administering injections and infusions, disinfect rubber septa with alcohol prior to access, and properly label IV lines and medications to avoid errors. Engineering controls such as needle safety devices and sharps disposal containers aid in preventing needle-stick injuries, which pose a significant occupational hazard. Quality improvement interventions have demonstrated significant improvements in compliance with safe injection practices after targeted education and monitoring, underscoring the importance of sustained training programs (Kottapalli et al., 2023).

Prevention of infections caused by invasive devices such as central lines, ventilators, and urinary catheters is imperative in clinical nursing care. Central line-associated bloodstream infection (CLABSI) prevention includes maximal barrier precautions during insertion, chlorhexidine skin antisepsis, and daily review of line necessity. Ventilator-associated pneumonia (VAP) bundles involve head-of-bed elevation, oral care with antiseptics, daily sedation vacations, and subglottic suctioning. Catheter-associated urinary tract infection (CAUTI) reduction depends on aseptic catheter insertion, maintenance of closed drainage systems, and prompt removal when no longer necessary. Continuous nurse education, adherence to protocols, and surveillance are vital to reducing device-associated infection rates, which remain a significant cause of morbidity in intensive care units (Gade et al., 2023).

Preventing surgical site infections (SSI) requires a multifactorial approach. Preoperative skin antisepsis using chlorhexidine or povidone-iodine reduces skin flora and contaminant burden. Antibiotic prophylaxis should be administered within 60 minutes prior to incision and discontinued within 24 hours post-surgery unless indicated otherwise. Postoperative wound care mandates sterile dressing changes, regular inspection for infection signs, and timely intervention. Nurses play a crucial role in monitoring wound conditions and educating patients on hygiene and wound care post-discharge. Adhering to evidence-based SSI prevention bundles has demonstrated reductions in postoperative infection rates, contributing significantly to improved surgical outcomes (Ritter et al., 2020).

Infection Surveillance Systems and Data Management

Infection surveillance systems and data management are critical pillars in the effort to reduce nosocomial infections and enhance patient safety within healthcare settings. Hospital infection surveillance programs are systematically designed to detect, monitor, and analyze healthcare-associated infections (HAIs), focusing especially on intensive care units (ICUs) and high-risk areas. These programs employ active, prospective surveillance methodologies involving multidisciplinary collaboration among ICU physicians, infection control (IC) link nurses, microbiology laboratories, and infection prevention and control (IPC) teams. Surveillance includes rigorous monitoring of device-associated infections, surgical site infections (SSIs), bloodstream infections, and antimicrobial resistance patterns. For example, active surveillance protocols frequently mandate inspections of patients during clinical rounds, review of laboratory data, and verification of infection classifications using standardized case definitions such as those from the CDC's National Healthcare Safety Network (NHSN) (Poirier et al., 2022).

National infection reporting standards and benchmarking play an indispensable role in harmonizing infection control efforts across institutions. Various countries have established programs such as the NHSN in the United States or the Canadian Nosocomial Infection Surveillance Program (CNISP), which collect standardized infection data from participating hospitals. These networks provide comprehensive frameworks for defining infection events, gathering denominator data, and risk adjustment to facilitate inter-facility comparison and quality improvement. Reporting standards often include legal mandates for timely notification of outbreaks and multidrug-resistant organism occurrences to public health authorities. Benchmarking against national standards enables healthcare providers to gauge their infection rates, antimicrobial usage, and adherence to preventive protocols against national norms, thus guiding targeted interventions (M.-O. Wright et al., 2017).

In recent years, digital tools and integration with electronic health records (EHRs) have revolutionized infection surveillance and control. EHR systems facilitate centralized data management by digitizing patient information and enabling automated extraction of clinical, laboratory, and pharmacy data relevant to infection monitoring. Advanced digital platforms incorporate algorithms capable of identifying potential HAIs by analyzing lab results, antibiotic usage, and patient risk profiles in real time. These tools not only improve the accuracy and timeliness of infection detection but also support targeted antimicrobial stewardship by generating actionable reports on resistance trends and antibiotic utilization patterns. Integration of surveillance technologies with EHRs promotes interdisciplinary communication, streamlines reporting requirements, and facilitates compliance with public health mandates. Emerging innovations include clinical dashboards that alert frontline clinicians about infection risks, predictive analytics, and artificial intelligence applications aimed at early outbreak detection and intervention (El Arab et al., 2025).

The impact of surveillance and data management is maximized through structured data feedback and quality improvement loops. Feedback mechanisms deliver timely, relevant information concerning infection rates, compliance with preventive measures, and antibiotic prescription patterns directly to healthcare workers and leadership teams. Effective feedback is individualized and aggregated, often visualized to enhance comprehension and foster engagement. The feedback process encourages goal-setting and the identification of positive deviations, thereby motivating clinical teams to improve adherence to infection prevention protocols. Research indicates that feedback integrated into continuous quality improvement initiatives contributes to substantial reductions in surgical site infections and other HAIs. However, the success of these interventions depends on the clinical relevance of the data, the frequency and manner of feedback delivery, and sustained leadership commitment. When feedback is used as a meaningful, actionable tool rather than a mere compliance exercise, it strengthens infection control culture and drives measurable improvements in patient safety outcomes (Ahuja et al., 2022).

Education, Training, and Competency of Nursing Staff

Education, training, and competency of nursing staff are fundamental pillars in reducing nosocomial infections through effective infection control in clinical nursing. Infection control competency encompasses the integration of knowledge, skills, and behaviors aligned with infection control standards, including basic microbiology, hand hygiene, communication, and critical thinking. Nurses equipped with these competencies can rapidly adopt new guidelines and contribute to reducing infection rates by applying the best available evidence in dynamic clinical environments. Continuous professional development (CPD) plays a crucial role, where ongoing education and training significantly enhance nurses' knowledge, attitudes, compliance, and skills in infection prevention and control (IPC), thereby directly impacting patient safety and care quality. These CPD activities respond to evolving IPC requirements and utilize diverse interactive methods such as simulations and quizzes, facilitating the translation of theoretical knowledge into practical behaviors that align with professional standards (Hyeon & Moon, 2024).

Simulation-based training stands out as a highly effective educational approach for infection control competency development among nursing staff. It bridges the gap between theoretical knowledge and clinical practice by offering realistic, hands-on scenarios in a controlled environment, fostering skill refinement and confidence. Studies, including those in neonatal intensive care units (NICUs), demonstrate that simulation interventions significantly improve adherence to IPC protocols, infection prevention behaviors, and patient safety outcomes. The immersive nature of simulation enables nurses to practice critical procedures such as isolation care and personal protective equipment use with immediate feedback during debriefing sessions, leading to measurable increases in self-confidence, satisfaction, and clinical performance (Yoshikawa et al., 2025).

Behavioral interventions to improve compliance with infection prevention guidelines are essential, as compliance rates among healthcare workers often remain suboptimal despite knowledge and protocols. The use of behavior change theories—such as the Theoretical Domains Framework (TDF) and Capability, Opportunity, Motivation, Behavior (COM-B) model—provides a structured understanding of the determinants influencing nurses' IPC behaviors. Interventions targeting beliefs about consequences, environmental context, and professional identity have shown promise in enhancing compliance with hand hygiene and antimicrobial stewardship practices. Integrating these behavior change techniques into IPC programs can yield measurable improvements in guideline adherence and thus reduce hospital-acquired infection rates (Greene & Wilson, 2022).

Role modeling and mentorship form an indispensable component of cultivating a robust infection prevention culture among nursing staff. Experienced nurses and IPC specialists serve as mentors and role models, demonstrating best practices, answering questions, and providing practical guidance to less experienced or new nurses. Mentorship programs have been shown to positively influence nurses' knowledge, attitudes, safety practices, and psychological readiness, amplifying the sustained application of infection control measures. The presence of strong mentorship encourages a learning climate where exemplary IPC behaviors are normalized and reinforced, reinforcing both individual competencies and organizational culture towards patient safety excellence (Burnett et al., 2025).

Emerging Challenges and Future Trends

Biofilm-resistant materials and antimicrobial surfaces, rapid diagnostics and point-of-care infection detection, artificial intelligence in infection prediction, climate and global mobility impact on nosocomial pathogens, and sustainable infection control are emerging challenges and future trends in clinical nursing that require urgent attention to reduce healthcare-associated infections. These interconnected domains represent a paradigm shift from reactive to proactive infection prevention, integrating advanced materials science, digital health technologies, environmental awareness, and systems thinking to create safer healthcare environments. The development and implementation of biofilm-resistant materials and antimicrobial surfaces represent a critical frontier in disrupting the primary mechanism of device-related nosocomial infections, as microbial biofilms—structured communities of microorganisms encased in a self-produced extracellular polymeric substance (EPS) matrix—confer up to 1,000-fold greater resistance to antibiotics and disinfectants compared to their planktonic counterparts, and are implicated in approximately 65% of all human microbial infections and 80% of chronic illnesses, posing a significant burden on healthcare systems with biofilm-associated infections contributing to prolonged hospital stays, increased treatment costs, and higher mortality rates. Innovative strategies to combat biofilm formation include contact-killing surfaces that utilize silver or copper ions to disrupt bacterial cell membranes, release-based coatings that slowly elute antimicrobial agents, anti-adhesive coatings made from hydrophilic polymers or superhydrophobic materials that prevent bacterial attachment, and responsive coatings that activate antimicrobial properties in response to environmental stimuli such as pH changes or light, with engineered topographies like Sharklet AF™ mimicking shark skin to interfere with Staphylococcus aureus biofilm formation, and smart titanium-based implants designed with pH-responsive layers that remain inert in healthy tissue but trigger antibacterial action in the acidic microenvironment of an infection, thereby promoting osseointegration while preventing colonization. These advanced materials are being applied to a wide range of medical devices and hospital surfaces, including catheters, implants, bed rails, and surgical instruments, with the goal of creating a continuous, passive defense against pathogen transmission that complements traditional cleaning and disinfection protocols, although challenges remain regarding the durability, biocompatibility, and cost-effectiveness of these coatings, which often require complex manufacturing processes and may lose efficacy over time in dynamic clinical environments (Norville et al., 2025).

The integration of rapid diagnostics and point-of-care testing (POCT) into clinical workflows is revolutionizing the early detection and management of nosocomial infections, enabling timely, targeted interventions that improve patient outcomes and support antimicrobial stewardship. Traditional diagnostic methods, which rely on culture-based techniques, can take days to yield results, delaying appropriate treatment and increasing the risk of inappropriate antibiotic use, whereas molecular POCT systems can deliver accurate pathogen identification and resistance profiling within hours or even minutes, allowing for immediate initiation of effective therapy and isolation of infected patients to prevent transmission. Studies have demonstrated that molecular tests for pathogens such as Escherichia coli, Klebsiella pneumoniae, and Staphylococcus aureus achieve significantly higher diagnostic accuracy compared to rapid antigen-based tests, which suffer from high false-negative rates, and lung ultrasound has shown high sensitivity and specificity (90% for both) in diagnosing bacterial pneumonia at the emergency department, outperforming chest X-ray in some settings. The deployment of POCT in high-risk areas such as intensive care units, emergency departments, and long-term care facilities allows for real-time surveillance and outbreak control, with streamlined POCT solutions enabling rapid infectious disease screening at the bedside, although current systems face challenges related to sample processing time, operator training, and integration with electronic health records (EHRs), which must be addressed to ensure widespread adoption and optimal clinical utility. By providing actionable data at the point of care, these technologies empower nurses and other healthcare providers to make evidence-based decisions, reduce diagnostic uncertainty, and implement infection control measures more effectively, ultimately decreasing the incidence of healthcare-associated infections and the emergence of multidrug-resistant organisms (De Felice et al., 2023).

Artificial intelligence (AI) is emerging as a transformative tool in infection prediction and prevention, leveraging vast datasets from EHRs, laboratory results, and environmental monitoring to identify patients at high risk of developing nosocomial infections before clinical symptoms appear. AI models, including machine learning and deep learning algorithms such as neural networks, decision trees, and random forests, have demonstrated high predictive accuracy for surgical site infections and urinary tract infections, with area-under-the-curve (AUC) scores frequently exceeding 0.80, indicating strong reliability, and when integrated with real-time surveillance systems, these models can enhance compliance with hand hygiene protocols and support antimicrobial stewardship by predicting the emergence of multidrug-resistant organisms and guiding optimal antibiotic selection, thereby reducing reliance on broad-spectrum agents and minimizing collateral damage to the patient microbiome. Explainable AI (XAI) frameworks and interpretability tools such as Shapley additive explanations (SHAP) values are increasing clinician trust by providing transparent, actionable insights into the factors driving infection risk, such as comorbidities, medication use, and procedural history, allowing for personalized preventive interventions. However, the successful implementation of AI in infection control requires overcoming significant barriers, including the need for comprehensive clinician training, high integration costs, data privacy concerns, and ensuring compatibility with existing clinical workflows, particularly in resource-constrained settings where non-real-time AI models using historical EHR data may offer a more scalable solution for infection surveillance and control. As AI systems become more sophisticated and accessible, they will play an increasingly central role in creating intelligent, adaptive infection prevention programs that can respond dynamically to changing patient and environmental conditions (Assudani et al., 2025).

The impact of climate change and global mobility on nosocomial pathogens is an under-recognized but growing threat to infection control, as rising temperatures, altered precipitation patterns, and increased human and animal movement are expanding the geographic range and transmission potential of infectious agents. Climate change is driving the spread of vector-borne diseases such as dengue, malaria, and Lyme disease by altering the habitats of mosquitoes, ticks, and other arthropods, with higher minimum temperatures and increased humidity creating more favorable conditions for pathogen replication and transmission, and studies have shown significant associations between local temperature and the prevalence of antibiotic-resistant E. coli, Klebsiella pneumoniae, and Staphylococcus aureus infections, suggesting that climate-driven environmental changes are contributing to the rising burden of antimicrobial resistance. Global mobility, including international travel and migration, facilitates the rapid dissemination of novel and resistant pathogens across borders, as demonstrated by the global spread of SARS-CoV-2 and other emerging infectious diseases, which can overwhelm healthcare systems and lead to nosocomial outbreaks in vulnerable populations. These factors are creating a more complex and dynamic infectious disease landscape that requires infection control programs to adopt a broader, more anticipatory approach, incorporating climate and mobility data into risk assessments and outbreak preparedness plans, and strengthening surveillance systems to detect and respond to emerging threats in a timely manner.

Sustainable infection control practices are gaining prominence as healthcare systems recognize the need to balance patient safety with environmental stewardship, addressing the significant ecological footprint of traditional infection prevention measures. The overuse of single-use personal protective equipment (PPE), disinfectants, and sterilization chemicals contributes to pollution, resource depletion, and climate change, creating a paradox where efforts to prevent infection may inadvertently harm planetary health, which in turn affects human health. Sustainable strategies include the adoption of reusable PPE and medical devices where safe and effective, the use of environmentally friendly disinfectants with lower toxicity and biodegradability, and the implementation of waste reduction programs in high-consumption areas such as operating theatres, which are major contributors to a healthcare facility's carbon footprint. Infection prevention and control (IPC) programs can guide the design of healthcare facilities and workflows to minimize environmental impact without compromising patient safety, for example, by promoting sustainable glove use through education and monitoring, and by engaging in multidisciplinary collaborations with public health, environmental, and policy organizations to develop IPC policies that prioritize both patient and planetary health. This holistic approach recognizes that infection control is not an isolated clinical function but an integral component of a resilient, sustainable healthcare system that must adapt to the interconnected challenges of antimicrobial resistance, climate change, and global health security (Tsakonas et al., 2024).

Conclusion

Infection control in clinical nursing remains essential for safeguarding patient safety and reducing the burden of nosocomial infections. Nurses serve as frontline agents in implementing and advocating for comprehensive infection prevention measures including meticulous hand hygiene, appropriate PPE use, aseptic techniques, environmental sanitation, and device-related infection bundles. Continuous professional education, behavioral interventions, and mentorship play vital roles in sustaining high compliance and fostering a culture of safety. Advances in surveillance systems, digital integration, and emerging technologies such as rapid diagnostics and artificial intelligence enhance early detection and targeted interventions. Addressing challenges such as antimicrobial resistance, resource constraints, and environmental sustainability requires ongoing leadership, teamwork, and policy support. Ultimately, strengthening nursing roles through education, accountability, and innovation is critical for achieving sustained reductions in healthcare-associated infections and improving clinical outcomes.

References

1. Ahuja, S., Peiffer-Smadja, N., Peven, K., White, M., Leather, A. J. M., Singh, S., Mendelson, M., Holmes, A., Birgand, G., & Sevdalis, N. (2022). Use of Feedback Data to Reduce Surgical Site Infections and Optimize Antibiotic Use in Surgery. Annals of Surgery, 275(2), e345–e352. https://doi.org/10.1097/SLA.0000000000004909
2. Alhumaid, S., Al Mutair, A., Al Alawi, Z., Alsuliman, M., Ahmed, G. Y., Rabaan, A. A., Al-Tawfiq, J. A., & Al-Omari, A. (2021). Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: A systematic review. Antimicrobial Resistance and Infection Control, 10, 86. https://doi.org/10.1186/s13756-021-00957-0
3. Alp Meşe, E., Carrara, E., Tartari, E., Mutters, N. T., Tsioutis, C., Birgand, G., & Tacconelli, E. (2025). Prioritizing isolation precautions: A patient-centered approach to infection prevention and control. Antimicrobial Stewardship & Healthcare Epidemiology : ASHE, 5(1), e123. https://doi.org/10.1017/ash.2025.173
4. Assudani, P. J., Bhurgy, A. S., Kollem, S., Bhurgy, B. S., Ahmad, Md. O., Kulkarni, M. B., & Bhaiyya, M. (2025). Artificial intelligence and machine learning in infectious disease diagnostics: A comprehensive review of applications, challenges, and future directions. Microchemical Journal, 218, 115802. https://doi.org/10.1016/j.microc.2025.115802
5. Burnett, E., Palatty, J., Joesph, S., George, R., Mukona, D., Abdulla, S., & Khalaf, A. (2025). Infection prevention and control blind spots in education and practice: Qualitative insights from healthcare professionals and healthcare students. Journal of Infection Prevention, 17571774251366943. https://doi.org/10.1177/17571774251366943
6. Cappelli, E., Zaghini, F., Fiorini, J., & Sili, A. (2025). Healthcare-associated infections and nursing leadership: A systematic review. Journal of Infection Prevention, 26(2), 78–90. https://doi.org/10.1177/17571774241287467

7. Chen, C., & Liu, J. (2024). Enhancing Nosocomial Infection Control through the Implementation of High-Quality Nursing Practices. Alternative Therapies in Health and Medicine, 30(8), 300–305.
8. Cole, M. (2024). The “5 Moments for Hand Hygiene”: Casting a critical eye on the implications for practice. British Journal of Nursing (Mark Allen Publishing), 33(22), 1062–1068. https://doi.org/10.12968/bjon.2024.0106
9. De Felice, M., De Falco, M., Serra, A., Frisulli, V., Antonacci, A., Isticato, R., de Stefano, L., & Scognamiglio, V. (2023). Fighting nosocomial antibiotic-resistant infections through rapid and sensitive isothermal amplification-powered point-of-care (POC) diagnostics. TrAC Trends in Analytical Chemistry, 165, 117135. https://doi.org/10.1016/j.trac.2023.117135
10. Douedi, S., & Douedi, H. (2023). Precautions, Bloodborne, Contact, and Droplet. In StatPearls [Internet]. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK551555/
11. El Arab, R. A., Almoosa, Z., Alkhunaizi, M., Abuadas, F. H., & Somerville, J. (2025). Artificial intelligence in hospital infection prevention: An integrative review. Frontiers in Public Health, 13. https://doi.org/10.3389/fpubh.2025.1547450
12. Gade, N., Burri, R., Sujiv, A., Mishra, M., Pradeep, B. E., Debaje, H., Sable, T., & Kaur, A. (2023). Promoting Patient Safety: Exploring Device-Associated Healthcare Infections and Antimicrobial Susceptibility Pattern in a Multidisciplinary Intensive Care Units. Cureus. https://doi.org/10.7759/cureus.50232
13. Greene, C., & Wilson, J. (2022). The use of behaviour change theory for infection prevention and control practices in healthcare settings: A scoping review. Journal of Infection Prevention, 23(3), 108–117. https://doi.org/10.1177/17571774211066779
14. Gregory, M. E., MacEwan, S. R., Sova, L. N., Gaughan, A. A., & McAlearney, A. S. (2023). A Qualitative Examination of Interprofessional Teamwork for Infection Prevention: Development of a Model and Solutions. Medical Care Research and Review : MCRR, 80(1), 30–42. https://doi.org/10.1177/10775587221103973
15. Hill, B., Lamichhane, G., & Wamburu, A. (2024). Infection prevention and control: Critical strategies for nursing practice. British Journal of Nursing (Mark Allen Publishing), 33(17), 804–811. https://doi.org/10.12968/bjon.2024.0286
16. Hyeon, Y. H., & Moon, K. J. (2024). Development of an infection control competency scale for clinical nurses: An instrument design study. BMC Nursing, 23, 250. https://doi.org/10.1186/s12912-024-01904-1
17. Kanamori, H., Weber, D. J., & Rutala, W. A. (2016). Healthcare Outbreaks Associated With a Water Reservoir and Infection Prevention Strategies. Clinical Infectious Diseases, 62(11), 1423–1435. https://doi.org/10.1093/cid/ciw122
18. Khan, H. A., Baig, F. K., & Mehboob, R. (2017). Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine, 7(5), 478–482. https://doi.org/10.1016/j.apjtb.2017.01.019
19. Kottapalli, P., Podduturi, N. C. R., Aswini, G., Jyothi, S., & Naveen, A. (2023). Safe injection, infusion and medication-vial practices at a tertiary care centre: A quality improvement initiative. GMS Hygiene and Infection Control, 18, Doc03. https://doi.org/10.3205/dgkh000429
20. Mishra, A., Aggarwal, A., & Khan, F. (2024). Medical Device-Associated Infections Caused by Biofilm-Forming Microbial Pathogens and Controlling Strategies. Antibiotics, 13(7), 623. https://doi.org/10.3390/antibiotics13070623
21. Norville, P., Dangleben, S., & Hardy, S. (2025). Biofilms and antimicrobial resistance in healthcare: Evaluating chlorine dioxide as a candidate to protect patient safety. Journal of Hospital Infection, 162, 121–126. https://doi.org/10.1016/j.jhin.2025.04.034
22. Poirier, E., Boulanger, V., MacLaurin, A., & Quach, C. (2022). National healthcare-associated infections surveillance programs: A scoping review. Canada Communicable Disease Report, 48(7–8), 340–349. https://doi.org/10.14745/ccdr.v48i78a05
23. Raoofi, S., Pashazadeh Kan, F., Rafiei, S., Hosseinipalangi, Z., Noorani Mejareh, Z., Khani, S., Abdollahi, B., Seyghalani Talab, F., Sanaei, M., Zarabi, F., Dolati, Y., Ahmadi, N., Raoofi, N., Sarhadi,

Y., Masoumi, M., sadat Hosseini, B., Vali, N., Gholamali, N., Asadi, S., … Ghashghaee, A. (2023). Global prevalence of nosocomial infection: A systematic review and meta-analysis. PLOS ONE, 18(1), e0274248. https://doi.org/10.1371/journal.pone.0274248

24. Ritter, B., Herlyn, P. K. E., Mittlmeier, T., & Herlyn, A. (2020). Preoperative skin antisepsis using chlorhexidine may reduce surgical wound infections in lower limb trauma surgery when compared to povidone-iodine—A prospective randomized trial. American Journal of Infection Control, 48(2), 167–172. https://doi.org/10.1016/j.ajic.2019.08.008
25. Rn), O. R. for N. (Open, Ernstmeyer, K., & Christman, E. (2021). Chapter 4 Aseptic Technique. In Nursing Skills [Internet]. Chippewa Valley Technical College. https://www.ncbi.nlm.nih.gov/books/NBK593203/
26. Saikeerthana, D., Prabha, P., Vijayashree, V., & Krishna, G. N. M. (2021). Overview of Pathogens causing Nosocomial Infections in Various Wards of a Tertiary Health Care Hospital and their Antimicrobial Susceptibility Pattern—A Prospective Surveillance Study. Journal of Pure and Applied Microbiology, 15(4), 1940–1946. https://doi.org/10.22207/JPAM.15.4.15
27. Shenoy, E. S., & Branch-Elliman, W. (2023). Automating surveillance for healthcare-associated infections: Rationale and current realities (Part I/III). Antimicrobial Stewardship & Healthcare Epidemiology : ASHE, 3(1), e25. https://doi.org/10.1017/ash.2022.312
28. Stewart, S., Robertson, C., Pan, J., Kennedy, S., Haahr, L., Manoukian, S., Mason, H., Kavanagh, K., Graves, N., Dancer, S. J., Cook, B., & Reilly, J. (2021). Impact of healthcare-associated infection on length of stay. Journal of Hospital Infection, 114, 23–31. https://doi.org/10.1016/j.jhin.2021.02.026
29. Taye, Z. W., Abebil, Y. A., Akalu, T. Y., Tessema, G. M., & Taye, E. B. (2023). Incidence and determinants of nosocomial infection among hospital admitted adult chronic disease patients in University of Gondar Comprehensive Specialized Hospital, North–West Ethiopia, 2016–2020. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1087407
30. Tobin, E. H., & Zahra, F. (2025). Nosocomial Infections. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK559312/
31. Tsakonas, K., Badyal, S., Takaro, T., & Buse, C. G. (2024). Rapid review of the impacts of climate change on the health system workforce and implications for action. The Journal of Climate Change and Health, 19, 100337. https://doi.org/10.1016/j.joclim.2024.100337
32. Valdez, A. M. (2015). Are You Covered? Safe Practices for the use of Personal Protective Equipment. Journal of Emergency Nursing, 41(2), 154–157. https://doi.org/10.1016/j.jen.2014.11.011
33. Wright, D., Christie, J., Lawrence, J., Vaughn, K. L., & Walsh, T. F. (2024). Effectiveness of dry hydrogen peroxide in reducing air and surface bioburden in a multicenter clinical setting. Infection Control & Hospital Epidemiology, 45(4), 501–508. https://doi.org/10.1017/ice.2023.153
34. Wright, M.-O., Allen-Bridson, K., & Hebden, J. N. (2017). Assessment of the accuracy and consistency in the application of standardized surveillance definitions: A summary of the American Journal of Infection Control and National Healthcare Safety Network case studies, 2010–2016. American Journal of Infection Control, 45(6), 607–611. https://doi.org/10.1016/j.ajic.2017.03.035
35. Xia, J., Gao, J., & Tang, W. (2016). Nosocomial infection and its molecular mechanisms of antibiotic resistance. Bioscience Trends, 10(1), 14–21. https://doi.org/10.5582/bst.2016.01020
36. Yoshikawa, A., Ohtsuka, H., Aoki, K., Tashiro, N., Togo, S., Komaba, K., Nogawa, S., Osawa, M., & Enokida, M. (2025). Simulation-based infection prevention and control training for medical and healthcare students: A systematic review. Frontiers in Medicine, 12, 1529557. https://doi.org/10.3389/fmed.2025.1529557