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Preventive Practices And The Contribution Of Nursing And Radiology Staff To Infection Prevention In Hospitals

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Abstract

Hospital-acquired infections (HAIs) pose a significant global public health challenge, affecting millions of patients annually and resulting in substantial clinical, economic, and societal burdens. Nursing and radiology staff play pivotal yet underappreciated roles in infection prevention within hospitals. This review synthesizes the epidemiology of HAIs, the core components of infection prevention programs, and the critical contributions of nursing and radiology personnel in reducing infection transmission. Key pathogens such as MRSA, VRE, C. difficile, and P. aeruginosa are highlighted, along with major risk factors across intensive care, surgical, and diagnostic imaging settings. Foundational principles of infection prevention are discussed, including the chain of infection, standard and transmission-based precautions, and the integration of administrative, environmental, and personal protective controls. Nurses are central to implementing bedside and procedural asepsis, conducting surveillance and reporting, providing patient education, and leading quality improvement initiatives. Radiology staff face unique challenges related to equipment decontamination, aseptic techniques during interventional procedures, and compliance with infection control protocols. Emerging issues such as antimicrobial resistance, technological innovations in automated disinfection and digital surveillance, and the application of artificial intelligence in predicting infection trends are explored. Future research should rigorously evaluate infection dynamics within radiology departments, behavioral determinants of staff compliance, and the impact of interdepartmental interventions. Sustainable infection prevention models require strong leadership commitment and effective policy frameworks. Ultimately, this review aims to promote the development of evidence-based,

multidisciplinary infection prevention strategies that engage nursing and radiology staff to reduce the risk and consequences of HAIs worldwide.

Keywords Hospital-acquired infections (HAIs); infection prevention and control (IPC); nursing; radiology; aseptic technique; disinfection; healthcare-associated infections; antimicrobial resistance; patient safety; multidisciplinary collaboration; environmental hygiene; radiology workflow; healthcare leadership; antimicrobial stewardship; hospital infection control.

1. Introduction

Hospital-acquired infections (HAIs) remain a major public health challenge worldwide, imposing huge clinical, economic, and societal burdens on health systems and populations. This section reviews the global scope of the HAI crisis, its wide-ranging impact, the structure of infection prevention programs, and the underappreciated yet essential roles of nursing and radiology staff, concluding with the aims of the current review (Tobin & Zahra, 2025).

1.1 Global Burden of Hospital-Acquired Infections

HAIs are among the most frequent and preventable adverse events in healthcare, affecting around 1 in 10 hospitalized patients globally. Recent data estimate over 3.5 million HAI cases annually in the European Union/European Economic Area, with more than 90,000 related deaths each year. In the United States, there were an estimated 687,200 HAI episodes in 2015, and developing countries face even higher prevalence rates, with pooled analyses showing an average prevalence as high as 15.5% in some regions. The burden of HAIs is disproportionately greater in resource-limited settings, driven by shortages in infection control resources, staff training, and monitoring systems (Abban et al., 2023).

1.2 Economic, Clinical, and Public Health Implications

HAIs extend hospital stays, increase healthcare costs, and contribute to significant morbidity and mortality. In the United States alone, the annual direct costs of treating HAIs are estimated to range from $28.4 billion to $45 billion. When including indirect costs such as lost productivity and increased mortality, societal losses can exceed $200 billion each year. HAIs cause prolonged patient suffering, additional diagnostic and treatment requirements, and create major barriers to effective healthcare delivery. Critically, infections with multidrug-resistant organisms are increasingly part of the HAI burden, exacerbating individual and system risks (Scott et al., 2019).

The public health severity of HAIs is further magnified by the risk of transmission to healthcare workers and the surrounding community, as witnessed during pandemic events and routine care. Such infections not only undermine trust in healthcare systems but also pose sustainability and health equity challenges across global health (Miraj, 2024).

1.3 Infection Prevention as a Multidimensional System

Modern infection prevention programs utilize comprehensive, system-wide interventions including surveillance, environmental cleaning, hand hygiene, use of personal protective equipment (PPE), antimicrobial stewardship, and ongoing staff education. These programs are multidimensional, requiring collaboration across departments, organizational leadership, and adherence to evidence-based standards. Standard precautions and transmission-based precautions are universally enforced, with continuous development of new strategies in response to emerging threats such as antimicrobial resistance and pandemic outbreaks (Leblebicioglu et al., 2013).

Multidisciplinary teams routinely perform infection control rounds, monitor compliance, and provide feedback, resulting in marked reductions in key infection rates such as central line-associated bloodstream infections (CLABSI) and surgical site infections (SSI). These efforts are critical in achieving and maintaining low infection rates in both high-risk and general hospital environments (Jeong et al., 2020).

1.4 Under-Recognized Contribution of Nursing and Radiology Departments

Despite extensive literature focused on infection control in intensive care and surgical settings, contributions from nursing and radiology departments often receive less recognition but are equally vital. Nurses are at the center of direct patient care, managing invasive devices, administering medications, and ensuring the implementation of standard precautions. Their vigilance, skill, and adherence to infection prevention protocols profoundly impact patient safety and HAI outcomes (Abuzaid et al., 2022).

Radiology staff, meanwhile, are increasingly exposed to infectious risks due to expanded roles in diagnostic imaging, especially during large-scale outbreaks such as COVID-19. Radiographers handle patients who may be colonized with multidrug-resistant organisms or highly contagious pathogens. Infection prevention in the radiology department involves critical IPC practices, such as stringent equipment and surface disinfection, PPE use, safe patient transport protocols, staff training, and risk management procedures to prevent cross-infection. Institutional support, targeted education, and robust IPC guidelines are required to maximize the efficacy of these multidisciplinary efforts (Jimenez & Lewis, 2023).

1.5 Aim and Scope of the Review

The aim of this review is to thoroughly examine the burden and impact of hospital-acquired infections and to synthesize the multidisciplinary infection prevention strategies in modern hospitals. Special emphasis is placed on the central, but frequently undervalued, roles of nursing and radiology staff in infection control. The scope includes the epidemiology of HAIs, clinical and economic consequences, core components of infection prevention programs, and practical strategies for integrating nursing and radiology perspectives into hospital-wide IPC initiatives.

This review aspires to promote the development and implementation of sustainable infection prevention systems across diverse hospital settings, stimulate greater interdisciplinary engagement, and highlight actionable approaches to reduce the risk and consequences of HAIs worldwide.

2. Epidemiology of Healthcare-Associated Infections

2.1 Prevalence and Incidence in Hospital Settings

HAIs occur in all types of healthcare facilities, but the incidence varies due to differences in patient populations, procedures, and infection control measures. A multicenter European study estimated approximately 8.9 million healthcare-associated infections annually across the EU/EEA, with 4.5 million episodes in acute care hospitals (ACH) and 4.4 million in long-term care facilities (LTCF). In the United States, CDC estimated 687,000 HAIs occurred in acute care hospitals in 2015, resulting in about 72,000 deaths during hospitalization. Prevalence surveys report infection rates typically ranging from 1.3% to 9%, with higher rates found in settings with less robust infection control, such as some overseas institutions where prevalence may reach up to 40.7% (Haque et al., 2018).

2.2 Common Pathogens: MRSA, VRE, Clostridioides difficile, Pseudomonas aeruginosa

The most frequently implicated organisms in HAIs include multidrug-resistant pathogens such as Methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant Enterococci (VRE), Clostridioides difficile (CDI), and Pseudomonas aeruginosa. MRSA accounts for more than half of S. aureus strains isolated from hospital patients in the USA and causes approximately 50% of all nosocomial S. aureus infections. VRE poses significant treatment challenges due to resistance patterns. C. difficile commonly causes hospital-onset diarrheal illness due to antibiotic disturbance of gut flora. P. aeruginosa is a major agent in device-related and ventilator-associated infections, especially in intensive care and surgical settings. These pathogens are frequently associated with invasive infections such as pneumonia, bloodstream infections, surgical site infections, and urinary tract infections (Szabó et al., 2022).

2.3 Transmission Routes: Contact, Droplet, Airborne, Device-Related

Hospital pathogens may be transmitted via several key routes: direct and indirect contact, droplet, airborne, and those associated with medical devices.

- **Contact transmission** often involves contaminated hands of healthcare personnel or inanimate objects such as instruments, dressings, and surfaces.
- **Droplet transmission** is associated with respiratory activities such as coughing, sneezing, or talking, as well as specific procedures like suctioning and bronchoscopy, where droplets reach mucosal surfaces within approximately one meter.
- **Airborne transmission** occurs via aerosolized droplet nuclei or dust containing pathogens, suspended and transmitted over longer distances, with diseases such as tuberculosis, measles, and varicella as typical examples.
- **Device-related transmission** is particularly relevant for central lines, urinary catheters, and ventilators, which provide a direct route for pathogens to enter sterile sites. These devices are a leading risk factor for HAIs such as central line-associated bloodstream infections (CLABSI) and catheter-associated urinary tract infections (CAUTI) (Ferreira et al., 2017).

2.4 Risk Factors in Different Units: ICU, Surgical, Diagnostic Imaging

Specific hospital areas have distinct risk profiles:

- **Intensive Care Units (ICU):** Patients are highly susceptible due to critical illness, frequent use of invasive devices, and broad-spectrum antibiotics. Central lines, mechanical ventilation, and high patient acuity increase infection risk (Ferreira et al., 2017).
- **Surgical Units:** Risk factors include breaches in skin integrity, implant placement, and prolonged hospital stays. Surgical site infections (SSI) are common, especially following major or emergent procedures (Ferreira et al., 2017).
- **Diagnostic Imaging and Radiology:** Radiology departments face rising risk due to increased patient throughput, transit of infected and non-infected patients, and the use of complex equipment that is difficult to clean. Radiology equipment (e.g., CT/X-ray machines) and shared workstations can harbor pathogens, and invasive/interventional radiology presents further risks due to direct patient contact with devices and personnel (Alamer et al., 2022).

2.5 WHO and CDC Global Surveillance Data Trends

Global surveillance efforts led by WHO and CDC have advanced the understanding and reduction of HAIs. CDC's National Healthcare Safety Network (NHSN) provides comprehensive data on HAIs, antimicrobial resistance, and infection prevention adherence across U.S. healthcare facilities. WHO's Global Report on Infection Prevention and Control highlights the ongoing burden of HAIs, demonstrating progress in some areas but continued high infection rates worldwide, especially in resource-limited settings. The European Centre for Disease Prevention and Control (ECDC) points to respiratory tract, surgical site, and urinary tract infections as the most commonly reported HAIs across acute care hospitals in Europe.

3. Principles of Infection Prevention in Hospitals

Infection prevention in hospital settings is a critical component of patient safety and quality healthcare. Preventing healthcare-associated infections (HAIs) requires a comprehensive understanding of the mechanisms of infection transmission, adoption of standardized precaution protocols, multi-layered defense strategies, and integration of institutional governance such as infection control committees.

3.1 Chain of Infection and Targets for Interruption

The chain of infection describes the sequence of events required for an infection to spread, comprising six critical links: infectious agent, reservoir, portal of exit, mode of transmission, portal of entry, and susceptible host. Interruption of this chain at any point effectively prevents the spread of pathogens. Hand hygiene is the cornerstone intervention interrupting transmission by eliminating pathogens on healthcare personnel's hands before and after patient contact. Other interruption strategies include proper use of personal protective equipment (PPE), environmental cleaning, sterilization of medical devices, respiratory hygiene, and vaccination of healthcare workers and patients to reduce susceptibility and reservoirs of infectious agents (Soni et al., 2025).

3.2 Standard Precautions and Additional Precautions

Standard precautions form the baseline infection prevention practices applied universally to all patient care to minimize the risk of transmission of bloodborne and other pathogens. These include hand hygiene, use of gloves, gowns, masks, and eye protection when exposure to blood or bodily fluids is anticipated, safe injection practices, and environmental cleaning (Soni et al., 2025).

Additional transmission-based precautions are implemented for patients known or suspected to be infected or colonized with infectious agents requiring further containment:

- **Contact Precautions:** Used for infections spread by direct or indirect contact with the patient or their environment, such as multidrug-resistant organisms (MDROs). Healthcare workers should wear gloves and gowns and practice rigorous hand hygiene. Patients ideally are placed in single rooms or cohorted with similarly infected patients (Douedi & Douedi, 2023).
- **Droplet Precautions:** Applied for pathogens transmitted by large respiratory droplets generated during coughing, sneezing, or talking (e.g., influenza, pertussis). Healthcare workers wear surgical masks when within 3 to 6 feet of the patient. Spatial separation and patient masking during transport are recommended (Douedi & Douedi, 2023).
- **Airborne Precautions:** Required for infections spread by airborne droplet nuclei smaller than 5 micrometers that remain suspended in air (e.g., tuberculosis, measles). These include placing patients in negative pressure airborne infection isolation rooms (AIIRs), and healthcare workers wear fit-tested N95 or higher-level respirators (Douedi & Douedi, 2023).

3.3 Layers of Defense in Infection Prevention

Effective infection control is based on multiple layers of defense designed to work synergistically:

- **Administrative Controls:** Hospital policies, training programs, immunization programs, surveillance systems for HAIs, and resource allocation to infection prevention form the administrative backbone. Leadership engagement and fostering a safety culture are essential to enforcement and compliance.
- **Environmental Controls:** Robust cleaning and disinfection of patient care environments and medical equipment minimize reservoirs of pathogens. Innovations such as ultraviolet light (UV-C) and hydrogen peroxide vapor automated disinfection technologies have enhanced environmental hygiene in hospitals.
- **Personal Controls:** Personal protective equipment, hand hygiene adherence, respiratory hygiene, safe injection practices, and appropriate patient placement are frontline defenses for healthcare workers and patients alike.

3.4 Integration with Hospital Infection Control Committees

Hospital Infection Control Committees (ICC) provide governance, oversight, and coordination for infection prevention programs. Typically composed of multidisciplinary members including hospital administrators,

infection control nurses, microbiologists, infectious disease physicians, and representatives from key clinical specialties, the ICC develops infection control policies, educates staff, monitors infection incidence, and ensures compliance with regulatory standards. The committee's visibility and direct ties to hospital leadership enhance program effectiveness and foster accountability (Pegues, 2018).

ICC responsibilities include conducting risk assessments, managing outbreaks, reviewing and updating protocols, facilitating training and vaccination of staff, and ensuring the availability of necessary supplies such as PPE. Regular meetings and integration with hospital quality improvement initiatives are important to institutionalize infection prevention as a core healthcare priority (Pegues, 2018).

4. The Role of Nursing in Infection Prevention

4.1 Bedside and Procedural Asepsis

Nurses implement bedside and procedural asepsis through strict adherence to hand hygiene protocols, evidence-based aseptic techniques during wound care, catheter management, and intravenous line insertion. Hand hygiene remains a cornerstone, but compliance is often challenged by a lack of resources, skin irritation, workload, and competing clinical priorities. Maintaining a sterile field is critical for invasive procedures, with differentiation between sterile techniques (used for central line dressing changes and catheter insertion) and clean techniques (applied during peripheral IV or non-invasive wound care) guided by institutional protocols. Clinical waste handling, decontamination, and prompt disposal further reduce environmental contamination and cross-infection risk, supported by collaboration with environmental services teams (Afework & Tamene, 2025).

4.2 Surveillance and Reporting

Nurses are key to early infection detection by closely observing vital signs, wound appearance, catheter sites, and symptoms suggestive of healthcare-associated infections (HAIs). Surveillance responsibilities include accurate documentation within electronic medical records, monitoring infection risks, and reporting findings to infection control teams for rapid intervention. Nurses' active participation in incident reporting, outbreak management, and data-driven decision-making enables hospitals to track trends and respond to emerging threats, ensuring prompt isolation of affected patients and containment of infection spread (Copanitsanou & Santy-Tomlinson, 2021).

4.3 Patient and Family Education

Nursing staff serve as primary educators for patients and families, focusing on infection prevention strategies during admission, hospitalization, and discharge. Health literacy interventions include counseling on hand hygiene, respiratory etiquette, wound care, and the importance of following isolation precautions. Instruction about infection symptoms, when to seek medical attention, and post-discharge wound or catheter care empowers patients and reduces readmission rates. Nurses also advocate for vaccination by promoting awareness and providing information about schedule, efficacy, and safety (Collins, 2008).

4.4 Nurse-Led Infection Prevention Programs

Structured nurse-led initiatives have demonstrated significant reductions in CAUTI (catheter-associated urinary tract infections), CLABSI (central line-associated bloodstream infections), and SSI (surgical site infections) through protocol-driven interventions, continuous education, and cross-disciplinary collaboration. For example, dedicated CLABSI prevention nurses conducting daily bundle compliance audits, immediate feedback, and real-time education have resulted in marked decreases in infection rates and improved patient outcomes. Nurse-led quality improvement projects such as "Stop the Line," where nurses are empowered to halt procedures violating aseptic protocol, also enhance safety culture and accountability. Evidence supports that sustained nurse engagement, leadership in infection reporting, and ongoing professional development directly translate to lower HAI incidence (Star et al., 2024).

6. The Role of Radiology Staff in Infection Prevention in Hospitals

6.1 Radiology Workflow-Related Risks

Radiology staff face significant infection risks during imaging procedures, particularly in diagnostic imaging like portable radiography and ultrasound. These risks arise largely from the close and frequent contact between staff, patients, and imaging equipment, creating potential cross-contamination pathways. Portable radiography, ultrasound probes, and other shared devices serve as vectors for microbial transmission if not properly disinfected. High-touch surfaces in the radiology environment, including control panels, imaging tables, machine bores (MRI), and patient positioning aids, are frequent reservoirs for pathogens that can persist and spread infections. Special consideration is required during outbreaks of highly contagious diseases such as COVID-19, where radiology staff occupational risk parallels that of intensive care units. Workflow factors such as patient transport routes, waiting areas, and open access to diagnostic suites reinforce the necessity for establishing clearly demarcated "clean" and "contaminated" zones and dedicated transfer protocols to minimize infection transmission (Jimenez & Lewis, 2023).

6.2 Equipment Decontamination and Environmental Hygiene

The disinfection of imaging modalities and radiology environment plays an essential role in infection prevention. MRI machines, CT scanners, ultrasound probes, and x-ray equipment require routine and rigorous cleaning protocols aligned with manufacturers' guidelines and infection control standards. For example, ultrasound probes require distinct approaches depending on their use: probes applied to intact skin are subjected to low-level disinfection, while those contacting mucous membranes or used in invasive procedures necessitate high-level disinfection or sterilization and use of protective covers. Surface disinfection using appropriate agents such as chlorine-based disinfectants or hydrogen peroxide solutions, combined with ultraviolet (UV) light environmental disinfection, is recommended to control pathogens in the radiology suite. Radiographers are pivotal in executing environmental hygiene protocols, ensuring all equipment and high-touch surfaces receive appropriate and timely cleaning. Their role extends to monitoring adherence to disinfection schedules and facilitating training for cleaning personnel and staff involved in infection prevention procedures (Sureka et al., 2021).

6.3 Aseptic and Sterile Technique in Interventional Radiology

In interventional radiology (IR), the infection risk escalates due to the invasive nature of image-guided procedures such as biopsies, drainages, angiography, and catheter placements. Maintaining an aseptic zone within the procedural area is critical to minimize surgical site infections (SSIs). Sterile draping of the patient and equipment, along with appropriate use of personal protective equipment (PPE) including sterile gloves, gowns, masks, and eye protection, constitute the cornerstone of infection control in IR. Strict adherence to sterile technique protocols, proper hand hygiene, and regular staff training are mandatory. The use of dedicated sterile instruments and barriers, coupled with environmental controls, helps reduce the incidence of catheter-related bloodstream infections and procedure-associated sepsis. Radiology staff must be proficient in aseptic principles and continually update their knowledge and skills to uphold the highest safety standards during these minimally invasive yet infection-prone interventions (Mukund et al., 2019).

6.4 Radiology Staff Training and Compliance

Effective infection prevention in radiology departments depends heavily on targeted education and consistent compliance with hygiene protocols. Specialized training tailored to radiology staff roles enhances awareness of infection risks specific to imaging technologies and workflows. Monitoring adherence through audits, observational studies, and feedback mechanisms is essential to identify gaps and reinforce best practices. The involvement of radiology supervisors and designated infection control liaisons

fosters accountability and continuous improvement in infection prevention measures. Regular refresher courses, competency assessments, and the integration of new evidence-based guidelines into departmental policies strengthen the capacity of radiology teams to prevent healthcare-associated infections effectively. Investments in staff education and leadership in infection control have demonstrated improved compliance rates and safer patient care environments (Lau et al., 2025).

7. Hospital Environmental Infection Control Measures

Preventive practices for hospital environmental infection control play a critical role in reducing healthcare-associated infections (HAIs), especially through meticulous cleaning and disinfection, maintaining optimal HVAC and ventilation standards, effective waste management, and controlling waterborne pathogens like Legionella. Both nursing and radiology staff contribute significantly to these measures to maintain a safe hospital environment.

7.1 Cleaning and Disinfection Protocols

Hospitals implement rigorous cleaning and disinfection protocols targeting all environmental surfaces with particular attention to high-touch areas such as bedrails, tabletops, and medical equipment surfaces. Cleaning should precede disinfection and may utilize detergents and EPA-registered disinfectants effective against prevalent pathogens including MRSA, VRE, and C. difficile. Effective cleaning protocols require prior visual assessment, cleaning from cleaner to dirtier areas to avoid cross-contamination, and changing cleaning materials frequently to prevent recontamination. Training and collaboration between nursing staff and environmental services are essential to ensure adherence and effectiveness. Radiology suites, which contain sensitive imaging equipment, require tailored protocols that avoid damage while ensuring surface disinfection to prevent pathogen transmission (Rutala & Weber, 2016).

7.2 HVAC and Ventilation Standards

Ventilation systems in critical hospital areas such as operating rooms, radiology suites, and intensive care units must meet stringent standards to minimize airborne infection risks. Operating rooms typically require a minimum of 15–20 total air changes per hour with positive pressure airflow, using HEPA or MERV 14 filtration to create sterile environments around patients and staff. Radiology areas, including MRI and CT suites, have distinct ventilation requirements often mandating 6–12 air changes per hour with controlled airflow direction and humidity levels maintained between 30–60%. High-efficiency HVAC design helps control aerosolized pathogens by ensuring appropriate filtration, humidity control, and air exchange rates, supporting infection control in both routine imaging and invasive radiologic procedures (Humphreys, 2021).

7.3 Waste Management Strategies

Effective hospital waste management segregates infectious waste from general waste and ensures its safe handling, transport, treatment, and disposal to prevent disease transmission. Infectious waste, which includes materials contaminated with blood, body fluids, or pathogens, requires secure containment, treatment by autoclaving or incineration, and adherence to national and international regulations. Nursing and radiology staff play important roles by ensuring proper waste segregation at the point of generation and complying with protocols to prevent environmental contamination. Coordinated efforts between infection control teams, environmental services, and municipal waste authorities are vital for a sustainable and safe waste management program (Miamiliotis & Talias, 2023).

7.4 Water Safety and Surface Contamination Control

Water systems in hospitals pose risks for Legionella colonization and other waterborne pathogens, necessitating comprehensive water safety plans. Preventive measures include commissioning new plumbing systems with pre-chlorination, regular flushing of stagnant outlets, maintaining disinfectant

residuals, and point-of-entry filtration in high-risk areas. Special attention is given to areas housing immunocompromised patients by avoiding aerosol-generating devices like showers or tap aerators. Surface contamination control extends beyond floors and walls to include sampling and monitoring of high-touch surfaces for microbial load, with cleaning protocols adjusted accordingly to prevent transmission. Nurses and radiology staff contribute by ensuring adherence to water safety guidelines and effective surface hygiene practices in their respective units (National Academies of Sciences et al., 2019).

8. Emerging Challenges and Technological Innovations

8.1 Antimicrobial Resistance Monitoring and Stewardship Programs

Antimicrobial resistance (AMR) poses a critical and growing challenge in hospital infection prevention, threatening the efficacy of existing antibiotics and complicating treatment outcomes. To combat AMR, hospitals implement Antimicrobial Stewardship Programs (ASPs) that optimize antibiotic prescribing practices to reduce misuse, ensure cost-effective care, and improve patient outcomes. ASPs incorporate regular monitoring of antimicrobial resistance patterns, antibiotic use audits, and prescriber education. Despite their importance, global implementation remains inconsistent, especially in resource-limited settings, with many hospitals lacking routine AMR surveillance or robust stewardship policies. Nursing and radiology staff contribute significantly by adhering to stewardship protocols, promoting appropriate diagnostic testing, and supporting infection control measures that prevent resistant infections (Hamdy et al., 2022).

8.2 Automated Disinfection Systems

Traditional cleaning interventions in hospitals often rely on operator-dependent processes, which can be variable in efficacy. Automated room disinfection (ARD) systems employing technologies such as ultraviolet-C (UV-C) light and hydrogen peroxide vapor (HPV) offer consistent, effective surface decontamination. UV-C systems emit germicidal radiation that disrupts microbial DNA but require multiple placements to overcome shadows and ensure exposure to all surfaces. Hydrogen peroxide vapor systems deliver sporicidal and bactericidal action by distributing vapor throughout enclosed spaces, sterilizing hard-to-reach areas though requiring sealed environments and safety monitoring. These automated systems reduce healthcare-associated infection (HAI) risk by achieving higher and more reliable surface disinfection compared to manual cleaning, supplementing nursing and ancillary staff efforts in environmental hygiene (Otter et al., 2020).

8.3 Digital Infection Surveillance Software

Emerging digital surveillance platforms integrate electronic health records, laboratory data, and patient movement to provide real-time infection monitoring at the hospital and network levels. Examples include advanced clinical surveillance systems like Baxter Healthcare's ICNET, implemented in multiple healthcare regions, enhancing integrated patient care by early detection of healthcare-associated infections (HCAIs) and providing actionable alerts to clinicians. Such tools improve data accuracy, reduce labor-intensive traditional surveillance, and facilitate infection control teams' rapid response. Nursing and radiology personnel benefit from timely updates and alerts enabling prompt isolation and diagnostic workflows to reduce infection spread (Biermann et al., 2025).

8.4 Artificial Intelligence in Infection Trend Prediction

Artificial intelligence (AI) is revolutionizing infection prevention by predicting infection trends based on large datasets incorporating past infection rates, social behavior changes, and variables such as vaccination rollouts and variants. AI models, such as the PandemicLLM system, dynamically select and train predictive models tailored to specific epidemiological contexts, improving accuracy in forecasting outbreaks and resource needs. This precision supports hospital infection control planning, enabling proactive interventions

and resource allocation. AI can thus empower nursing and radiology departments by guiding patient screening priorities and optimizing infection prevention strategies (Zhao et al., 2024).

8.5 Novel Personal Protective Equipment and Antimicrobial Surface Materials

Innovations in personal protective equipment (PPE) and antimicrobial surfaces target persistent microbial contamination on high-touch objects. Newly developed PPE incorporates materials with enhanced protection, comfort, and antimicrobial properties suitable for prolonged clinical use. Parallelly, novel antimicrobial coatings such as copper-based composites like Copper Armour™ demonstrate rapid bactericidal activity against pathogens, including MRSA and multidrug-resistant organisms. These coatings reduce microbial burden on environmental surfaces such as bed rails and tables, complementing manual cleaning and reducing transmission risks. The integration of such advanced materials enhances the overall infection prevention environment maintained by nursing and radiology staff (Sheridan et al., 2022).

9. Future Directions and Research Gaps

9.1 Areas Needing Rigorous Study

Despite significant advances in infection prevention and control (IPC) within hospitals, multiple knowledge gaps remain, particularly regarding infection dynamics within radiology departments and behavioral determinants among healthcare staff. The radiology department (RD) is a critical area with increasing risk of healthcare-associated infections (HCAIs) given the high patient throughput, shared use of imaging modalities, and complexity of devices such as MRI and CT scanners. Studies have demonstrated contamination on radiology equipment, from lead aprons to ultrasound probes, harboring multidrug-resistant organisms including MRSA and Gram-negative bacteria. However, the exact infection rates directly linked to radiology services remain underexplored in rigorous epidemiological studies, calling for well-designed prospective investigations that quantify infection transmission chains associated with specific radiological procedures and equipment usage (Ilyas et al., 2019).

Behavioral determinants influencing IPC compliance among nursing and radiology staff also present critical research needs. Nursing staff infection prevention behavior is modulated by complex factors including workplace climate, peer influences, workload, and managerial commitment to hygiene practices. Notably, auditory feedback and herd behavior strongly impact adherence, sometimes leading to deviations due to fear of criticism or high staff turnover. Understanding these psychosocial and contextual variables through mixed methods research including behavioral science frameworks will enable targeted interventions that improve compliance sustainably (Arvidsson et al., 2025).

9.2 Evaluation of Interdepartmental Interventions

Effective IPC requires seamless collaboration across hospital departments, particularly between nursing and radiology teams, given their shared responsibility in patient care pathways. Current evidence for interdepartmental infection prevention interventions remains limited, with a need to evaluate multimodal strategies involving education, standardized protocols, environmental decontamination, and workflow redesign. For example, interventions such as nurse training in disinfection techniques, surface material innovations, and enhanced communication protocols have shown promise but lack comprehensive assessments across units. Future research should employ controlled implementation studies and quality improvement frameworks to measure how integrated approaches affect infection rates, staff behavior, and patient outcomes on a hospital-wide scale (Dramowski et al., 2022).

9.3 Leadership and Policy Support for Sustainable Models

Strong leadership commitment and effective policy frameworks are paramount to maintaining robust infection prevention programs. Executive leadership visibility, engagement, and communication support have been shown to elevate infection control priorities and enhance frontline staff motivation. Leadership

interventions that include regular quality metric reporting, frontline rounding by executives, and resource allocation lead to improved hand hygiene compliance and reductions in device-associated infections. Nonetheless, there is a research gap concerning the best leadership models and policy mechanisms that ensure sustainability of IPC efforts, especially in the evolving healthcare context of staff shortages, emerging pathogens, and technological advances (McAlearney et al., 2021).

Conclusion

Hospital-acquired infections (HAIs) continue to pose a global challenge, threatening patient safety, prolonging hospital stays, and increasing healthcare costs. This review underscores the critical yet often underappreciated roles of nursing and radiology staff in infection prevention and control (IPC). Nurses, through direct patient care, aseptic techniques, surveillance, and education, form the backbone of infection prevention at the bedside. Radiology staff, meanwhile, ensure safe diagnostic and interventional procedures through meticulous equipment decontamination, adherence to sterile techniques, and implementation of environmental hygiene practices.

Collaborative, multidisciplinary approaches that integrate these two departments within hospital infection control frameworks are essential for reducing infection transmission. Investments in continuous education, leadership support, and technological innovations such as automated disinfection, digital surveillance, and antimicrobial materials further enhance infection prevention outcomes. Ultimately, strengthening the synergy between nursing and radiology staff, supported by institutional commitment and evidence-based policy, is key to achieving sustainable, system-wide reductions in HAIs and improving overall patient safety and healthcare quality.

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