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"Preventing Hospital-Acquired Infections: The Essential Role of Healthcare Providers in Nosocomial Infection Control"

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Chapter 1: Introduction to Hospital-Acquired Infections (HAIs)

Hospital-acquired infections (HAIs) persistently impact hospital care quality, with morbidity and mortality rates from HAIs on the rise despite advances in healthcare interventions and facilities (Voidazan et al., 2020). The World Health Organization (WHO) recognizes HAIs as significant public health concerns, as they lead to longer hospital stays, higher healthcare costs, negative patient outcomes, and increased mortality rates (Blot et al., 2022). These infections are prevalent globally, regardless of a country's development level. Also known as nosocomial or healthcare-associated infections (derived from the Greek word "nosokomeion" for hospital), HAIs are defined as infections that develop in a healthcare setting, typically manifesting 48 hours or more after admission, with no sign of infection upon the patient's arrival (Yokoe et al., 2023; Nayek, 2019; Sahiledengle et al., 2020).

HAIs contribute to elevated medical expenses, extended hospital stays, complications, and worsened patient health outcomes. Common types include bloodstream infections linked to central lines, catheter-

associated infections, ventilator-associated pneumonia, and surgical site infections (Stewart et al., 2021). Ignaz Semmelweis, in the mid-19th century, observed a high incidence of childbed fever in mothers at an obstetric ward, hypothesizing that medical students were transferring pathogens from cadaver work. His introduction of handwashing with chlorinated lime showed notable reductions in maternal mortality, a discovery foundational to germ theory (Escobar & Pegues, 2021; Lee & Yang, 2024).

Following Semmelweis's contributions, infection control in healthcare gained global attention. In the 1960s, the CDC's Comprehensive Hospital Infections Project introduced lasting surveillance and control methods. The establishment of the National Healthcare Safety Network (NHSN) underscored infection control's importance on a public health level, making HAI reduction an international priority (Johnstone et al., 2019; Etheridge, 2023). Hospital-acquired infections include various conditions like ventilator-associated pneumonia, bloodstream infections, urinary tract infections, and skin, soft tissue, respiratory, gastrointestinal, and cardiovascular infections. These are caused by diverse pathogens, including bacteria, fungi, viruses, and parasites (Despotovic et al., 2021). WHO data indicates a high global incidence of HAIs, affecting 7% of patients in high-income and 10% in developing countries. Effective monitoring and preventive measures are essential for reducing HAI rates (Maki & Zervos, 2021).

According to WHO, HAIs are the most frequent adverse event among hospitalized patients. Recent studies report over 2.5 million HAI cases yearly in Europe, with over 90,000 deaths linked to the six most common infections, including healthcare-associated pneumonia, urinary tract infections, surgical site infections, Clostridium difficile infections, neonatal sepsis, and bloodstream infections (Despotovic et al., 2020).

Chapter 2: Pathogenesis and Risk Factors

Hospital-Acquired Infections HAIs are caused by different microorganisms such as fungi, bacteria, parasites, or viruses. The major causative microorganisms are Acinetobacter spp., Pseudomonas aeruginosa, Klebsiella pneumoniae, and Staphylococcus aureus (Viksne et al., 2023). All patients can get infected by nosocomial infections but some patients are at a higher risk of contracting the infections than others. Such high-risk patients include: patients with increasing age, patients with comorbid conditions, patients with longer hospital stays, and patients with more invasive equipment and procedures. Klebsiella pneumoniae demonstrated a 50% increase in resistance to third-generation cephalosporins (Du et al., 2021).

Other HAI including Pseudomonas aeruginosa and C diff are demonstrating increased antimicrobial resistance. Infection is spread to the susceptible patient in the clinical setting by various means. Healthcare staff also spread infection, in addition to contaminated equipment, bed linens, or air droplets (Abbas et al., 2021). The infection can originate from the outside environment, another infected patient, staff that may be infected, or in some cases, the source of the infection cannot be determined. In some cases the microorganism originates from the patient's own skin microbiota, becoming opportunistic after surgery or other procedures that compromise the protective skin barrier (Abbasi et al., 2020).

Means of Transmission, among patients and health care personnel, microorganisms are spread to others through four common routes of transmission: contact (direct and indirect), respiratory droplets, airborne spread, and common vehicle. Vectorborne transmissions (from mosquitoes, fleas, and other vermin) are atypical routes in hospitals (Bestilleiro et al., 2021). Contact transmission, this is the most important and frequent mode of transmission in the health care setting. Organisms are transferred through direct contact between an infected or colonized patient and a susceptible health care worker or another person (Divatia et al., 2020).

Patient organisms can be transiently transferred to the intact skin of a health care worker (not causing infection) and then transferred to a susceptible patient who develops an infection from that organism, this demonstrates an indirect contact route of transmission from one patient to another (Rhee et al., 2020). An infected patient touching and contaminating a doorknob, which is subsequently touched by a health care worker and carried to another patient, is another example of indirect contact. Microorganisms that can be spread by contact include those associated with impetigo, abscess, diarrheal diseases, scabies, and

antibiotic-resistant organisms (e.g., methicillin-resistant *Staphylococcus aureus* [MRSA] and vancomycin-resistant enterococci [VRE]) (Lemiech-Mirowska et al., 2021).

Respiratory droplets, Droplet-size body fluids containing microorganisms can be generated during coughing, sneezing, talking, suctioning, and bronchoscopy. They are propelled a short distance before settling quickly onto a surface. They can cause infection by being deposited directly onto a susceptible person's mucosal surface (e.g., conjunctivae, mouth, or nose) or onto nearby environmental surfaces, which can then be touched by a susceptible person who autoinoculates own mucosal surface. Examples of diseases where microorganisms can be spread by droplet transmission are pharyngitis, meningitis, and pneumonia (Saraswathy et al., 2021).

Airborne spread, when small-particle-size microorganisms (e.g., tubercle bacilli, varicella, and rubeola virus) remain suspended in the air for long periods of time, they can spread to other people (Kollef et al., 2021). The CDC described an approach to reduce transmission of microorganisms through airborne spread in its Guideline for Isolation Precautions in Hospitals. Proper use of personal protective equipment (e.g., gloves, masks and gowns), aseptic technique, hand hygiene, and environmental infection control measures are primary methods to protect the patient from transmission of microorganisms from another patient and from the health care worker. Personal protective equipment also protects the health care worker from exposure to microorganisms in the health care setting (Khodadadi et al., 2024).

Common Vehicle, Common vehicle (common source) transmission applies when multiple people are exposed to and become ill from a common inanimate vehicle of contaminated food, water, medications, solutions, devices, or equipment. Bacteria can multiply in a common vehicle, but viral replication cannot occur (Alhumaid et al., 2021). Examples include improperly processed food items that become contaminated with bacteria, waterborne shigellosis, and bacteremia resulting from use of intravenous fluids contaminated with a gram-negative organism, contaminated multi-dose medication vials, or contaminated bronchoscopes. Common vehicle transmission is likely associated with a unique outbreak setting (Obeagu et al., 2023).

All patients can get infected by nosocomial infections but some patients are at a higher risk of contracting the infections than others. Such high-risk patients include: patients with increasing age, patients with comorbid conditions, patients with longer hospital stays, and patients with more invasive equipment and procedures. Intrinsic risk factors predispose patients to HAIs (Sharma et al., 2020). The higher likelihood of infection is reflected in vulnerable patients who are immunocompromised because of age (neonate, elderly), underlying diseases, severity of illness, immunosuppressive medications, or medical/surgical treatments (Alrubaiee et al., 2021).

Patients with alterations in cellular immune function, cellular phagocytosis, or humoral immune response are at increased risk of infection and the ability to combat infection. A person with a primary immunodeficiency (e.g., anemia or autoimmune disease) is likely to have frequently recurring infections or more severe infections, such as recurrent pneumonia (Al Mutair et al., 2021). Secondary immunodeficiencies (e.g., chemotherapy, corticosteroids, diabetes, leukemia) increase patient susceptibility to infection from common, less virulent pathogenic bacteria, opportunistic fungi, and viruses. Considering the severity of a patient's illness in combination with multiple risk factors, it is not unexpected that the highest infection rates are in ICU patients (Logue et al., 2020).

Also, HAI rates in adult and pediatric ICUs are approximately three times higher than elsewhere in hospitals (Grasselli et al., 2021). Extrinsic risk factors include surgical or other invasive procedures, diagnostic or therapeutic interventions (e.g., invasive devices, implanted foreign bodies, organ transplantations, immunosuppressive medications), and personnel exposures, at least 90 percent of infections associated with invasive devices. Invasive medical devices bypass the normal defense mechanism of the skin or mucous membranes and provide foci where pathogens can flourish, internally shielded from the patient's immune defenses (Mwanyika et al., 2021).

In addition to providing a portal of entry for microbial colonization or infection, these devices also facilitate transfer of pathogens from one part of the patient's body to another, from health care worker to patient, or from patient to health care worker to patient (Mackey et al., 2021). Infection risk associated with these extrinsic factors can be decreased with the knowledge and application of evidence-based infection control practices. Prolonged hospitalization, due to a higher acuity of illness, contributes to host susceptibility as there is more opportunity to utilize invasive devices and more time for exposure to exogenous microorganisms (Buetti et al., 2022).

These patients are also more susceptible to rapid microbial colonization as a consequence of the severity of the underlying disease, depending on the function of host defenses and the presence of risk factors (e.g., age, extrinsic devices, extended length of stay) (Koh et al., 2020). Exposure to these colonizing microorganisms is from such sources as endemic pathogens from an endogenous source, hospital flora in the health care environment, and hands of health care workers (Zhou et al., 2020).

Chapter 3: Healthcare Providers' Role in Nosocomial Infection Control

Clinical care staff and healthcare workers are the primary line of defense in enforcing daily infection control practices to prevent the spread of infections and transmission of pathogens among patients (Baker et al., 2020). While the Occupational Safety and Health Administration mandates annual training to prevent bloodborne pathogen exposures, additional infection control training and regular assessments of aseptic practices should be provided to clinical nurses and other healthcare staff as part of a planned safety initiative (Magani, 2023).

Nurses play a crucial role in minimizing healthcare-associated infections by identifying and using evidence-based strategies to protect both patients and staff (Haque et al., 2020). They actively prevent infections by ensuring adherence to aseptic practices, overseeing environmental cleaning to stop cross-patient contamination, and identifying ill visitors or staff members who may need to be referred for further care. Effective hospital infection control should be a priority in quality management systems (Blot et al., 2022).

For patient safety and healthcare quality, hospital infections should be treated as potential adverse events requiring corrective and preventive measures (Alayt et al., 2022). Healthcare providers are central to HAI prevention, involved in essential hygiene, monitoring infection-prone areas (such as catheter sites), observing systemic infection signs, implementing quality improvement initiatives, conducting accurate microbiological sampling, and supporting antibiotic stewardship (Ahsan et al., 2021).

Recent efforts have reduced device-related HAIs significantly, though HAI rates may rise in the future due to increased care intensity, an aging population, the prevalence of severe underlying conditions in ICU patients, and the spread of multidrug-resistant organisms (MDRO) within hospitals and communities (Sagar et al., 2023). Effective HAI prevention programs require awareness among all healthcare workers, including support staff (Mazzeffi et al., 2021).

Infection prevention specialists and nurse practitioners can facilitate communication across departments and refine educational materials for targeted groups. To mitigate infections, strategies should include minimizing the need for and length of invasive procedures, re-evaluated daily (Engel et al., 2022). Evidence-based prevention strategies, applied through care bundles or checklists, improve adherence rates. During implementation, infection preventionists and nurse practitioners should provide ongoing education and foster accountability (Sartelli et al., 2024).

Constant quality improvement in healthcare relies on monitoring both the factors that contribute to healthcare-associated infections (HAIs) and the effectiveness of prevention efforts, along with outcomes. It is essential to provide detailed feedback to unit leaders and bedside personnel, which includes information on adherence rates to recommended practices and data on HAI outcomes. This feedback is crucial for refining prevention strategies and boosting the commitment of all involved stakeholders (Puro et al., 2022). Using antiseptic and antibiotic compounds appropriately is essential for the prevention of nosocomial infections. In the upper-right quadrant of the infection control model, certain prerequisites—such as the prevention and management of multidrug-resistant organisms (MDROs), rigorous hand hygiene, and

comprehensive monitoring of nosocomial infections—are necessary. Without meeting these foundational requirements, any efforts to implement preventive strategies using antiseptics or antibiotics will likely be ineffective (Voidazan et al., 2020).

The right lower quadrant emphasizes the importance of these measures, particularly for high-risk patients or when infection risks remain elevated even after the prerequisites are in place. In contrast, the left upper quadrant focuses on situations where MDRO prevalence is low, or when the evidence of MDRO-related infection spread is minimal. Frequent surface contamination contributes significantly to bacterial transmission and patient colonization or infection. Several risk factors for hand contamination among healthcare workers include positive environmental cultures, the time spent in a room, physical examination, and ventilator contact. Intensive Care Units (ICUs) should be considered high-risk areas, and therefore, routine bio-cleaning should be strictly implemented. This bio-cleaning must encompass both detergent and disinfection phases, carried out at least once daily (Albarrak et al., 2022).

Healthcare workers identify various factors that influence their ability and willingness to adhere to infection prevention and control (IPC) guidelines, especially when managing respiratory infectious diseases. These factors include the clarity of the guideline content, the effectiveness of communication, the level of managerial support, the workplace culture, the quality of training provided, the availability of adequate physical space, access to and confidence in personal protective equipment (PPE), and a genuine desire to provide excellent patient care (Zhang et al., 2024). Shortages in staffing, due to either low availability or high turnover rates, can lead to an overwhelming patient load, delays in patient care, and even burnout among staff. These conditions create significant barriers to patient safety, quality outcomes, efficiency, and healthcare worker satisfaction (Branch & Amiri, 2020).

Across various healthcare facilities, it has been challenging to effectively educate staff on the importance of infection prevention, especially amid competing priorities. Staff members emphasize the need for clear and consistent communication regarding IPC guidelines (Glowicz et al., 2023). Many healthcare workers also cite a lack of training on specific infections and the correct use of PPE as problematic. They believe training should be mandatory for all employees, including support staff like cleaners, porters, and kitchen workers, as well as other auxiliary personnel. Additionally, insufficient isolation spaces, the lack of anterooms and showers, and limited access to handwashing stations remain ongoing issues (Khraisat & Al-Bashaireh, 2024).

Implementing practical measures to minimize infection risks is critical. These include reducing overcrowding, expediting the care of infected patients, and restricting visitor access. Concerns over inadequate and poor-quality PPE are common among healthcare workers and facility managers. Supply levels must be adjusted according to the evolving needs during an outbreak. Some healthcare workers find PPE uncomfortable, and in some cases, patients report feeling isolated or frightened when encountering staff in full protective gear (Park et al., 2023). Many healthcare workers report a stronger adherence to IPC guidelines when they understand the benefits, such as minimizing the risk of infecting themselves or their families or ensuring patient protection. Additionally, keeping staff informed of both positive and negative infection control outcomes in a “no-blame” culture fosters greater awareness, problem-solving, and dedication to infection prevention practices (Cocker et al., 2024).

Chapter 4: Evidence-Based Practices for Infection Prevention

Guidelines for preventing and managing healthcare-associated infections (HCAIs) involve evidence-based approaches, categorized as vertical and horizontal interventions. Vertical strategies aim to control specific pathogens by focusing on reducing colonization, infection, and transmission through targeted actions, including surveillance testing for asymptomatic carriers, isolation measures, and decolonization techniques (Haque et al., 2020). On the other hand, horizontal strategies focus on minimizing infection risks for a broader spectrum of pathogens by emphasizing consistent hand hygiene, responsible antimicrobial usage, and maintaining a clean environment (de Miranda Costa et al., 2020).

Infection control programs must evaluate the risks and benefits of these interventions, considering both efficacy and cost. Hand hygiene remains a fundamental horizontal intervention; however, compliance rates vary significantly across hospitals globally, with reports of low adherence in some regions (Thandar et al., 2021). Besides hand hygiene, universal decolonization strategies like chlorhexidine gluconate bathing for high-risk patients have shown better outcomes in reducing HCAIs than pathogen-specific surveillance. Factors influencing adherence to hand hygiene protocols include individual and systemic aspects, underscoring the importance of creating a safety culture backed by administrative support for resources and incentives (Thandar et al., 2022).

Improving hand hygiene adherence requires a multidisciplinary approach to identify beliefs, motivations, and barriers among healthcare workers. The responsibility of hand hygiene is shared between individual practitioners and healthcare institutions. Establishing a patient safety culture, supported by institutional leadership, is essential for sustained success (Alotaibi et al., 2022). Intrahospital transfers, or patient movements within the hospital, also increase HCAI risks due to potential delays and poor coordination between units (Patel, 2020).

Additionally, each transfer takes approximately one hour, adding significantly to nursing workloads. Infection control programs should continuously monitor hospital populations to adapt their strategies and minimize the burden of HCAIs by reducing intrahospital transfers and improving care coordination (García et al., 2022; Igunma & Adebudo, 2023).

Environmental cleanliness is crucial in healthcare settings, as patient surroundings may harbor various pathogens originating from patients' intact skin or wounds. Surfaces like blood pressure cuffs, nursing uniforms, and computer keyboards can serve as reservoirs, transmitting pathogens to other patients (Thandar et al., 2021; Tchouaket et al., 2022).

Healthcare personnel can inadvertently acquire microorganisms on their gloves or bare hands by touching contaminated surfaces, even without direct patient contact. Routine hand hygiene is essential to reduce contamination risks before touching shared surfaces or equipment (Pandey, 2021; Alhareth et al., 2024). Consistent hand hygiene practices, complemented by proper surface disinfection, are necessary to minimize both direct and indirect transmission of infections (Lacotte et al., 2020; Nguemeleu et al., 2020).

Patients with infections caused by multidrug-resistant organisms or Clostridium difficile require additional precautions, alongside standard precautions, to prevent transmission from the patient and contaminated surroundings. Nurses can play a key role in ensuring medical equipment is cleaned between uses and in collaborating with cleaning staff to maintain sanitized conditions (Munoz-Mozas, 2023; Tchouaket Nguemeleu et al., 2020).

Personal protective equipment (PPE), including gloves, gowns, masks, and face shields, is essential in infection control practices to protect both healthcare workers and patients from occupational exposure. PPE safeguards workers' skin and mucous membranes against exposure to infectious materials (Cawthorne et al., 2021; Alshehri, 2023). The Occupational Safety and Health Administration mandates training for healthcare workers on the appropriate use of PPE to prevent work-related exposures, emphasizing proper usage, wear, and removal for optimal protection (Watkin et al., 2023). However, PPE alone may not provide complete protection due to potential breaches or unrecognized exposures (Escobar & Pegues, 2021).

Gloves help prevent hand contamination when handling body fluids and reduce pathogen transmission risks. Still, gloves may have small, undetectable flaws or can tear during use, which makes hand hygiene crucial even after glove removal (Okeah et al., 2021; Mehta & Mehta, 2021). The Centers for Disease Control and Prevention recommend EPA-registered chemical germicides for disinfecting medical equipment that contacts multiple patients. For Clostridium difficile infections, hypochlorite-based disinfectants are advised. It is vital that cleaning staff consistently adhere to disinfection protocols, particularly for frequently touched surfaces like bed rails and doorknobs (Escobar & Pegues, 2021; Wang et al., 2023).

Disposable items are preferred for patients needing contact precautions, such as those with MRSA or C. difficile, to prevent cross-contamination. Families, visitors, and patients should also be educated about the

importance of hand hygiene to reduce contamination from respiratory or fecal matter. Facilities may consider adopting a pledge to ensure robust infection control and environmental cleanliness (McCloy et al., 2024). A surgical mask protects both patients and healthcare workers from large droplets, though resistance to airflow increases when masks become damp from exhaled air (Savul et al., 2020).

Professional organizations provide evidence-based guidelines for infection control and HCAI prevention, offering prioritized recommendations based on scientific evidence and practical applicability across various healthcare settings (Cawthorne et al., 2020; Ismaeil, 2024). Despite healthcare workers' awareness of aseptic practices, adherence to infection control guidelines is inconsistent. Reasons for non-compliance include time constraints, inconvenience, and assumptions about patient infection status. Addressing multidrug-resistant organisms requires antimicrobial stewardship, active surveillance, and effective infection control to minimize resistance spread (Jeong, 2022; Collins et al., 2022). Antimicrobial stewardship involves selecting the right antibiotic, dosage, and treatment duration to maximize infection management (Patrzała et al., 2023).

Chapter 5: Organizational Policies and Leadership in Infection Control

Translation of evidence-based guidelines into clinical settings may demand more than simply relying on a practitioner's knowledge and good intentions (Ilesanmi et al., 2021). To fully understand the obstacles that inhibit the effective review and integration of evidence-based practices into daily clinical routines, organizational interventions could be necessary. Policies and standards of care must be specific regarding time, quantifiable, and clearly define the exact patient population they aim to impact (Lynch et al., 2024).

When an institution adopts a new evidence-based guideline that updates an existing policy, a multidisciplinary approach should be devised. This should ensure that the staff agrees with the changes, understands the criticality of the new approach, receives the necessary knowledge, staff, and resources for implementation, and has an established system for evaluating the effectiveness of the change (Smallwood et al., 2022).

Both hospital administrators and healthcare workers are accountable for showcasing the success of infection control programs, guaranteeing adequate infection control training for staff, ensuring that surveillance outcomes are linked to performance improvements, reassessing priorities based on ongoing risk analyses, maintaining sufficient numbers of skilled infection control practitioners, and performing evaluations of the program using quality improvement tools as required (Kim et al., 2021). Healthcare workers invest significant effort in meeting the complex medical needs of patients, striving to heal and advancing quality care through scientific development, all while adhering to the ethical principle of "Primum non nocere" (First, do no harm) (Tomczyk et al., 2022).

Effective and robust systems, including Infection Prevention (IP) programs and efforts toward process improvement, are essential for embedding error reduction into daily practices, improving outcomes, and fostering highly dependable care. Building such programs encompasses every project and collaborative effort within an organization that is aimed at achieving institutional goals (Giordano et al., 2022). When a program is well-equipped to manage the complexities, risks, and expenses inherent in modern healthcare, it can optimize the replication of best practices and prevent errors. In the context of infectious diseases, Infection Prevention and Control (IPC) programs must be standardized and sufficiently strong to respond swiftly and effectively (Weinberg et al., 2020).

Risk reduction is a shared responsibility, involving the institution's administrators, directors, and individual practitioners. Leaders shape organizational values, values influence behaviors, and behaviors drive organizational performance (Haque et al., 2020). An organization's collective behaviors are a reflection of its culture. Engaging nursing leaders to work closely with coworkers and hospital administrators in fostering safety, teamwork, and effective communication is essential to enhancing safe and reliable care (Labrague, 2021).

When developed and implemented together, these elements create a support framework for the effective application of new technologies and evidence-based practices. If patients are not receiving all appropriate

evidence-based care (regardless of whether it is related to infectious outcomes), healthcare professionals have a duty to take the lead in developing ways to improve that care. A significant challenge is finding methods to foster and maintain the changes needed to embed infection prevention knowledge into routine clinical practice (Salam et al., 2023). As each individual acknowledges their role in this shared responsibility, their leadership and role-modeling will foster a standardized culture and set expectations for all healthcare workers and support personnel to adopt best practices (Obeagu et al., 2023).

Each healthcare institution must effectively communicate evidence-based practices to its staff, ensure access to infection control expertise, provide the necessary resources and incentives to facilitate change, and supply real-time feedback using national and hospital-specific comparative data (Majumder et al., 2020). Health institutions must expect and strive for more consistent adherence to essential infection-control practices like hand hygiene and the proper use of gloves. It is no longer acceptable for hospitals with poor adherence rates to excuse their performance by comparing it to the generally low compliance reported in other publications (Tan et al., 2023).

Institutional improvements should concentrate on process enhancements that uphold best practices, using multifaceted approaches and commitment from top administration through every level of staff to implement best practices. Healthcare workers sometimes question whether to follow local guidelines when they differ from national or international standards, particularly when guidelines are lengthy, impractical, or change frequently (Qadri et al., 2022). Additionally, using personal protective equipment (PPE) and engaging in extra cleaning as per Infection Prevention and Control (IPC) guidelines can lead to increased workload and fatigue. Healthcare workers' adherence to IPC guidelines is often influenced by the level of support received from management and the prevailing workplace culture (Gidey et al., 2023).

Educational initiatives, combined with posted outcome metrics and progress reports on areas requiring improvement, should be implemented with a focus on continuous quality improvement rather than assigning blame (Anders et al., 2021). Everyone present in a healthcare facility, whether as staff, patient, or visitor, is a stakeholder and could contribute to problems or solutions. Active engagement from top executives to entry-level workers is vital. Infection control must be seen as a collective responsibility (Mudenda et al., 2023).

Chapter 6: Innovations and Future Directions

The expansion of healthcare-associated infection (HAI) activities has encountered challenges. Despite significant progress, coordination of HAI efforts among various agencies remains ongoing (Truong, 2023). The implementation of the Inpatient Prospective Payment System (IPPS) and End-Stage Renal Disease (ESRD) reporting requires accurate validation of data for payment decisions, a task that the Centers for Medicare & Medicaid Services (CMS) and the Centers for Disease Control and Prevention (CDC) are addressing together. Additionally, the National Healthcare Safety Network (NHSN) infrastructure must be strengthened to meet the increasing demands from state and federal levels (Cannon & Pohida, 2022).

The CDC is committed to enhancing NHSN to better accommodate the growing number of users and functions, aiming for simplified reporting, consistent case finding, and robust data validation (Van Mourik et al., 2021). As healthcare surveillance transitions towards electronic systems, CDC collaborates with partners such as Health Level Seven International, healthcare technology vendors, and hospital systems. However, state health departments face difficulties in meeting the increased demands of HAI prevention due to limited resources (Au et al., 2021).

Although investments and technical support have significantly helped, variability in state-level HAI prevention programs has led to inconsistent national efforts. Some states with strong programs worry about sustaining them, while others lack adequate resources for comprehensive HAI data validation. States that have pioneered HAI data validation work with the CDC on diverse validation activities to support their efforts (Bolcato et al., 2023).

At the facility level, resource constraints are also problematic. The workload for front-line epidemiologists and infection preventionists has surged without corresponding increases in support, hindering their HAI

prevention efforts (Tariq et al., 2023). Expanding the action plan to non-acute care settings, such as dialysis centers, ambulatory surgery centers, and nursing homes, presents further challenges, as new surveillance definitions and metrics need to be developed. Despite these challenges, expanding into these areas is crucial for a comprehensive understanding of HAIs. The HHS Action Plan to Prevent HAIs has successfully raised awareness and provided a framework to address HAI challenges across multiple healthcare settings (Garcia et al., 2022).

References

1. Abbas, M., Robalo Nunes, T., Martischang, R., Zingg, W., Iten, A., Pittet, D., & Harbarth, S. (2021). Nosocomial transmission and outbreaks of coronavirus disease 2019: the need to protect both patients and healthcare workers. *Antimicrobial Resistance & Infection Control*, *10*, 1-13.
2. Abbasi, S. H., Aftab, R. A., & Chua, S. S. (2020). Risk factors associated with nosocomial infections among end stage renal disease patients undergoing hemodialysis: a systematic review. *PloS one*, *15*(6), e0234376.
3. Ahsan, A., Dewi, E. S., Suharsono, T., Setyoadi, S., Soplanit, V. G., Ekowati, S. I., & Laili, N. (2021). Knowledge management-based nursing care educational training: A key strategy to improve healthcare associated infection prevention behavior. *SAGE Open Nursing*, *7*, 23779608211044601.
4. Al Mutair, A., Alhumaid, S., Al Alawi, Z., Zaidi, A. R. Z., Alzahrani, A. J., Al-Tawfiq, J. A., ... & Al-Omari, A. (2021). Five-year resistance trends in pathogens causing healthcare-associated infections at a multi-hospital healthcare system in Saudi Arabia, 2015–2019. *Journal of global antimicrobial resistance*, *25*, 142-150.
5. Alayt, M. M. M., Alshallali, N. M., Alalawiy, R. I., Alorem, M. M., Al Roman, A. S., Ali, Z. O., ... & Algmele, A. H. N. (2022). Investigating the role of nursing interventions in reducing hospital acquired infections. *Chelonian Research Foundation*, *17*(2), 3088-3098.
6. Albarrak, S. H., Alenzey, A. S., Alrasheedi, A. F., Al-reshidi, A. S. M., Alblwei, K. H., Al Rashidy, S. A., ... & Alresheedi, A. I. (2022). The Nurse's Role in Hospital Infection Prevention. *Journal of Positive Psychology and Wellbeing*, *6*(3), 325-336.
7. Alhareth, S. J., Almaqsudi, H. H., Almarhabi, F. A., AL-Jaidan, F. Q., Alkhamis, A. A., Alkhamis, S. A., ... & Al Hatrash, S. M. (2024). Effective strategies for reducing healthcare-associated infections: a comprehensive review for nursing practice. *Chelonian Research Foundation*, *19*(01), 746-760.
8. Alhumaid, S., Al Mutair, A., Al Alawi, Z., Alsuliman, M., Ahmed, G. Y., Rabaan, A. A., & Al-Omari, A. (2021). Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. *Antimicrobial Resistance & Infection Control*, *10*(1), 86.
9. Alotaibi, M. H., Lrouwaily, A. M. G., Alsuhaiman, N. K., Albanagi, G. M., Ahazimy, M. O., & Lhazmi, T. H. (2022). Effective strategies for reducing healthcare-associated infections: a comprehensive review for nursing practice. *Neuropsychopharmacologia Hungarica*, *20*(4).
10. Alrubaiee, G. G., Baharom, A., Faisal, I., Shahar, H. K., Daud, S. M., & Basaleem, H. O. (2021). Implementation of an educational module on nosocomial infection control measures: a randomised hospital-based trial. *BMC nursing*, *20*, 1-10.
11. Alshehri, A. A. (2023). Factors Impacting Compliance with Infection Control Guidelines among healthcare providers in Neonatal Intensive Care Unit, referral hospital, Saudi Arabia. *Saudi J Nurs Health Care*, *6*(12), 455-60.
12. Anders, C., Bloom, C., Braouzou, V., Finch, D., Reid, M., Zanini, M., & Shaw, C. (2021). Hospitals. In *Metric Handbook* (pp. 20-1). Routledge.
13. Assiri, H., Almutairi, M., Alotaibi, A. M., & Al Ameer, A. (2021). Progressing Infection Control Practices: Strategies For Healthcare Professionals. A New Appraisal. *Journal of Namibian Studies: History Politics Culture*, *30*, 188-206.
14. Au, J. K. L., Suen, L. K. P., & Lam, S. C. (2021). Observational study of compliance with infection control practices among healthcare workers in subsidized and private residential care homes. *BMC infectious diseases*, *21*, 1-11.

15. Baker, T. L., Greiner, J. V., Maxwell-Schmidt, E., Lamothe, P. H., & Vesonder, M. (2020). Guidelines for frontline health care staff safety for COVID-19. *Journal of primary care & community health*, *11*, 2150132720938046.
16. Bestilleiro, R. S., Senaris, D. M., Rodriguez, M. J. P., Vazquez, R. G., Rodriguez, R. G., Rodriguez, M. T. G., & Diaz, S. P. (2021). Nosocomial infection outbreak due to SARS-COV-2 in a hospital unit of particularly vulnerable patients. *International Journal of Medical Sciences*, *18*(10), 2146.
17. Blot, S., Ruppé, E., Harbarth, S., Asehnoune, K., Poulakou, G., Luyt, C. E., & Zahar, J. R. (2022). Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies. *Intensive and Critical Care Nursing*, *70*, 103227.
18. Bolcato, V., Robustelli della Cuna, F. S., Fassina, G., Odone, A., Gervasio, L., Bosone, D., & Blandi, L. (2023, November). Preventing Healthcare-Associated Infections: Hand Disinfection Monitoring Using an Automated System in an Italian Neurological Hospital. In *Healthcare* (Vol. 11, No. 23, p. 3018). MDPI.
19. Branch, R., & Amiri, A. (2020). Environmental surface hygiene in the OR: Strategies for reducing the transmission of health care–associated infections. *AORN journal*, *112*(4), 327-342.
20. Buetti, N., Marschall, J., Drees, M., Fakih, M. G., Hadaway, L., Maragakis, L. L., ... & Mermel, L. A. (2022). Strategies to prevent central line-associated bloodstream infections in acute-care hospitals: 2022 Update. *Infection Control & Hospital Epidemiology*, *43*(5), 553-569.
21. Cannon, M. F., & Pohida, J. (2022). Would" Medicare for All" Mean Quality for All? How Public-Option Principles Could Reverse Medicare's Negative Impact on Quality. *Quinnipiac Health LJ*, *25*, 181.
22. Cawthorne, K. R., & Cooke, R. P. D. (2021). A survey of commercially available electronic hand hygiene monitoring systems and their impact on reducing healthcare-associated infections. *Journal of Hospital Infection*, *111*, 40-46.
23. Cawthorne, K. R., Dean, J., & Cooke, R. P. (2020). The financial impact of improved hand hygiene on healthcare-associated infections in the UK. *Canadian Journal of Infection Control*, *35*(3).
24. Cocker, D., Birgand, G., Zhu, N., Rodriguez-Manzano, J., Ahmad, R., Jambo, K., & Holmes, A. (2024). Healthcare as a driver, reservoir and amplifier of antimicrobial resistance: opportunities for interventions. *Nature Reviews Microbiology*, *22*(10), 636-649.
25. Collins, C., Van Poel, E., Šantrić Milićević, M., Tripkovic, K., Adler, L., Bjerve Eide, T., & Willems, S. (2022). Practice and system factors impact on infection prevention and control in general practice during COVID-19 across 33 countries: results of the PRICOV cross-sectional survey. *International journal of environmental research and public health*, *19*(13), 7830.
26. de Miranda Costa, M. M., Santana, H. T., Hernandez, P. S., Carvalho, A. A., & da Silva Gama, Z. A. (2020). Results of a national system-wide quality improvement initiative for the implementation of evidence-based infection prevention practices in Brazilian hospitals. *Journal of Hospital Infection*, *105*(1), 24-34.
27. Despotovic, A., Milosevic, B., Cirkovic, A., Vujovic, A., Cucanic, K., Cucanic, T., & Stevanovic, G. (2021). The impact of COVID-19 on the profile of hospital-acquired infections in adult intensive care units. Antibiotics, 10(10), 1146.
28. Despotovic, A., Milosevic, B., Milosevic, I., Mitrovic, N., Cirkovic, A., Jovanovic, S., & Stevanovic, G. (2020). Hospital-acquired infections in the adult intensive care unit—Epidemiology, antimicrobial resistance patterns, and risk factors for acquisition and mortality. American journal of infection control, 48(10), 1211-1215.)
29. Dhar, S., Sandhu, A. L., Valyko, A., Kaye, K. S., & Washer, L. (2021). Strategies for effective infection prevention programs: structures, processes, and funding. *Infectious Disease Clinics*, *35*(3), 531-551.
30. Divatia, J. V., Pulinilkunnathil, J. G., & Myatra, S. N. (2020). Nosocomial infections and ventilator-associated pneumonia in cancer patients. *Oncologic Critical Care*, 1419-1439.
31. Du, Q., Zhang, D., Hu, W., Li, X., Xia, Q., Wen, T., & Jia, H. (2021). Nosocomial infection of COVID-19: A new challenge for healthcare professionals. *International journal of molecular medicine*, *47*(4), 31.

32. Engel, F. D., dos Santos Cunha, K., Magalhães, A. L. P., Meirelles, B. H. S., & de Mello, A. L. S. F. (2022). Management actions for prevention and control of healthcare-associated infections: A grounded theory approach. *Journal of Nursing Management*, *30*(5), 1355-1365.
33. Escobar, D., & Pegues, D. (2021). Healthcare-associated infections: where we came from and where we are headed. BMJ Quality & Safety, 30(6), 440-443.
34. Escobar, D., & Pegues, D. (2021). Healthcare-associated infections: where we came from and where we are headed. *BMJ Quality & Safety*, *30*(6), 440-443.
35. Etheridge, E. W. (2023). *Sentinel for health: a history of the Centers for Disease Control*. Univ of California Press. Illustrated, reprint, Pp.xvi
36. García, A. M., Cross, J. H., Fitchett, E. J., Kawaza, K., Okomo, U., Spotswood, N. E., ... & Lawn, J. E. (2022). Infection prevention and care bundles addressing health care-associated infections in neonatal care in low-middle income countries: a scoping review. *EClinicalMedicine*, *44*.
37. Garcia, R., Barnes, S., Boukidjian, R., Goss, L. K., Spencer, M., Septimus, E. J., & Levesque, M. (2022). Recommendations for change in infection prevention programs and practice. *American journal of infection control*, *50*(12), 1281-1295.
38. Gidey, K., Gidey, M. T., Hailu, B. Y., Gebreamlak, Z. B., & Niriayo, Y. L. (2023). Clinical and economic burden of healthcare-associated infections: A prospective cohort study. *Plos one*, *18*(2), e0282141.
39. Giordano, F., Cipolla, A., & Ungar, M. (2022). Building resilience for healthcare professionals working in an Italian red zone during the COVID-19 outbreak: A pilot study. *Stress and Health*, *38*(2), 234-248.
40. Glowicz, J. B., Landon, E., Sickbert-Bennett, E. E., Aiello, A. E., Dekay, K., Hoffmann, K. K., ... & Ellingson, K. D. (2023). SHEA/IDSA/APIC practice recommendation: strategies to prevent healthcare-associated infections through hand hygiene: 2022 Update. *Infection Control & Hospital Epidemiology*, *44*(3), 355-376.
41. Grasselli, G., Scaravilli, V., Mangioni, D., Scudeller, L., Alagna, L., Bartoletti, M., & Bandera, A. (2021). Hospital-acquired infections in critically ill patients with COVID-19. *Chest*, *160*(2), 454-465.
42. Haque, M., McKimm, J., Sartelli, M., Dhingra, S., Labricciosa, F. M., Islam, S., & Charan, J. (2020). Strategies to prevent healthcare-associated infections: a narrative overview. *Risk management and healthcare policy*, 1765-1780.
43. Igunma, A., & Adebudo, O. (2023). Healthcare-associated infections and control strategies. *Nigerian Journal of Medical and Dental Education*, *5*(2), 81-87.
44. Ilesanmi, O. S., Afolabi, A. A., Akande, A., Raji, T., & Mohammed, A. (2021). Infection prevention and control during COVID-19 pandemic: realities from health care workers in a north central state in Nigeria. *Epidemiology & Infection*, *149*, e15.
45. Ismaeil, R., Mat-Nor, M. B., Kamarudin, N. B., Abubakar, U., Nahas, A. R. F., & Mohamed, M. H. N. (2024). Development and Usability Evaluation of a Mhealth Application for Health-Care Associated Infections among Health-Care Providers in Malaysia. *Journal of Pharmacy and Bioallied Sciences*, *16*(3), 114-120.
46. Jeong, Y. (2022). Status of infection prevention and control capacity in Korean hospitals: implications for disaster response and pandemic preparedness. *Public Health*, *213*, 100-106.
47. Johnstone, J., Garber, G., & Muller, M. (2019). Health care-associated infections in Canadian hospitals: still a major problem. *CMAJ*, *191*(36), E977-E978.
48. Khodadadi, B., Sharafi, M., Modarres Moghaddam, M. R., & Fazli, B. (2024). Assessment of Staff Knowledge and Practices for Nosocomial Infection Control and Prevention. *Health Education and Health Promotion*, *12*(1), 159-164.
49. Khraisat, O. M. A., & Al-Bashaireh, A. M. (2024). Evidence-based nursing practice and improving pediatric patient care outcomes in the prevention of infection transmission: Emergency department findings. *PLOS ONE*, *19*(6), e0305001.
50. Kim, E., Kim, S. S., & Kim, S. (2021). Effects of infection control education for nursing students using standardized patients vs. peer role-play. *International journal of environmental research and public health*, *18*(1), 107.

51. Koh, W. C., Naing, L., Chaw, L., Rosledzana, M. A., Alikhan, M. F., Jamaludin, S. A., & Wong, J. (2020). What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PloS one*, *15*(10), e0240205.
52. Kollef, M. H., Torres, A., Shorr, A. F., Martin-Loeches, I., & Micek, S. T. (2021). Nosocomial infection. *Critical care medicine*, *49*(2), 169-187.
53. Labrague, L. J. (2021). Psychological resilience, coping behaviours and social support among health care workers during the COVID-19 pandemic: A systematic review of quantitative studies. *Journal of nursing management*, *29*(7), 1893-1905.
54. Lacotte, Y., Årdal, C., Ploy, M. C., & European Union Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections (EU-JAMRAI). (2020). Infection prevention and control research priorities: what do we need to combat healthcare-associated infections and antimicrobial resistance? Results of a narrative literature review and survey analysis. *Antimicrobial Resistance & Infection Control*, *9*, 1-10.
55. Lee, S. H., & Yang, I. S. (2024). Empowering hospital-associated infection prevention and control: a quasi-experimental study on the effect of scenario-based simulation training. *Nurse Education in Practice*, *76*, 103936.
56. Lemiech-Mirowska, E., Kiersnowska, Z. M., Michałkiewicz, M., Depta, A., & Marczak, M. (2021). Nosocomial infections as one of the most important problems of healthcare system. *Annals of Agricultural and Environmental medicine*, *28*(3).
57. Logue, J. M., Zucchetti, E., Bachmeier, C. A., Krivenko, G. S., Larson, V., Ninh, D., & Locke, F. L. (2020). Immune reconstitution and associated infections following axicabtagene ciloleucel in relapsed or refractory large B-cell lymphoma. *Haematologica*, *106*(4), 978.
58. Lynch, J. B., Davitkov, P., Anderson, D. J., Bhimraj, A., Cheng, V. C. C., Guzman-Cottrill, J., & Morgan, R. L. (2024). Infectious Diseases Society of America Guidelines on Infection Prevention for Healthcare Personnel Caring for Patients with Suspected or Known COVID-19 (November 2021). *Clinical Infectious Diseases*, *78*(7), e230-e249.
59. Mackey, K., Ayers, C. K., Kondo, K. K., Saha, S., Advani, S. M., Young, S., & Kansagara, D. (2021). Racial and ethnic disparities in COVID-19–related infections, hospitalizations, and deaths: a systematic review. *Annals of internal medicine*, *174*(3), 362-373.
60. Magani, O. N. (2023). Comparative Analysis of Handwashing with Soap and Hand Rubbing with Handrub: Efficacy and Practical Implications among Nurses. International Journal on ObGyn and Health Sciences, 2(1), 32-38.
61. Majumder, M. A. A., Rahman, S., Cohall, D., Bharatha, A., Singh, K., Haque, M., & Gittens-St Hilaire, M. (2020). Antimicrobial stewardship: fighting antimicrobial resistance and protecting global public health. *Infection and drug resistance*, 4713-4738.
62. Maki, G., & Zervos, M. (2021). Health care–acquired infections in low-and middle-income countries and the role of infection prevention and control. *Infectious Disease Clinics*, *35*(3), 827-839.
63. Mazzeffi, M., Galvagno, S., & Rock, C. (2021). Prevention of healthcare-associated infections in intensive care unit patients. *Anesthesiology*, *135*(6), 1122-1131.
64. McCloy, O., McGuinness, A., & Craig, S. (2024). Infection prevention and control: understanding the fundamentals. *Nursing Standard*, *39*(10), 39-44.
65. Mehta, C., & Mehta, Y. (2021). Prevention of healthcareassociated infections in Intensive Care Unit. *Prevention of healthcare associated infections: infection prevention and control. New Delhi: Jaypee Brothers Medical Publishers*, 359-64.
66. Mudenda, S., Chabalenge, B., Daka, V., Mfune, R. L., Salachi, K. I., Mohamed, S., ... & Matafwali, S. K. (2023). Global strategies to combat antimicrobial resistance: a one health perspective. *Pharmacology & Pharmacy*, *14*(8), 271-328.
67. Munoz-Mozas, G. (2023). Preventing intravenous catheter-related bloodstream infections (CRBSIs). *British Journal of Nursing*, *32*(Sup7), S4-S10.

68. Mwanyika, G. O., Mboera, L. E., Rugarabamu, S., Ngingo, B., Sindato, C., Lutwama, J. J., & Misinzo, G. (2021). Dengue virus infection and associated risk factors in Africa: a systematic review and meta-analysis. *Viruses*, *13*(4), 536.
69. Nayek, S. (2019). A study on hospital acquired infection and prevention in CCU at College of Medicine &JNM Hospital. *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS).[Online]*, *18*(3), 51-72.
70. Nguemeleu, E. T., Beogo, I., Sia, D., Kilpatrick, K., Séguin, C., Baillot, A., & Boivin, S. (2020). Economic analysis of healthcare-associated infection prevention and control interventions in medical and surgical units: systematic review using a discounting approach. *Journal of Hospital Infection*, *106*(1), 134-154.
71. Obeagu, E. I., Obeagu, G. U., Akinleye, C. A., & Igwe, M. C. (2023). Nosocomial infections in sickle cell anemia patients: Prevention through multi-disciplinary approach: A review. *Medicine*, *102*(48), e36462.
72. Okeah, B. O., Morrison, V., & Huws, J. C. (2021). Antimicrobial stewardship and infection prevention interventions targeting healthcare-associated Clostridioides difficile and carbapenem-resistant Klebsiella pneumoniae infections: a scoping review. BMJ open, 11(8), e051983.
73. Pandey, S. S. (2021). Role of Nursing and Infection Control Nurses in Prevention and Control of Healthcare-associated Infections. *Prevention of Healthcare Associated Infections: Infection Prevention and Control*, 349.
74. Park, E., Park, H. R., & Lee, J. H. (2023). Barriers to learning healthcare-associated infections prevention and control during clinical practicum among nursing students in Korea: A focus group study. *International Journal of Environmental Research and Public Health*, *20*(14), 6430.
75. Patel, M. (2020). Healthcare-associated infection: best practice in prevention and control. *Evaluation*, *14*, 34.
76. Patrzała, A., Bączyk, G., Basa, A., Jankowiak-Bernaciak, A., Guzmán Ordaz, R., Pinto, M. D. R., & Parreira, P. (2023). Healthcare-associated infection prevention and control learning and teaching processes in European higher education institutions-a qualitative study. *Polish Nursing*, *3*(89), 91-101.
77. Puro, V., Coppola, N., Frasca, A., Gentile, I., Luzzaro, F., Peghetti, A., & Sganga, G. (2022). Pillars for prevention and control of healthcare-associated infections: an Italian expert opinion statement. *Antimicrobial Resistance & Infection Control*, *11*(1), 87.
78. Qadri, H., Shah, A. H., Ahmad, S. M., Alshehri, B., Almilaibary, A., & Mir, M. A. (2022). Natural products and their semi-synthetic derivatives against antimicrobial-resistant human pathogenic bacteria and fungi. *Saudi Journal of Biological Sciences*, *29*(9), 103376.
79. Rhee, C., Baker, M., Vaidya, V., Tucker, R., Resnick, A., Morris, C. A., & CDC Prevention Epicenters Program. (2020). Incidence of nosocomial COVID-19 in patients hospitalized at a large US academic medical center. *JAMA network open*, *3*(9), e2020498-e2020498.
80. Sagar, S. S. H., Almasfuh, A. A. M., Al Abbas, T. H., Al Mansour, M. F. H., Sager, J. S. H., & Al Bahri, T. S. M. (2023). Assessing the Effectiveness of Nursing Practices In Preventing Hospital-Acquired Infections In ICU Settings: A Comprehensive Review Of Government Hospitals. *Journal of Survey in Fisheries Sciences*, 1300-1305.
81. Sahiledengle, B., Seyoum, F., Abebe, D., Geleta, E. N., Negash, G., Kalu, A., & Quisido, B. J. E. (2020). Incidence and risk factors for hospital-acquired infection among paediatric patients in a teaching hospital: a prospective study in southeast Ethiopia. *BMJ open*, *10*(12), e037997.
82. Salam, M. A., Al-Amin, M. Y., Salam, M. T., Pawar, J. S., Akhter, N., Rabaan, A. A., & Alqumber, M. A. (2023, July). Antimicrobial resistance: a growing serious threat for global public health. In *Healthcare* (Vol. 11, No. 13, p. 1946). MDPI.
83. Saraswathy, T., Nalliah, S., Rosliza, A. M., Ramasamy, S., Jalina, K., Shahar, H. K., & Amin-Nordin, S. (2021). Applying interprofessional simulation to improve knowledge, attitude and practice in hospital-acquired infection control among health professionals. *BMC medical education*, *21*, 1-11.
84. Sartelli, M., Marini, C. P., McNelis, J., Coccolini, F., Rizzo, C., Labricciosa, F. M., & Petrone, P. (2024). Preventing and Controlling Healthcare-Associated Infections: The First Principle of Every Antimicrobial Stewardship Program in Hospital Settings. Antibiotics, 13(9), 896.

85. Savul, S., Lalani, F. K., Ikram, A., Khan, M. A., Khan, M. A., & Ansari, J. (2020). Infection prevention and control situation in public hospitals of Islamabad. *The Journal of Infection in Developing Countries*, *14*(09), 1040-1046.
86. Sharma, A., Fernandez, P. G., Rowlands, J. P., Koff, M. D., & Loftus, R. W. (2020). Perioperative infection transmission: the role of the anesthesia provider in infection control and healthcare-associated infections. Current Anesthesiology Reports, 10, 233-241.
87. Shettigar, S., Aradhya, A. S., Ramappa, S., Reddy, V., & Venkatagiri, P. (2021). Reducing healthcare-associated infections by improving compliance to aseptic non-touch technique in intravenous line maintenance: a quality improvement approach. *BMJ Open Quality*, *10*(Suppl 1), e001394.
88. Smallwood, N., Harrex, W., Rees, M., Willis, K., & Bennett, C. M. (2022). COVID-19 infection and the broader impacts of the pandemic on healthcare workers. *Respirology*, *27*(6), 411-426.
89. Stewart, S., Robertson, C., Pan, J., Kennedy, S., Haahr, L., Manoukian, S., & Reilly, J. (2021). Impact of healthcare-associated infection on length of stay. *Journal of Hospital Infection*, *114*, 23-31.
90. Tan, H., Wong, K. Y., Othman, M. H. D., Kek, H. Y., Nyakuma, B. B., Ho, W. S., ... & Yatim, A. S. (2023). Why do ventilation strategies matter in controlling infectious airborne particles? A comprehensive numerical analysis in isolation ward. *Building and Environment*, *231*, 110048.
91. Tariq, A., Lancaster, L., Elugunti, P., Siebeneck, E., Noe, K., Borah, B., & Patel, B. N. (2023). Graph convolutional network-based fusion model to predict risk of hospital acquired infections. *Journal of the American Medical Informatics Association*, *30*(6), 1056-1067.
92. Tartari, E., Tomczyk, S., Pires, D., Zayed, B., Rehse, A. C., Kariyo, P., & Allegranzi, B. (2021). Implementation of the infection prevention and control core components at the national level: a global situational analysis. *Journal of Hospital Infection*, *108*, 94-103.
93. Tchouaket Nguemeleu, E., Boivin, S., Robins, S., Sia, D., Kilpatrick, K., Brousseau, S., & Parisien, N. (2020). Development and validation of a time and motion guide to assess the costs of prevention and control interventions for nosocomial infections: A Delphi method among experts. *PloS one*, *15*(11), e0242212.
94. Tchouaket, E. N., Kruglova, K., Beogo, I., Sia, D., Robins, S., Bélanger, E., & Létourneau, J. (2022). Economic evaluation of healthcare-associated infection prevention and control in long-term care: a systematic review protocol. *Systematic reviews*, *11*(1), 261.
95. Thandar, M. M., Matsuoka, S., Rahman, O., Ota, E., & Baba, T. (2021). Infection control teams for reducing healthcare-associated infections in hospitals and other healthcare settings: a protocol for systematic review. *BMJ open*, *11*(3), e044971.
96. Thandar, M. M., Matsuoka, S., Rahman, O., Ota, E., & Baba, T. (2021). Protocol: Infection control teams for reducing healthcare-associated infections in hospitals and other healthcare settings: a protocol for systematic review. *BMJ Open*, *11*(3).
97. Thandar, M. M., Rahman, M. O., Haruyama, R., Matsuoka, S., Okawa, S., Moriyama, J., & Baba, T. (2022). Effectiveness of infection control teams in reducing healthcare-associated infections: a systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, *19*(24), 17075.
98. Tomczyk, S., Twyman, A., de Kraker, M. E., Rehse, A. P. C., Tartari, E., Toledo, J. P., ... & Allegranzi, B. (2022). The first WHO global survey on infection prevention and control in health-care facilities. *The Lancet Infectious Diseases*, *22*(6), 845-856.
99. Truong, C. B. (2023, July). Progress of Investment Projects in Civil and Industrial Construction. In *International Conference on Interdisciplinary Approaches in Civil Engineering for Sustainable Development* (pp. 581-592). Singapore: Springer Nature Singapore.
100. Van Mourik, M. S., van Rooden, S. M., Abbas, M., Aspevall, O., Astagneau, P., Bonten, M. J., & Gastmeier, P. (2021). PRAISE: providing a roadmap for automated infection surveillance in Europe. *Clinical Microbiology and Infection*, *27*, S3-S19.
101. Viksne, R., Racenis, K., Broks, R., Balode, A. O., Kise, L., & Kroica, J. (2023). In vitro assessment of biofilm production, antibacterial resistance of staphylococcus aureus, Klebsiella pneumoniae,

Pseudomonas aeruginosa, and Acinetobacter spp. obtained from tonsillar crypts of healthy adults. *Microorganisms*, *11*(2), 258.
102. Voidazan, S., Albu, S., Toth, R., Grigorescu, B., Rachita, A., & Moldovan, I. (2020). Healthcare associated infections—a new pathology in medical practice? *International journal of environmental research and public health*, *17*(3), 760.
103. Wang, X., Liu, C., Du, Y., Wang, D., & Zhang, X. (2023). Do knowledge, attitudes, and barrier perception affect the prevention and control of healthcare-associated infections? A structural equation modelling approach. *Infection and Drug Resistance*, 3051-3063.
104. Watkin, S., Ciric, L., Kiernan, M., & Cloutman-Green, E. (2023). A proposed classification system for opportunistic pathogens for improved healthcare infection prevention and control risk assessments. *Journal of Hospital Infection*, *135*, 206-207.
105. Weinberg, S. E., Villedieu, A., Bagdasarian, N., Karah, N., Teare, L., & Elamin, W. F. (2020). Control and management of multidrug resistant Acinetobacter baumannii: A review of the evidence and proposal of novel approaches. *Infection Prevention in Practice*, *2*(3), 100077.
106. Yokoe, D. S., Advani, S. D., Anderson, D. J., Babcock, H. M., Bell, M., Berenholtz, S. M., & Maragakis, L. L. (2023). Introduction to a compendium of strategies to prevent healthcare-associated infections in acute-care hospitals: 2022 updates. *Infection Control & Hospital Epidemiology*, *44*(10), 1533-1539.
107. Zhang, M., Wu, S., Ibrahim, M. I., Noor, S. S. M., & Mohammad, W. M. Z. W. (2024). Significance of ongoing training and professional development in optimizing healthcare-associated infection prevention and control. *Journal of Medical Signals & Sensors*, *14*(5), 14.
108. Zhou, Q., Gao, Y., Wang, X., Liu, R., Du, P., Wang, X., & Yang, K. (2020). Nosocomial infections among patients with COVID-19, SARS and MERS: a rapid review and meta-analysis. *Annals of Translational Medicine*, *8*(10).