

Hospital Microbial Contamination, Aseptic Technique Compliance, and Microbial Spread among Healthcare Workers: A Narrative Review

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Doi: 10.5281/zenodo.20678407

Received: 18 May 2026

Accepted: 27 May 2026

Abstract

Healthcare associated infections (HAIs) represent one of the primary challenges to healthcare systems worldwide and are associated with a high incidence of mortality, morbidity, long hospital stays and elevated healthcare costs. Hospital environments are potent sources of pathogenic microorganisms which spread through contaminated environmental surfaces, devices, airborne vectors and direct contact with health care professionals. Aseptic techniques including hand hygiene, sterilization, and the correct use of personal protective equipment are not implemented sufficiently by healthcare workers. Health care professionals themselves are central to the transmission of the microorganisms which may even lead to increased cases of infections from multidrug-resistant organisms such as MRSA and resistant Gram-negative bacteria. This narrative review will cover the principal microbial reservoirs of contamination found in hospitals, the extent to which healthcare professionals comply with aseptic techniques and spread of microbes within a hospital setting as well as the ever-increasing threat of antibiotic resistance. Effective infection prevention and control measures such as the disinfection of hospitals, encouraging hand hygiene, antimicrobial control and continuous worker education will be highlighted as strategies which may reduce the rate of healthcare associated infections.

Keywords

Hospital-acquired infections; microbial contamination; aseptic technique; healthcare workers; infection control; antimicrobial resistance; nosocomial infections; hand hygiene

Introduction

Hospital acquired infections (HAIs) are a huge burden for hospitals worldwide (World Health Organization, 2009). Hospitals can provide ideal environments for virulent organisms to thrive, and the organisms can be transmitted via infected surfaces, equipment, air, or unsterilised equipment (Dancer, 2014). Healthcare professionals can both spread the microorganisms as well as contribute to the spread of the microorganisms. Unsuccessful aseptic technique, failed hand hygiene, and non-sterilised equipment allow the microbial growth and spread of a range of multidrug-resistant organisms [8]

Staphylococcus aureus, *Pseudomonas aeruginosa*, *E. Coli*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii* are frequently encountered organisms causing HAIs. These organisms can transmit via direct contact, via aerosols or via surfaces or following invasive procedures, especially within intensive care and surgical wards. The review discusses contamination of hospital environment and observance of aseptic technique and transmission of the microorganisms between health professionals.[4]

Sources of hospital microbial contamination

The hospital is the most suitable environment for micro organisms to multiply and be transferred. Contamination in hospitals can arise from the inanimate surfaces, medical equipment, air, water and even from the health-care workers (Fig 1). Since a lot of invasive procedures are performed, high patient turnover and also the presence of antibiotics, there is a high microbial load in the hospital environments .[3]

Examples of inanimate surfaces in the hospital that contain pathogenic micro organisms includes bed rails, door handles, monitors, stethoscopes, keyboards, bedside tables etc. In the absence of adequate cleaning and disinfection, they may exist for a longer time in the hospital environment, which aids in indirect transmission .[4]

Medical devices such as urinary catheters, ventilators, endoscopes and surgical instruments can be implicated in infection when not adequately sterilized. Some of these devices are associated with common hospital acquired complications, examples are urinary catheters in CAUTI and ventilator devices in VAP.[7]

Airborne contamination is a source of micro organism transfer and can occur as a result of coughing, suctioning, nebulization and surgical operations, particularly in overcrowded, ill ventilated hospitals. Water and drainage systems can also carry opportunistic pathogens like *Pseudomonas* and *Legionella* spp.[5]

Health-care workers are one of the key vehicles that can transfer microorganisms on their hands, gloves, clothing and personal belongings such as mobile phones, ID badges and stethoscopes, all of which are known to carry multi-drug resistant organisms .

These many contamination sources confirm the necessity of adequate cleaning, sterilization, surveillance and infection prevention strategies in hospitals.[3]

Healthcare Workers' adherence to Aseptic Technique

Basic components of aseptic technique in clinical settings are Hand Hygiene, Maintenance of sterile field, Sterilization of instruments, correct use of personal protection equipment and safe disposal of infected wastes (World Health Organization, 2009). Hand hygiene although important for preventing microorganism's transmission to other clients is still poorly practiced by many professionals in healthcare settings. [8]

Lack of trained staff due to workload, insufficient staff facilities and training, emergency care of patients, lack of resources are the cause of poor aseptic practice compliance. Healthcare-associated infection and multi-drug resistant organisms are likely to spread due to poor glove use, lack of sterilization and disinfection.[2]

Staff should be provided with education and training; audits and feedback should be conducted and institutional support must be promoted for better aseptic standards and infection control practices .[6]

Role of Healthcare Workers in microbial dissemination

The role of healthcare workers in the transmission of microorganisms within the hospital is high due to the constant direct contact with patients, potentially contaminated materials, medical equipment and body fluids. The inability of healthcare workers to properly adhere to guidelines related to infection control practice would elevate health care-associated infections significantly.[7]

Hands have been the prime source of microbial transmission. From a patient's examination, dressing change or simply when handling contaminated equipment and pathogens would spread from one area to another in the absence of the necessary hand hygiene (Kramer et al., 2006). Pathogens would be also introduced onto gloves, gowns, stethoscopes, IDs, cell phones and others used in personal capacity. Multiple studies have shown that frequently used medical items like identification badges, stethoscopes, cell phones and even lab coats are colonized by the multidrug-resistant organism (MRSA) .[4]

Some procedures which introduce the pathogen directly into the body such as catheterization, intravenous line, surgery, respiration therapy have to be done under strictly sterile conditions. Besides that, healthcare workers themselves could be carriers for organisms like *Staphylococcus aureus* which have caused an outbreak in the hospital especially in the intensive care unit and surgical ward .[5]

Increase in the staff education/training related to infection control practice, improved hands hygiene compliance rate, the necessity of routinely disinfecting the equipment and the program of surveillance systems are highly necessary to reduce microbial transmission in the hospital.[6]

Frequent pathogens and Antimicrobial Resistance

HAIs are caused by a range of pathogens found within the healthcare environment. These include bacteria, fungi, viruses, and opportunistic pathogens that can remain viable on surfaces and equipment for an extended period. With the increased incidence of AMR, infection control methods have become more complex.[9]

Common pathogenic bacteria that have been documented as causes of significant HAIs include *Staphylococcus aureus* strains such as MRSA and VRE. Enterococci, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* are major causes of UTIs, VAT pneumonia, bloodstream and surgical site infections, and frequently produce organisms such as ESBLs and carbapenemase producers (multidrug resistant pathogens) (Kampf, 2018). Increasingly, fungi such as *Candida* species are being documented in immunocompromised critically ill patients. Antibiotic overuse and lack of rational antibiotic stewardship, along with the possible transmission from surfaces, equipment, and staff in the environment lead to the increased spread of AMR .[10]

The impact of increasing resistance includes treatment failure, increased length of stay and mortality and healthcare costs and therefore the need for robust infection control, surveillance and antibiotic use.[10]

Common Pathogens and Antimicrobial Resistance

There are several different types of microorganisms found within a hospital that cause HAIs. The bacteria, viruses, fungi and opportunistic pathogens may persist on medical devices and hospital surfaces for an extended period. The increasing problem of antimicrobial resistance has become one of the foremost global health crises that pose serious treatment and prevention challenges. Bacterial pathogens: *Staphylococcus aureus* (especially methicillin resistant *Staphylococcus aureus* MRSA) has been linked to wound, blood stream, and pneumonia infections. [9]

Enterococci species (especially vancomycin resistant enterococci VRE) contribute to many hospital-acquired infections and also exhibit multiresistance. Gram-negative bacteria: *E. Coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* cause urinary tract, ventilator-associated pneumonia, blood stream, surgical site infections and may produce extended spectrum B-lactamases (ESBLs) and carbapenemases. Fungal pathogens: *Candida* species have recently gained notoriety amongst the immunosuppressed and the critically ill and are becoming increasingly prevalent causes of invasive infections.[10]

Excessive and inappropriate use of antibiotics in healthcare environments leads to increased resistance and rapid rise of multiple resistant organism due to overuse of broad-spectrum drugs, suboptimal treatment, and lack of antimicrobial stewardship where pathogens persist and thrive through inappropriate hygiene standards of surfaces and medical devices; and via patients and healthcare workers. The effects of the increased prevalence of resistance organisms are failure of therapy, increased duration of hospitalisation and healthcare costs, as well as increased mortality.[10]

Infection Prevention and Control Strategies

Hospital acquired contamination and infection control should also be incorporated as the hospital standard and as essential in the management of healthcare acquired infections. Hand hygiene is the simple and effective method to break the chain of transmission of microbes between patients and healthcare providers and is crucial in achieving hospital-based infection control.[2]

The hospital environment should be properly cleaned and disinfected, sterilization of re-usable medical devices and surgical instruments should also be implemented in efforts to avoid devices acquired infections and control the spread of multidrug resistant organisms (MDROs). Personal protective equipment such as gloves, masks, gowns, and face shields are useful in breaking the chain of microorganisms' transmission to and from patients and healthcare workers. Institution education, observation, awareness campaigns and the support from the hospital would be very important in the successful completion of the hospital guidelines for infection control. [7]

Surveillance programs for MDROs and HAI are important to detect outbreaks quickly and in tracking diseases (World Health Organization, 2009). Antimicrobial use programs may help to control spread of MDROs. Future technology can be implemented to minimize infection acquisition. Innovations such as UV light sterilization devices, antimicrobial coated medical devices and automated patient tracking systems are beneficial in terms of improving hospital-based infection control practices .[8]

Future directions

The field of infection prevention and control will still play a very significant role in the future to control microbial contamination in hospitals and the rate of hospital-acquired infections. Advances in technology, sophisticated tracking techniques and an increased understanding of antibiotic resistance will lead to the adoption of better infection control strategies in hospitals.[10]

Artificial intelligence and digital surveillance tools used to detect early infection proliferation and also for the tracking of adherence to aseptic techniques by health-care providers will be implemented more widely. Automated hand washing sensors, electronic surveillance techniques, and prediction algorithms will lead to higher adherence to infection prevention practices and efficient treatment of outbreaks. Innovative antimicrobial surfaces and self-disinfecting materials, including copper-coated surfaces, UVC cleaning tools and antimicrobial polymers, are other innovative strategies to reduce contamination in hospitals. [7]

Ventilation, air filters and negatively-pressurized environment in hospitals as part of an effective infection control system should also be emphasized. Sustained educational and behavioral training programs, simulator training, competency assessments and reaffirmation of aseptic technique will continue to be an important approach for long-term adherence by health-care providers. [6]

The investigation of new approaches to control antibiotic-resistant microorganisms by bacteriophage therapy, antimicrobial peptides, probiotics and nanobiotechnology-based therapies are raising a lot of interest among scientists. Global collaboration, enhanced infection surveillance networks and improved antimicrobial stewardship are also

going to play a very significant role to contain antibiotic resistance. Future health-care policies and strategies will focus on economically effective infection control and the efficient application of resources and optimal practices.[10]

Conclusion

Despite the advent of many new technological interventions, hospital contamination and lack of asepsis compliance along with microbe carrying behavior by healthcare providers in healthcare environments is a significant problem across the globe. Hospital surfaces, instruments, aerosols from the environment or patient, and soiled hands are important sources of pathogen dissemination.[3]

The role of health care personnel as vehicles for either infection dissemination or control is critical, and observance of infection control procedures and aseptic practices is vital. Ineffective hand washing, sterilization processes and the incorrect use of protective equipment in the health care facilities facilitate the propagation of health care associated infections.[2]

Multi-drug resistance in pathogens has recently brought to the forefront the crucial role that infection control and antimicrobial stewardship efforts should be afforded in health care facilities, and environmental disinfection along with aseptic training and infection surveillance, antibiotic stewardship, and repetitive health care worker training are crucial for diminishing hospital contamination. Technology such as automated surveillance devices and anti-microbial surfaces should be utilized where applicable to improve infection control and patient safety is the main goal and is achieved through evidence-based, multidisciplinary approach.[10]

Conflict of Interest

No conflict of interest was disclosed by the authors.

Funding Statement

The authors confirm that no funding was received for this work.

Ethical Consideration

This is a narrative review of literature that has been published already so was not required to obtain ethical approval. Optional:

Acknowledgment

The authors would like to acknowledge the work of researchers and healthcare professionals that has resulted in the published material that forms this review.

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