Sterilization and Disinfection: Key Responsibilities of Nurses in Preventing Healthcare-Associated Infections (Hais)

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***Abstract*:**

Sterilization and disinfection are critical processes in healthcare settings aimed at preventing healthcare-associated infections (HAIs), which pose significant risks to patient safety. Nurses play a pivotal role in maintaining these standards by ensuring that medical instruments and surfaces are either sterilized or appropriately disinfected before and after use. This involves adhering to established protocols, such as using autoclaves for sterilization or antiseptic solutions for disinfection, and verifying the effectiveness of these methods through regular training and adherence to infection control guidelines. Moreover, nurses are responsible for educating patients and other healthcare staff about the importance of these practices, thereby fostering a culture of safety and vigilance within the healthcare environment. In addition to direct actions related to sterilization and disinfection, nurses must also engage in ongoing surveillance and reporting of HAIs to identify trends and potential outbreaks. This responsibility includes monitoring compliance with infection control practices, participating in quality improvement initiatives, and implementing evidence-based strategies to reduce infection rates. Effective communication and teamwork are essential, as nurses collaborate with infection prevention specialists and other healthcare professionals to ensure comprehensive care that minimizes risks. By proactively addressing sterilization and disinfection practices, nurses not only protect their patients but also contribute to the overall integrity and safety of the healthcare system.

***Keywords*:** Sterilization, disinfection, healthcare-associated infections (HAIs), nurses' responsibilities, infection control, patient safety, medical instruments, antiseptic solutions, education

Introduction:

In contemporary healthcare settings, the fight against healthcare-associated infections (HAIs) has become a paramount concern for medical professionals, particularly nurses, who play a critical role in infection prevention and control. HAIs, which are infections acquired by patients during the course of receiving treatment for other conditions within a healthcare environment, pose significant risks to patient safety and public health [1]. According to the Centers for Disease Control and Prevention (CDC), HAIs account for an estimated 1 in 31 hospitalized patients in the United States, leading to extended hospital stays, increased healthcare costs, and higher morbidity and mortality rates. As such, nurses are entrusted with the pivotal task of preventing these infections through rigorous protocols of sterilization and disinfection, ensuring the integrity of patient care within various healthcare settings [2].

Sterilization and disinfection represent two fundamental concepts in the domain of infection control, each encompassing a diverse range of practices and techniques aimed at eliminating pathogens from surfaces, instruments, and environments. Sterilization refers to the complete eradication of all forms of microbial life, including bacterial spores, while disinfection pertains to the use of antimicrobial agents to significantly reduce the presence of pathogenic microorganisms on inanimate objects or surfaces [3]. Given the critical nature of these processes, nurses are often at the forefront of implementing and adhering to effective sterilization and disinfection protocols. Their responsibilities extend beyond standard practices, requiring a comprehensive understanding of microbiology, infection prevention guidelines, and the appropriate use of sterilization and disinfection methods specific to varied clinical situations [2].

The role of nurses in preventing HAIs through effective sterilization and disinfection practices is multifaceted. It encompasses direct patient care responsibilities, as well as the maintenance of a safe healthcare environment. Nurses are tasked with ensuring that medical equipment is properly sterilized before procedures, implementing high-level disinfection for semi-critical instruments, and monitoring the cleanliness of patient care areas. Furthermore, they must educate patients and their families about the importance of maintaining hygiene, such as handwashing, which serves as the first line of defense against HAIs. The integration of these practices into patient care not only reduces the risk of infection but also fosters a culture of safety and accountability within healthcare institutions [4].

Despite the importance of sterilization and disinfection, challenges persist within healthcare settings that can hinder the effectiveness of these critical measures. Factors such as inadequate staffing, the high turnover of nursing personnel, varied levels of training and education, and inconsistent adherence to infection prevention guidelines can undermine the efforts to combat HAIs. Moreover, the emergence of antibiotic-resistant organisms has complicated the landscape of infection control, necessitating an increased emphasis on preventive protocols. Addressing these issues is vital for nurses to fulfill their responsibilities effectively, thereby enhancing patient outcomes and the overall quality of healthcare [5].

The Importance of Sterilization and Disinfection in Healthcare Settings

The rationale for strict sterilization and disinfection protocols in healthcare settings is rooted in the understanding of how infectious diseases are transmitted. Many pathogens are capable of surviving on surfaces and medical instruments for extended periods, posing a significant risk for selection and transmission among patients and healthcare providers. HAIs can lead not only to prolonged hospital stays and increased medical expenses but also to significant morbidity and mortality [6].

According to the World Health Organization, hundreds of millions of patients worldwide develop infections as a result of receiving care. These infections can originate in multiple contexts: surgical procedures, the use of indwelling catheters, ventilators, and other clinical interventions. The role of effective sterilization and disinfection is integral in addressing these infection risks. By systematically eradicating potential pathogens, healthcare facilities can mitigate the risk of HAIs, thus preserving patient health and enhancing clinical outcomes [7].

The steps involved in establishing a rigorous sterilization and disinfection process can be categorized into several key methodologies.

1. **Cleaning:** This is the initial step in preventing infection and involves the removal of visible debris and organic material from surfaces and instruments. Effective cleaning is critical because contaminants can shield microorganisms from disinfection processes [8].

2. **Disinfection:** Once cleaning has occurred, disinfection processes are employed using appropriate agents tailored to the type of surface and degree of contamination. The efficacy of disinfectants is influenced by factors such as concentration, contact time, and environmental conditions [9].

3. **Sterilization:** For instruments that pose a higher risk of infection due to invasive procedures, sterilization must follow disinfection. Various sterilization methods—including steam under pressure, ethylene oxide gas, and radiation—must be carefully selected based on the material and type of the instrumentation involved [10].

4. **Monitoring and Quality Control:** Continuous monitoring of the sterilization and disinfection processes is essential. Biological indicators, chemical indicators, and environmental monitoring can help ascertain the effectiveness of these processes, ensuring compliance with safety standards and regulations [7].

Despite the well-established importance of sterilization and disinfection, healthcare settings face multiple challenges in implementing these practices consistently. One of the primary hurdles is the increasing prevalence of antibiotic-resistant organisms, colloquially known as "superbugs." These organisms require higher concentrations of disinfectants or more aggressive sterilization techniques to be effectively eliminated, necessitating advancements in methods and technologies [9].

Moreover, human factors—such as adherence to protocols and staff training—are critical components of successful sterilization and disinfection strategies. Inadequate staff education and inconsistent practices can lead to lapses in infection control, resulting in potential outbreaks within healthcare facilities [10].

Responsibilities of Nurses in Infection Control

1. **Adherence to Standard Precautions**: Nurses must consistently follow standard precautions, which include hand hygiene, the use of personal protective equipment (PPE), and safe injection practices. Hand hygiene is particularly crucial; studies indicate that proper handwashing can significantly reduce the transmission of pathogens. Nurses are responsible for ensuring that these precautions are adhered to not only by themselves but also by other healthcare professionals and caregivers [11].

2. **Surveillance of Infections**: Nurses are usually the first to notice signs of infection in patients. They play a critical role in monitoring patients for symptoms such as fever, inflammation, and unusual discharge. Effective surveillance entails meticulous documentation of any observed changes in a patient's condition and timely reporting to the healthcare team, which can facilitate early diagnosis and management of infections [12].

3. **Education and Training**: Another vital responsibility of nurses in infection control is educating patients, families, and other healthcare staff on various infection prevention strategies. This can include educating patients about postoperative care, proper wound hygiene, and the importance of completing prescribed antibiotic regimens. Nurses also have the responsibility to educate fellow staff members about infection control policies and best practices through training sessions and ongoing mentorship [13].

4. **Implementing Infection Control Protocols**: Nurses are pivotal in the development and implementation of infection control policies within healthcare facilities. They must be well-versed in guidelines established by organizations such as the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO). Nurses are tasked with ensuring that these protocols are followed diligently within their practice areas, which often involves conducting regular audits and providing feedback to improve practices when necessary [11].

5. **Managing Medical Devices**: The use of medical devices, such as catheters and ventilators, presents a significant risk of infection. Nurses are responsible for the proper insertion, maintenance, and removal of these devices. This includes adhering

to sterile techniques, conducting regular assessments for signs of infection, and ensuring that devices are used only when necessary to minimize associated risks [14].

6. **Outbreak Response and Investigation**: In the event of an infection outbreak, nurses are on the front lines of response. They assist in the investigation of the outbreak to identify sources and transmission routes while also implementing immediate measures to control its spread. This responsibility may involve coordinating with infection control teams and public health officials to track infection patterns and ensure that containment strategies are effectively executed [15].

7. **Advocacy for Patient Safety**: Nurses serve as advocates for patient safety and quality of care. They must communicate effectively with the healthcare team to highlight infection control concerns, promoting a culture of safety and vigilance. This responsibility involves encouraging open dialogue about potential risks and advocating for necessary resources, such as access to PPE or improved sanitation measures [13].

8. **Continuous Professional Development**: The field of infection control is constantly evolving as new pathogens emerge and evidence-based practices are updated. Nurses must engage in continuous education and training to stay informed of the latest infection control techniques, policies, and guidelines. This commitment to professional development enables nurses to provide the best care possible and to elevate the standards of infection control within their institutions [11].

Common Sterilization Methods

1. Heat Sterilization

Heat sterilization is one of the oldest and most widely used methods. It primarily involves two techniques: moist heat and dry heat.

- **Moist Heat Sterilization:** This technique employs steam under pressure to kill microorganisms. It is commonly performed using an autoclave, which operates by raising the temperature of steam beyond 100°C. The most accepted parameters for effective sterilization include maintaining 121°C for 15 minutes or 134°C for 3 minutes. The moist heat method is effective because the high temperature denatures proteins and enzymes critical for microbial survival [16].
- **Dry Heat Sterilization:** Unlike moist heat, dry heat sterilization operates at higher temperatures but lower moisture levels, typically around 160°C to 180°C for a duration of 2 to 4 hours. This technique is less efficient than moist heat because it requires longer exposure times to achieve the same level of microbial kill. The mechanism primarily involves the oxidation of microbial components [17].

2. Chemical Sterilization

Chemical sterilization utilizes specific chemical agents to eliminate microorganisms. Common agents include ethylene oxide (EO), hydrogen peroxide, and formaldehyde.

- **Ethylene Oxide Sterilization:** Ethylene oxide is used at low temperatures and is particularly effective for heat-sensitive medical instruments. The gas penetrates packaging, leading to microbial lethality through alkylation of DNA and proteins. The process can take several hours due to the need for aeration afterward to remove residues [18].
- **Hydrogen Peroxide Sterilization:** This method employs vaporized hydrogen peroxide to sterilize surfaces and instruments. It is effective against a broad spectrum of microbes and is increasingly preferred due to its environmentally friendly profile. The process involves the vaporization of hydrogen peroxide, which then undergoes hydrolysis to form reactive hydroxyl radicals that damage microbial components [19].
- **Liquid Chemical Sterilization:** Liquid chemical agents, such as glutaraldehyde, can also be used. Items are immersed in a solution for a specified time, yielding effective sterilization. However, the need for proper rinse and disposal practices can add complexity to this method [12].

3. Radiation Sterilization

Radiation sterilization involves the use of ionizing radiation, such as gamma rays, electron beams, or X-rays, which can penetrate packages and deactivate microorganisms.

- **Gamma Radiation:** This technique is widely used in the sterilization of disposable medical supplies and food products. Gamma rays penetrate deeply and alter the DNA structure of microorganisms, leading to their inactivation. This

method allows for the sterilization of large volumes of products quickly [20].

- **Electron Beam:** Electron beam sterilization provides a rapid and effective method for sterilizing products. It involves the use of high-energy electrons to disrupt the DNA of the organisms present. The equipment needed for this method is more complex and costly than that for gamma irradiation [21].

4. Filtration Sterilization

Filtration sterilization is often applicable in liquid and gas purification. It involves passing substances through a filter with pores small enough to trap bacteria and viruses.

- **Membrane Filters:** Typically with pore sizes of 0.22 micrometers, these filters are effective for sterilizing heat-sensitive liquids and are widely used in the pharmaceutical industry to ensure product sterility [22].

Best Practices in Sterilization

1. Validation and Monitoring

Validation and monitoring are foundational elements of any sterilization process. Validation refers to the systematic approach used to ensure that the sterilization method consistently achieves the desired level of microbial kill. This is typically accomplished through the use of biological indicators, such as bacterial spores, which are known for their resistance to sterilization processes. By placing these indicators in the sterilization load and subsequently culturing them post-process, facilities can confirm that the sterilization conditions were effective [23].

In addition to biological indicators, routine monitoring of critical parameters—such as temperature, pressure, and time—is essential for maintaining process reliability. Each sterilization method, whether steam, ethylene oxide, or dry heat, has specific parameters that must be met to ensure effective sterilization. Regular monitoring not only helps in identifying deviations from these parameters but also aids in the early detection of potential equipment malfunctions. Implementing a robust validation and monitoring system ensures that the sterilization process is both effective and reproducible [24].

2. Proper Packaging

Proper packaging is another crucial aspect of the sterilization process. The choice of sterilization packaging must consider the specific sterilization method employed, as well as the nature of the items being sterilized. Packaging materials should be designed to withstand the rigors of the sterilization process while maintaining their integrity during handling and storage. This means that the materials must be compatible with the sterilizing agent, whether it be steam, gas, or radiation [12].

Moreover, effective sterilization packaging must allow for the penetration of the sterilizing agent while providing a barrier to contaminants. For example, steam sterilization requires porous packaging to enable steam penetration, while ethylene oxide sterilization may utilize gas-permeable materials. It is also essential to ensure that the packaging is sealed properly to prevent recontamination after sterilization. By selecting appropriate packaging and ensuring its integrity, facilities can significantly enhance the effectiveness of the sterilization process [23].

3. Cleaning and Decontamination

Before any sterilization process can take place, thorough cleaning and decontamination of instruments and surfaces is imperative. Cleaning involves the removal of organic material, dirt, and biofilm, all of which can shield microorganisms and reduce the efficacy of the sterilization process. Residual organic matter can protect bacteria from the effects of sterilization, leading to inadequate microbial kill rates [25].

To achieve effective cleaning, a multi-step approach is often employed. This may include pre-soaking instruments in enzymatic cleaners, followed by manual cleaning or the use of ultrasonic cleaners. After cleaning, instruments should be rinsed and dried thoroughly to remove any remaining cleaning agents that could interfere with sterilization. By prioritizing cleaning and decontamination, facilities can ensure that the sterilization process is applied to clean surfaces, thereby maximizing its effectiveness [26].

4. Training and Protocol Development

The development and implementation of standard operating procedures (SOPs) for sterilization processes are vital for ensuring consistency and reliability. SOPs should outline every step of the

sterilization process, including cleaning, packaging, sterilization parameters, and post-sterilization handling. These procedures should be based on current guidelines and best practices from reputable organizations, such as the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) [18].

Training staff on these protocols is equally important. Personnel involved in sterilization must be well-versed in the SOPs to ensure that they can carry out the processes effectively and with confidence. Regular training sessions and assessments can help reinforce knowledge and skills, ensuring that all staff members are up to date with the latest practices and technologies. By investing in training and protocol development, facilities can enhance the overall quality and safety of their sterilization processes [22].

5. Documentation

Accurate documentation is a critical component of effective sterilization practices. Maintaining detailed logs of sterilization cycles, including the parameters used and outcomes, not only aids in troubleshooting potential issues but also ensures regulatory compliance. Documentation should include information such as the date and time of sterilization, the operator's name, the type of sterilization method used, and the results of biological indicator testing [27].

In addition to serving as a record for compliance and quality assurance, thorough documentation can also provide valuable insights for continuous improvement. By analyzing trends and patterns in sterilization data, facilities can identify areas for enhancement and implement corrective actions as needed. This proactive approach to documentation fosters a culture of accountability and quality within the organization [26].

The Importance of Infection Prevention Education

Infection prevention is a fundamental aspect of nursing practice, directly influencing patient outcomes and the broader healthcare environment. HAIs remain a significant challenge, contributing to morbidity, prolonged hospital stays, and increased healthcare costs. According to the Centers for Disease Control and Prevention (CDC), approximately 1 in 31 hospital patients has at least one healthcare-associated infection on any given day. As frontline healthcare providers, nurses play a crucial role in minimizing the risk of infections through adherence to established protocols and guidelines [28].

Moreover, effective infection prevention education empowers nursing staff with the knowledge and skills necessary to implement evidence-based practices. This education fosters a culture of safety and accountability within healthcare settings, encouraging nurses to be proactive in identifying and mitigating risks associated with infections. The World Health Organization (WHO) advocates for ongoing training, emphasizing that well-educated nursing staff is essential for the success of infection control programs worldwide [29].

Effective training programs for nursing staff on infection prevention encompass several key components:

1. **Understanding Microbiology and Pathways of Infection**: A foundational aspect of infection prevention education is a thorough understanding of the microorganisms that can cause infections, including bacteria, viruses, fungi, and parasites. Nurses must grasp how these pathogens are transmitted—whether through direct contact, droplets, or fomites—to recognize potential risks in various clinical scenarios [30].

2. **Standard and Transmission-Based Precautions**: Nurses must be well-versed in standard precautions applicable to all patient interactions, including hand hygiene, use of personal protective equipment (PPE), and safe injection practices. Additionally, education on transmission-based precautions—specifically designed for certain pathogens, such as airborne or contact precautions—ensures that nursing staff can implement appropriate measures based on patient risk assessments [31].

3. **Surveillance and Data Reporting**: Training should also emphasize the importance of infection surveillance. Nurses should be trained to recognize and report signs of infections promptly. Understanding surveillance systems and participating in data reporting contributes to the identification of infection trends, ultimately helping in the development of targeted prevention strategies [29].

4. **Handling of Medical Equipment and Waste**: Proper training in cleaning, disinfecting, and sterilizing medical equipment is essential. Nurses should be educated on protocols for handling and disposing of biohazardous waste, understanding that improper practices can lead to outbreaks of infection [14].

5. **Patient and Family Education**: Infection prevention is not solely the responsibility of healthcare providers; patients and their families must be educated about infection risks and prevention strategies. Training nursing staff to communicate effectively about these topics enhances the overall safety culture [6].

Implementing effective training methodologies is essential to ensure that nursing staff fully grasp the complexities of infection prevention. Some effective strategies include:

1. **Interactive Learning**: Traditional lecture-based training can be enhanced by incorporating interactive learning techniques, such as simulations, role-playing, and group discussions. These methods engage nursing staff and allow them to practice skills in a controlled environment [30].

2. **E-Learning Modules**: The rise of technology in education provides opportunities for nurses to access online courses and modules that offer flexibility and convenience. E-learning can accommodate various learning styles and facilitate continuous education without the constraints of traditional classroom settings [31].

3. **Regular Workshops and Refresher Courses**: Host regular workshops where nursing staff can refresh their knowledge and skills related to infection prevention. These sessions should also provide updates on the latest guidelines and recommendations from public health organizations [32].

4. **Multidisciplinary Training**: Collaborating with other healthcare professionals, such as infection control practitioners, pharmacists, and epidemiologists, fosters a team-based approach to infection prevention. Multidisciplinary training encourages a holistic understanding of infection prevention within the healthcare setting [33].

5. **Monitoring and Assessment**: Ongoing assessment of nursing practices related to infection prevention is essential. Utilizing tools such as audits and observational assessments helps determine the effectiveness of training programs. Feedback from these assessments can inform future training initiatives [34].

Conclusion:

In conclusion, the roles of nurses in sterilization and disinfection processes are integral to the prevention of healthcare-associated infections (HAIs) and the overall safety of patients in healthcare settings. By meticulously adhering to established protocols, participating in ongoing education, and fostering a culture of infection control, nurses not only protect their patients but also contribute significantly to the healthcare system's efficacy. Their responsibilities extend beyond the direct application of sterilization and disinfection techniques; they also encompass vigilant monitoring, reporting of infection trends, and collaboration with multidisciplinary teams. As healthcare continues to evolve, ongoing training and adaptation to emerging challenges in infection prevention will be essential. By prioritizing these practices, nurses serve as frontline defenders against HAIs, ultimately enhancing patient outcomes and sustaining the integrity of healthcare environments.

References:

1. Spach D.H., Silverstein F.E., Stamm W.E. Transmission of infection by gastrointestinal endoscopy and bronchoscopy. Ann Intern Med. 1993;118:117–128. doi: 10.7326/0003-4819-118-2-199301150-00008.
2. Mathur P. Hospital acquired infections prevention and control. 1st ed. Lippicott Williams & Wilkins; Philadelphia (PA): 2010.
3. Gillespie T.G., Hogg L., Budge E., Duncan A., Coia J.E. Mycobacterium chelonae isolated from rinse water within an endoscope washer-disinfector. J Hosp Infect. 2000;45:332–334. doi: 10.1053/jhin.2000.0782.
4. Rutala W.A., Waber D.J. New disinfection and sterilization methods. Emerg Infect Dis. 2001;7(2):348–353. doi: 10.3201/eid0702.010241.
5. Belay E.D., Schonberger L.B. The public health impact of prion diseases. Annu Rev Public Health. 2005;26:191–212. doi: 10.1146/annurev.publhealth.26.021304.144536.
6. Collins S.J., Lawson V.A., Masters C.L. Transmissible spongiform encephalopathies. Lancet. 2004;363:51–61. doi: 10.1016/S0140-6736(03)15171-9.
7. Rutala W.A., Weber D.J. Guideline for disinfection and sterilization of prion-contaminated medical instruments. Infect Control Hosp Epidemiol. 2010;31:107–117. doi: 10.1086/650197.
8. Spaulding E.H. Chemical disinfection of medical and surgical materials. In: Lawrence C., Block S.S., editors. Disinfection, sterilization, and preservation. Lea & Febiger; Philadelphia (PA): 1968. pp. 517–531.
9. Weissmann C. Birth of a prion: spontaneous generation revisited. Cell. 2005;122:165–168. doi: 10.1016/j.cell.2005.07.001.
10. Biron F., Verrier B., Peyramond D. Transmission of the human immunodeficiency virus and hepatitis C virus. N Engl J Med. 1997;337:348–349. doi: 10.1056/NEJM199707313370515.
11. Sopwith W., Hart T., Garner P. Preventing infections from reusable medical equipment: a systematic review. BMC Infect Dis. 2002;2:4. doi: 10.1186/1471-2334-2-4.
12. Schelenz S., French G. An outbreak of multidrug-resistant Pseudomonas aeruginosa infection associated with contamination of bronchoscopes and an endoscope washer-disinfector. J Hosp Infect. 2000;46:23–30. doi: 10.1053/jhin.2000.0800.
13. Srinivasan A., Wolfenden L.L., Song K., Mackie T., Hartsell L., Jones H.D. An outbreak of Pseudomonas aeruginosa infections associated with flexible bronchoscopes. N Engl J Med. 2003;348:221–227. doi: 10.1056/NEJMoa021808.
14. Favero M.S., Bond W.W. Chemical disinfection of medical and surgical materials. In: Block S.S., editor. Disinfection, sterilization, and preservation. 5th ed. Lippincott Williams & Wilkins; Philadelphia (PA): 2001. pp. 881–917.
15. Ratula W.A., Weber J.A. Guidelines for disinfection and sterilization in health care facilities. CDC; Atlanta (GA): 2008.
16. CDC. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the healthcare infection control practices advisory committee (HICPAC). U.S. Department of Health and Human Services, CDC; Atlanta (GA): 2003.
17. Nelson D.B., Jarvis W.R., Rutala W.A., Foxx-Orenstein A.E., Isenberg G., Dash G.R. Multi society guideline for reprocessing flexible endoscopes. Society for health care epidemiology of America. Infect Control Hosp Epidemiol. 2003;24:532–537. doi: 10.1086/502237.
18. Rutala W.A., Weber D.J. Disinfection and sterilization in health care facilities: what clinicians need to know. Clin Infect Dis. 2004;39:702–709. doi: 10.1086/423182.
19. Dancer S.J. Importance of the environment in the methicillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008;8:101–103. doi: 10.1016/S1473-3099(07)70241-4.

20. WHO. Practical guidelines for infection control in health care facilities. WHO; Geneva (Switzerland): 2003.

21. Nelson D.B., Muscarella L.F. Current issues in endoscope reprocessing and infection control during gastrointestinal endoscopy. World J Gastroenterol. 2006;12:3953–3964. doi: 10.3748/wjg.v12.i25.3953.

22. Ayeliff G.A.J., Fraise A.P., Geddes A.M., Michell K. Control of hospital infection. 4th ed. Arnold; New York: 2000.

23. Rutala W.A. APIC guideline for selection and use of disinfectants. AJIC Am J Infect Control. 1996;24:313–342. doi: 10.1016/s0196-6553(96)90066-8.

24. Alfa M.J., Jackson M.A. A new hydrogen peroxide-based medical-device detergent with germicidal properties: comparison with enzymatic cleaners. Am J Infect Control. 2001;29:168–177. doi: 10.1067/mic.2001.113616.

25. Hutchisson B., LeBlanc C. The truth and consequences of enzymatic detergents. Gastroenterol Nurs. 2005;28:372–376. doi: 10.1097/00001610-200509000-00003.

26. Culver D.A., Gordon S.M., Meheta A.C. Infection control in the bronchoscopy suite. Am J Resp Crit Care Med. 2003;24:532–537. doi: 10.1164/rccm.200208-797CC.

27. Laboratory centres for the Disease control Bureau of Infectious Diseases. Infection control guidelines. Communicable disease report. Laboratory centre for Disease control Bureau of Infectious Diseases; Ottawa (Canada): 1998.

28. Widmer A.F., Frei R. Decontamination, disinfection and sterilization. In: Pealler M.A., editor. The clinical microbiology laboratory in infection detection, prevention and control. 3rd ed. 2001.

29. Communicable Diseases Network Australia, The National Public Health Partnership and Australian Health Ministers' Advisory Council. Infection control guidelines for the prevention of transmission of infectious diseases in the healthcare setting. Canberra (Australia): January 2004.

30. Rutala W.A., Weber D.J. New developments in reprocessing semicritical items. Am J Infect Control. 2013;41:S60–S66. doi: 10.1016/j.ajic.2012.09.028.

31. Roberts C.G. Studies on the bioburden on medical devices and the importance of cleaning. In: Rutala W.A., editor. Disinfection, sterilization and antisepsis: principles and practices in healthcare facilities. Association for Professionals in Infection Control and Epidemiology; Washington (DC): 2001. pp. 63–69.

32. Schembre D.B. Infectious complications associated with gastrointestinal endoscopy. Gastrointest Endosc Clin N Am. 2000;10:215–232.

33. Rutala WA, Weber DJ. Guideline for Disinfection and Sterilization in Healthcare Facilities. Healthcare Infection Control Practices Advisory Committee (HICPAC). 2008. pp. 1–158.

34. Association of Anaesthetists of Great Britain and Ireland. Guidelines-Infection Control in Anaesthesia. Anaesthesia. 2008;63:1027–36. doi: 10.1111/j.1365-2044.2008.05657.x.