Challenges in Implementing Sterilization Protocols for Nurses in Low-Resource Settings

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Abstract:

Implementing sterilization protocols for nurses in low-resource settings presents numerous challenges that can compromise patient safety and the effectiveness of healthcare delivery. One significant issue is the lack of essential equipment and supplies, including autoclaves, disinfectants, and personal protective equipment (PPE). Many healthcare facilities in these regions operate with limited budgets, making it difficult to maintain stringent sterilization practices. Moreover, inadequate training and varying levels of knowledge among nursing staff about proper sterilization techniques can lead to inconsistent application of protocols. This situation is exacerbated by high patient loads, which can pressure nurses to prioritize speed over safety, increasing the risk of healthcare-associated infections. Another challenge lies in the cultural perceptions and practices surrounding sterilization and cleanliness in these settings. Misunderstandings about the importance of sterilization can hinder compliance with established protocols, leading to resistance from both staff and patients. Additionally, the infrastructure in low-resource areas often lacks reliable access to running water and electricity, critical components for effective sterilization practices. Addressing these issues requires tailored training programs, community engagement to shift cultural perceptions, and robust support from health organizations to provide necessary resources. Collaborative efforts are essential to develop sustainable, context-specific solutions that can improve adherence to sterilization protocols and enhance patient care outcomes.

Keywords:- Sterilization protocols, Low-resource settings, Nurse training, Healthcare-associated infections, Personal protective equipment (PPE), Infrastructure challenges, Cultural perceptions, Community engagement, Compliance, Patient safety.

Introduction:

The provision of healthcare in low-resource settings is fraught with challenges that affect the quality of care delivered to patients. Among these challenges, the implementation of sterilization protocols is crucial, especially in environments where invasive procedures are conducted. Sterilization is recognized globally as a fundamental process for infection control, aiming to eliminate all forms of microbial life, thereby reducing the incidence of healthcare-associated infections (HAIs). However, the implementation of these protocols faces significant hurdles, particularly in low-resource settings, where financial, infrastructural, and educational limitations prevail. This introduction seeks to underscore the challenges confronting nurses in these settings, highlighting the complexities entwined with sterilization practices [1].

Low-resource healthcare environments are often characterized by insufficient funding, inadequate infrastructure, and limited access to essential supplies. These factors can severely compromise the effectiveness of sterilization protocols, which rely heavily on the availability of resources such as sterilization equipment, disinfectants, and single-use medical supplies. Substandard facilities not equipped with modern sterilization technologies, such as autoclaves, pose a significant challenge. Instead, many healthcare settings may resort to outdated methods that are less effective and potentially dangerous. For example, the use of boiling water or chemical agents with inconsistent temperatures and concentrations can lead to incomplete sterilization, thereby increasing the risk of infection transmission among patients and healthcare workers alike [2].

In addition to material resource constraints, the workforce in low-resource settings often faces a steep gradient of educational challenges. Nurses and other healthcare professionals may not receive adequate training in infection control practices and sterilization protocols. This lack of training can foster a culture of negligence or complacency regarding adherence to safety standards. In many cases, nurses are left to navigate complex protocols with little guidance, leading to inconsistent practices that do not align with established public health recommendations. Furthermore, the pressures of high patient loads and understaffing exacerbate the situation, forcing nurses to prioritize immediate patient care over the adherence to sterilization protocols [3].

Moreover, cultural factors and local practices can play a significant role in shaping the implementation of sterilization protocols. In some low-resource settings, traditional beliefs and practices surrounding health and hygiene may conflict with established medical protocols. For instance, certain communities may place trust in alternative healing methods or may not fully understand the importance of sterilization in preventing infections. This can hinder the acceptance and compliance of sterilization practices among healthcare workers and patients alike, resulting in a disconnect between recommended protocols and community behaviors. The intersection of cultural beliefs with medical practices is a critical area that requires sensitive navigation by healthcare professionals, highlighting the need for culturally competent training and supportive strategies [4].

Another challenge lies in the sustainability of sterilization practices, which are often disrupted by natural disasters, political instability, or socioeconomic fluctuations. Such disruptions can lead to shortages of necessary supplies, breakages in equipment, or, worse, the evacuation of healthcare personnel from affected areas. Thus, maintaining a consistent and effective sterilization protocol in times of crisis becomes an insurmountable challenge for nurses working on the frontlines. Additionally, political and economic factors can strain governmental efforts to ensure that hospitals and clinics are equipped with the necessary resources for sterilization, further perpetuating a cycle of compromised care and heightened risk of infectious disease outbreaks [5].

The implications of poor sterilization practices in low-resource settings extend beyond individual patient care, affecting public health at a community level. Healthcare-associated infections can lead to prolonged hospital stays, increased healthcare costs, and higher morbidity and mortality rates. Consequently, this places an additional burden on already stretched healthcare systems while eroding public trust in health institutions. The public health repercussions of ineffective sterilization practices magnify the urgency of addressing the challenges that nurses face in implementing these protocols [6].

Understanding Low-Resource Settings and Their Unique Healthcare Challenges:

In a world that is increasingly connected, the disparity in healthcare access and quality across different regions remains a profound challenge. Low-resource settings—defined as regions characterized by limited financial, human, and material resources—present unique healthcare challenges that require both innovative solutions and compassionate responses. These environments include rural areas, marginalized urban populations, and entire countries that face socioeconomic disadvantages affecting the availability and effectiveness of healthcare services. Understanding the root causes of these challenges, their implications on health outcomes, and the potential strategies for addressing them is crucial for both public health officials and the global community [7].

Low-resource settings can be understood through a multifaceted lens encompassing economic, infrastructural, and social indicators. Economically, these regions may struggle with high poverty rates, low gross domestic product (GDP) per capita, and limited financial investments in healthcare. Infrastructurally, healthcare systems may suffer from inadequate facilities, shortages of medical supplies, and poorly maintained equipment. Socially, cultural norms, education levels, gender

roles, and political instability can all play roles in shaping health outcomes in these areas [8].

The World Health Organization (WHO) often emphasizes the importance of addressing the social determinants of health in low-resource settings. These determinants include conditions in which people are born, grow, live, work, and age. For instance, living in a low-resource setting can lead to inadequate nutrition, decreased educational opportunities, and limited access to essential services—including healthcare itself. Understanding these factors is key to addressing the healthcare challenges that are prevalent in these environments [9].

1. **Access to Care**: One of the most glaring challenges in low-resource settings is access to healthcare services. Geographic barriers, particularly in rural areas, can hinder individuals from reaching clinics or hospitals, often resulting in delayed treatment or complete avoidance of the health system. Additionally, economic barriers can lead to situations where individuals cannot afford transportation costs, fees for services, or necessary medications. In many cases, the lack of health insurance exacerbates the issue [10].
2. **Workforce Shortages**: Many low-resource settings face critical shortages of healthcare professionals. Factors contributing to this include low wages, poor working conditions, and inadequate training opportunities. For instance, the WHO estimates that there is a shortage of 18 million healthcare workers globally, with many of these voids located in low-resource regions. The absence of doctors, nurses, and allied health professionals often results in overwhelming patient loads and compromised patient care [10].
3. **Inadequate Infrastructure**: The infrastructure of healthcare facilities in low-resource settings often falls short of basic requirements. Hospitals and clinics may lack essential medical equipment, consistent electricity, clean water, and sanitation facilities. Such inadequacies pose serious risks, as they can lead to increased infection rates, poor surgical outcomes, and overall deterioration of patient health [11].
4. **Disease Burden**: Low-resource settings frequently bear a disproportionate burden of both communicable and non-communicable diseases. Infectious diseases such as malaria, tuberculosis, and HIV/AIDS continue to thrive due to insufficient prevention, diagnosis, and treatment efforts. Concurrently, there is a growing prevalence of non-communicable diseases — such as diabetes and cardiovascular issues — exacerbated by poor lifestyle choices, limited health education, and inadequate access to preventive services [11].
5. **Health Literacy**: The level of health literacy in low-resource settings can be critically low, leading to misunderstandings regarding disease prevention, treatment options, and the importance of seeking timely healthcare. Cultural beliefs and stigmas surrounding certain diseases can further compound this issue. Health education programs, when available, often lack the necessary resources or are inadequately implemented [12].
6. **Funding and Sustainability**: Financial constraints pose one of the most formidable barriers to healthcare in low-resource settings. Low public funding for health services leads to a reliance on external funding sources, such as international aid and donations, which can be unpredictable and unsustainable. This lack of financial support can limit long-term planning and investment in the healthcare infrastructure necessary for lasting improvements in health outcomes [13].

Strategies for Improvement

Addressing the unique healthcare challenges in low-resource settings requires a multifaceted approach aimed at improving access, quality, and equity in health services. Several strategies can be employed:

1. **Community Health Workers**: Integrating community health workers (CHWs) into healthcare delivery can bridge the gap in workforce shortages. These individuals, often native to the communities they serve, can provide basic health education, preventive services, and even emergency care, thereby reducing the burden on formal healthcare facilities [14].
2. **Telemedicine**: Advancements in technology offer innovative solutions to the challenges of distance and access to care. Telemedicine can facilitate consultations, diagnostics, and monitoring from afar, thereby expanding healthcare reach to

remote populations. However, it is essential to ensure that the necessary technological infrastructure is in place to support such initiatives [15].

3. **Investment in Infrastructure**: Prioritizing investment in healthcare infrastructure is crucial. This includes not only building and renovating healthcare facilities but also ensuring the availability of essential medical equipment and basic necessities such as water and sanitation. Government and private partnerships can play a pivotal role in directing resources toward these areas [16].
4. **Education and Training**: An emphasis on education and training is vital in addressing workforce shortages and enhancing health literacy. Initiatives that support medical training for local individuals and programs that increase community health education can have lasting impacts. Engaging local leaders and stakeholders in these efforts enhances their cultural relevance and sustainability [16].
5. **Collaboration with Non-Governmental Organizations (NGOs)**: Collaborating with NGOs that have experience and established networks in low-resource settings can facilitate the implementation of targeted health interventions. These organizations often bring in necessary funding, expertise, and innovative approaches to complex health challenges [16].
6. **Addressing Social Determinants of Health**: Comprehensive strategies should also target the broader social determinants affecting health outcomes, including poverty alleviation, education access, and gender equity. Programs aimed at improving living conditions, economic opportunities, and access to education can indirectly lead to better health outcomes [17].

The Role of Nurses in Sterilization Practices:

In the realm of healthcare, maintaining a sterile environment is paramount to preventing infections and ensuring patient safety. Among the myriad of professionals dedicated to upholding these standards, nurses play a crucial role in sterilization practices [18].

Sterilization is the process of eliminating all forms of microbial life, including bacteria, viruses, fungi, and spores, from instruments and surfaces. It is critical in various healthcare settings, particularly in surgical wards, intensive care units, and during invasive procedures. The effectiveness of sterilization is paramount—failure to properly sterilize medical instruments can lead to healthcare-associated infections (HAIs), increased morbidity and mortality, extended hospital stays, and significant healthcare costs [19].

1. **Instrument Preparation**: Nurses are often the first line of defense in preparing surgical instruments and equipment for sterilization. They are responsible for the meticulous cleaning of instruments post-procedure to remove blood, tissue, and other contaminants, which is vital as organic matter can inhibit the sterilization process [20].
2. **Understanding Sterilization Methods**: Nurses must be well-versed in the various sterilization methods employed in healthcare, including steam sterilization (autoclaving), ethylene oxide gas, hydrogen peroxide gas plasma, and dry heat sterilization. Each method has specific applications depending on the materials involved, risks associated with them, and the types of pathogens present [20].
3. **Monitoring Sterilization Processes**: Once instruments are prepared, nurses often play a role in monitoring the sterilization process. They ensure that the sterilization equipment is functioning correctly, and they are responsible for documenting the sterilization cycles by using biological indicators, chemical indicators, and mechanical indicators to verify that sterilization parameters are met [20].
4. **Education and Training**: Nurses are also responsible for educating patients and other staff about the importance of sterilization in preventing infections and ensuring safety in healthcare settings. This includes training new staff and reinforcing best practices within their teams [20].
5. **Policy Implementation**: Nurses often contribute to the development and implementation of infection control policies related to sterilization. By participating in committees and quality improvement initiatives, nursing professionals help integrate evidence-based guidelines into clinical practice, thus enhancing patient safety [21].

Impact of Nurses on Patient Outcomes

The role of nurses in sterilization practices has a direct correlation with patient outcomes. Research has consistently shown that effective sterilization and adherence to infection control protocols can significantly reduce the incidence of HAIs. Nurses are instrumental in identifying lapses in standard procedures and acting swiftly to correct them. Their ability to apply the principles of sterilization in their daily routines ensures not only the safety of individual patients but also the broader public health [22].

Moreover, nurses' involvement in education and compliance checks promotes a culture of safety within healthcare organizations. Continual reinforcement of sterilization protocols through training and monitoring fosters an environment of accountability and vigilance among all healthcare staff, further mitigating the risk of infections [22].

Despite their significant contributions, nurses face numerous challenges in optimizing sterilization practices. One primary challenge is the rapid evolution of medical technology and procedures. As new instruments and techniques are developed, nurses must continually update their skills and knowledge to ensure compliance with the latest sterilization protocols [22].

Additionally, staffing shortages and high patient-to-nurse ratios can hinder effective training and execution of sterilization practices. When nurses are overburdened, the likelihood of lapses in protocol increases. Integration of advanced sterilization technologies requires adequate staff training, which can be resource-intensive [23].

Another hurdle is the variance in sterilization standards across different healthcare settings. Nurses working in diverse environments—such as hospitals, outpatient clinics, and long-term care facilities—must navigate differing regulations and practices concerning sterilization and infection control. This can complicate their ability to maintain consistent standards across the board [24].

The future of nursing in sterilization practices is promising yet requires focus on ongoing education and innovation. As healthcare continues to advance, the role of nurses will inevitably expand. Emphasis on interdisciplinary collaboration is vital; nurses must work closely with infection control teams, medical engineers, and microbiologists to enhance sterilization processes and develop strategies tailored to evolving challenges [25].

Technology will also play a significant role in shaping the future of sterilization practices. Innovations such as automated sterilization systems and advanced monitoring technologies can assist nurses in maintaining high standards of sterilization while reducing the potential for human error. As these tools become integrated into clinical workflows, training may pivot from manual processes to a greater focus on technology-driven solutions [26].

Furthermore, the growing recognition of the importance of infection prevention and control in healthcare will likely lead to increased investment in nursing education and research dedicated to sterilization practices. By emphasizing the significance of these practices within nursing curricula and professional development programs, the healthcare workforce will be better equipped to meet the challenges of modern medicine [27].

Barriers to Effective Sterilization Protocols:

Sterilization is a critical aspect of infection control and prevention in healthcare settings, aiming to eliminate all forms of microbial life, including bacterial spores, viruses, and fungi. Effective sterilization protocols are vital for ensuring patient safety, maintaining the integrity of medical instruments, and preventing healthcare-associated infections (HAIs). However, several barriers hinder the implementation and effectiveness of these sterilization protocols across various healthcare environments [28].

One of the most significant barriers to effective sterilization protocols is insufficient training and knowledge among healthcare personnel. Proper sterilization techniques and protocols often require specialized education and training to ensure that staff is not only aware of the importance of sterilization but also competent in performing the necessary procedures. In many healthcare facilities, especially in low-resource settings, continuing education may be limited. The rapid turnover of nursing and technical staff can also lead to variability in adherence to protocols, further compounding the problem [28].

Additionally, the perception of sterilization as a routine task rather than a critical component of infection control can diminish healthcare workers' focus on adherence to established guidelines. In some cases, practitioners might prioritize speed and workload management over protocol compliance, leading to lapses in sterilization practices. This highlights the need for a culture of safety within

healthcare organizations, where continuous education, awareness, and accountability are emphasized to support effective sterilization practices [29].

The allocation of resources plays a pivotal role in the effectiveness of sterilization protocols. Many healthcare facilities struggle with inadequate funding, leading to insufficient access to essential disinfectants and sterilization equipment. For instance, hospitals in low- and middle-income countries (LMICs) often experience shortages of steam sterilizers, and the high cost of maintaining advanced sterilization technologies can overwhelm budgets. This can result in reliance on outdated methods, which may not meet current infection control standards [30].

Moreover, the lack of infrastructure for sterile processing departments can introduce inefficiencies and increase the risk of contamination. Inadequate physical space for sterilization can lead to overcrowding, creating further opportunities for cross-contamination and procedural mistakes. During high patient volumes, sterilization protocols may be bypassed in favor of expediency, thus increasing the risk of infections. Ensuring that healthcare facilities are adequately resourced is crucial in overcoming these barriers to effective sterilization [30].

The evolution of sterilization technologies has significantly improved the efficiency and effectiveness of sterilization processes. However, numerous barriers still exist within the technological landscape. Many healthcare facilities lack access to state-of-the-art sterilization equipment or do not have the technical expertise required to operate complex machinery effectively. Aging equipment can also contribute to inconsistent sterilization outcomes, as older sterilizers may not achieve or maintain the necessary parameters for effective sterilization [31].

In addition, the reliance on single-use instruments and disposable products can create a false sense of security regarding sterilization. While single-use items can reduce the risk of cross-contamination, they often contribute to substantial waste and may not always be available in critical situations. When such products are used, the overall infrastructure for reprocessing reusable instruments may be neglected, resulting in a fragmented approach to sterilization that compromises patient safety [31].

Infection control practices play an integral role in the effectiveness of sterilization protocols. A disconnect may exist between sterilization processes and broader infection prevention strategies within healthcare settings. For instance, proper hand hygiene, environmental cleaning, and adherence to isolation protocols are essential complementary practices that enhance the effectiveness of sterilization. Without a holistic view of infection control, efforts to improve sterilization can yield limited benefits [31].

Furthermore, variances in infection control policies among departments or facilities can lead to inconsistencies in sterilization practices. In hospitals with multiple departments, different protocols may be implemented based on the specific needs of each unit. This lack of standardization and harmonization can result in confusing practices for staff, ultimately undermining overall infection control efforts. Developing comprehensive, organization-wide policies that align sterilization efforts with broader infection control objectives is essential for overcoming this barrier [32].

Cultural attitudes and behavioral practices also represent substantial barriers to effective sterilization protocols. The significance placed on sterilization can differ among various healthcare cultures, impacting staff motivation and prioritization of these practices. In some settings, there may be a cultural reluctance to question established practices, even if those practices are outdated or ineffective. This sense of complacency can prevent innovation and adaptation of practices toward more effective sterilization methods [32].

Additionally, behavioral factors such as stress, fatigue, and work overload can affect the diligence of healthcare personnel when adhering to sterilization protocols. Personnel feeling rushed or overworked may overlook critical steps in the sterilization process, decreasing the likelihood of effective sterilization. Addressing these cultural and behavioral factors through supportive management practices, adequate staffing, and a focus on staff well-being can foster an environment conducive to successful sterilization efforts [33].

Impact of Inadequate Training on Sterilization Compliance:

Sterilization is a critical process in healthcare that ensures instruments and equipment are free from viable microorganisms, thus preventing the risk of infections that can complicate patient outcomes and increase healthcare costs. Compliance with sterilization protocols is vital for the safety of both patients and healthcare providers. However,

inadequate training can severely impact sterilization practices, leading to increased infection rates, healthcare-associated infections (HAIs), and potential legal ramifications for healthcare facilities [33].

To appreciate the impact of inadequate training on sterilization compliance, it is essential first to understand sterilization protocols. These protocols typically encompass various methods, including steam sterilization (autoclaving), ethylene oxide sterilization, dry heat sterilization, and chemical sterilization. Each method has specific guidelines regarding the correct parameters for temperature, pressure, and exposure time, and it is critical for staff to be thoroughly aware of these details to ensure effective sterilization [34].

Moreover, compliance with sterilization protocols is not merely a step in the infection control process; it is interconnected with broader organizational practices, including inventory management, the maintenance of sterilization equipment, and adherence to safety regulations. Inadequate training can lead staff to misinterpret or entirely overlook these interconnected aspects, compounding the potential risks associated with improper sterilization [35].

1. **Increased Risk of Infections**: One of the most severe implications of inadequate training is the heightened risk of HAIs. Poorly trained personnel may not understand the importance of adhering to sterilization timelines or may improperly operate sterilization equipment, leading to insufficiently sterilized instruments being used in medical procedures. This negligence can result in the introduction of pathogens into sterile areas of the body, thus precipitating infections that complicate recovery, prolong hospital stays, and necessitate additional treatments [36].
2. **Legal and Financial Ramifications**: Healthcare facilities can face significant legal and financial consequences as a result of inadequate sterilization compliance. In cases where patients acquire infections due to negligence in sterilization practices, hospitals may face lawsuits, penalties, or increased scrutiny from regulatory bodies. Additionally, managing infections necessitates considerable financial resources, given the costs associated with treatment, extended hospital stays, and potential compensation claims. Therefore, a lapse in sterilization compliance not only endangers patient safety but also poses a substantial financial burden on healthcare systems [37].
3. **Erosion of Public Trust**: Public confidence in healthcare facilities is crucial for their continued success and functionality. Reports of infections linked to inadequate sterilization can erode this trust, leading to patient reluctance in seeking care. Public perception is significantly influenced by the perceived safety and quality of care provided, making it imperative for hospitals to demonstrate adherence to rigorous sterilization protocols. Inadequate training that leads to breaches in compliance can result in negative publicity, effectively damaging a facility's reputation and, consequently, its patient base [38].
4. **Compromised Staff Safety**: Inadequately trained staff are not only a liability for patient safety but also for their own. Understanding proper sterilization techniques is essential for ensuring that staff members are not inadvertently exposed to biohazardous materials. When personnel lack the knowledge necessary to perform their duties safely, they may increase their risk of infection or exposure to hazardous chemicals used in sterilization processes. This situation has both immediate health implications for staff members and long-term repercussions for workforce stability [39].

Strategies for Improvement

Given the profound consequences of inadequate training on sterilization compliance, it is imperative that healthcare facilities adopt effective strategies to enhance training processes.

1. **Comprehensive Training Programs**: Institutions should develop robust training programs tailored to the specific roles of staff involved in sterilization processes. These programs should include both theoretical education (covering the science behind sterilization methods and protocols) and practical skills training (allowing staff to engage with sterilization equipment under supervision) [40].
2. **Regular Updates and Continuing Education**: The field of healthcare is continuously evolving, with advancements in sterilization technologies and

regulations. Healthcare facilities should ensure that training programs are not static; they must be revisited periodically to account for new information, changes in best practices, and the introduction of new sterilization techniques [40].

3. **Utilization of Simulation and Technology**: Technological advancements can be leveraged to enhance training processes. Simulation training can provide staff with opportunities to practice and refine their skills in realistic scenarios without the pressure of actual patient care. Interactive learning tools, such as online courses and mobile applications, can also offer flexible, accessible education to reinforce learning and promote compliance [41].
4. **Regular Audits and Feedback**: Implementing a system of regular audits to assess compliance with sterilization protocols is essential. Constructive feedback should be provided to staff regarding their performance, emphasizing areas of strength and opportunities for improvement. Such audits not only reinforce accountability but also offer staff a sense of involvement and commitment to maintaining sterilization compliance [42].
5. **Promoting a Culture of Safety**: Creating an organizational culture that prioritizes safety and quality can enhance compliance with sterilization practices. Staff should feel encouraged to voice concerns regarding sterilization processes without fear of reprimand. Fostering an environment where adherence to safety protocols is recognized and rewarded can motivate staff to remain vigilant and committed to maintaining higher standards of care [43].

Cultural Perspectives and Public Awareness of Sterilization:

Sterilization procedures have been an integral part of reproductive health for decades, offering individuals and couples the chance to control their fertility. However, the understanding and acceptance of sterilization vary significantly depending on cultural contexts, societal norms, and levels of public awareness. The topic encompasses a myriad of factors that influence attitudes toward sterilization, including gender roles, religious beliefs, historical contexts, access to healthcare, and the repertoire of public education campaigns [44].

The history of sterilization is complex and often wrought with ethical dilemmas. In many countries, sterilization has been linked to coercive population control practices, particularly targeting marginalized populations. For instance, in the United States during the early 20th century, eugenics movements promoted forced sterilizations of individuals deemed "unfit" to reproduce, disproportionately affecting people of color, those with disabilities, and low-income individuals. Understanding this historical backdrop is crucial, as it breeds mistrust among certain groups regarding medical practices related to reproductive health [45].

Moreover, in some cultures, sterilization has been implemented as a governmental policy aimed at controlling population growth. In India, the government's aggressive sterilization campaign in the 1970s aimed to drastically reduce population growth; however, it resulted in significant human rights violations and left a lasting stigma around the procedure. Such historical perspectives can influence contemporary views on sterilization, where skepticism may prevail based on past abuses [46].

Cultural attitudes towards fertility and family planning significantly affect how sterilization is perceived. In many societies, traditional beliefs uphold large families as a sign of prosperity and social status. Couples may face pressure to have multiple children, impeding discussions surrounding sterilization. In these contexts, the notion of voluntarily relinquishing one's ability to have more children can be met with resistance, viewed as incompatible with social expectations and norms [47].

Conversely, in some cultures, particularly those where women's education and workforce participation are encouraged, attitudes towards family planning and sterilization are more progressive. In these environments, sterilization can be seen as a responsible choice, enabling individuals to pursue careers and personal development without the burden of unplanned pregnancies. Societies that prioritize women's autonomy over their reproductive choices often report higher acceptance rates of sterilization, viewing it as a means of empowering individuals [48].

Gender roles play a significant part in how sterilization is viewed across different cultures. In patriarchal societies, men often dominate decision-making processes regarding reproductive health, which can lead to disparities in access to and understanding of sterilization options. Women may

experience pressure to conform to traditional roles that prioritize motherhood, making them less likely to consider sterilization even if they desire to do so [49].

In contrast, more egalitarian societies tend to support shared decision-making in reproductive health matters. In these contexts, both partners may openly discuss and explore sterilization as a viable option for family planning. Programs that engage both genders in discussions about reproductive health can foster a culture of mutual understanding and respect, thus improving public awareness and acceptance of sterilization options [50].

Religious beliefs significantly shape cultural perspectives on sterilization. In many religious traditions, procreation is viewed as a sacred duty. For instance, certain interpretations of Christianity, Islam, and Hinduism may discourage voluntary sterilization or promote family planning methods that do not interfere with natural procreative acts. In these contexts, public awareness campaigns must navigate religious sensitivities while also providing accurate information about the options available to individuals [51].

However, various religious groups also recognize the importance of family planning in promoting health and well-being. Initiatives that approach sterilization from a health perspective, emphasizing the benefits of reproductive autonomy and family stability, can resonate more deeply within these communities. By framing sterilization within the context of responsible parenthood and health promotion, public awareness efforts can encourage a more nuanced understanding [52].

Public awareness is pivotal in shaping cultural perceptions of sterilization. Various stakeholders, including healthcare providers, non-governmental organizations, and advocacy groups, play a crucial role in disseminating information about sterilization options. Effective public awareness campaigns can demystify the procedure and alleviate concerns associated with it. Educational initiatives that include culturally sensitive materials can bridge gaps in knowledge and address misconceptions, thus encouraging informed decision-making [53].

Healthcare providers are often on the front lines of implementing these campaigns. Training medical professionals in culturally competent communication can enhance their ability to discuss sterilization options empathetically and effectively. Additionally, involving community leaders and trusted figures in public awareness efforts can amplify messages about sterilization acceptance within various cultural contexts [54].

Infrastructure Limitations Affecting Sterilization Efforts:

Sterilization is a critical component of public health that can significantly reduce the spread of infectious diseases. It is pivotal in settings ranging from healthcare facilities to public sanitation systems. Despite its importance, numerous challenges hinder effective sterilization efforts across different regions and contexts. One of the most significant factors affecting the efficiency of these efforts is the existing infrastructure, which varies drastically due to socioeconomic, geographic, and political factors [55].

A prominent limitation impacting sterilization efforts is the lack of proper facilities. In many developing countries, hospitals and medical facilities often lack the necessary equipped environments to facilitate effective sterilization. For instance, inadequate or outdated sterilization equipment such as autoclaves, which use steam to sterilize medical instruments, can lead to substandard sterilization processes. Without modern infrastructure, the consistency, efficiency, and effectiveness of sterilization procedures suffer [56].

Further complicating this issue is the inadequate number of facilities available in rural or underserved urban areas. In such settings, the absence of adequately equipped medical centres not only increases the risk of infections but also limits the availability of essential medical services. A 2020 report by the World Health Organization (WHO) indicated that a staggering 26% of healthcare facilities lack basic sanitation services worldwide. This statistic highlights a significant gap in infrastructure that greatly hampers sterilization efforts [57].

Infrastructure limitations are also prominently tied to resource availability. The availability of trained personnel, consumables, and financial resources is crucial for effective sterilization. In many regions, budgetary constraints severely limit the capabilities of healthcare systems. An inadequately funded health care system often leads to shortages of essential items used in sterilization processes, such as sterilization indicators, chemical agents, and growth media required for monitoring [58].

Moreover, the allocation of resources often prioritizes immediate healthcare needs over sterilization processes. For example, during a public health crisis like an outbreak of infectious diseases, governments may shift resources to emergency response teams rather than investing in long-term sterilization infrastructure. This creates a cycle of neglect, wherein sterilization efforts continuously receive inadequate attention and funding, undermining public health initiatives [59].

Technology plays a key role in modern sterilization practices. Advanced techniques, such as cryogenic sterilization and low-temperature plasma treatments, offer improved reliability and efficiency in ensuring the safety of medical instruments. However, many healthcare facilities, particularly in low-income countries, lack access to such innovations due to infrastructural limitations [60].

The absence of technology means that healthcare professionals often revert to traditional sterilization methods that may be less effective. For instance, methods such as boiling water or using alcohol-based wipes are widely employed in settings where modern equipment is unavailable. Such practices can be inadequate for the thorough decontamination of surgical instruments or for handling biohazardous waste, subsequently increasing the rate of hospital-acquired infections [61].

Additionally, a lack of training in advanced sterilization techniques can lead to improper procedures and high rates of contamination, further negating efforts to achieve effective sterility in medical environments. Therefore, access to the latest sterilization technology and adequate training are essential elements that require infrastructure development [62].

Government policies serve as a backbone for public health infrastructure, yet their limitations can also stymie efforts in sterilization practices. In regions where policymaking processes are characterized by corruption, inefficiency, or lack of public health priorities, investments directed toward healthcare infrastructure can be severely mismanaged or directed elsewhere. Without governmental support, hospitals cannot improve their sterilization capabilities, which negatively impacts community health [63].

Policymaking, furthermore, can determine the national standards for sterilization practices and the government’s commitment towards public health funding. Effective policies should prioritize research, operation standards, and education related to sterilization. Unfortunately, this is often not the case, especially in countries facing political instability or those with minimal support for health infrastructure [63].

Moreover, stringent regulatory measures can inadvertently complicate sterilization processes. If regulations are not aligned with the realities of local healthcare systems, they can serve as barriers, making it difficult for facilities that lack certain resources or technologies to comply fully. In such cases, regulatory frameworks need to be reassessed and tailored to support realistic and achievable sterilization standards [63].

Recommendations for Improving Sterilization Practices in Resource-Limited Environments:

Sterilization is a critical component of infection control and prevention in healthcare settings, ensuring that instruments and materials used in medical procedures are free from pathogens that could cause infections. In resource-limited environments, such as low-income countries or rural regions of developed nations, the challenges of providing efficient and effective sterilization processes are exacerbated by a lack of resources, infrastructure, and trained personnel. The consequences of insufficient sterilization can be dire, ranging from increased healthcare-associated infections (HAIs) to diminished patient trust and overall health outcomes. Improving sterilization practices in these settings therefore requires innovative approaches that are both practical and sustainable [64].

1. Training and Capacity Building

One of the foremost recommendations for improving sterilization practices in resource-limited environments is to invest in training and capacity building for healthcare workers. This encompasses not only formal training programs but also ongoing education that addresses the latest developments in sterilization techniques, materials, and protocols. Training programs should include practical sessions on the proper handling, cleaning, and sterilization of instruments, as well as knowledge on the importance of infection control practices [64].

Implementing "train-the-trainer" models can amplify the reach of educational initiatives. Local health workers who are trained can subsequently instruct their colleagues, fostering a culture of continuous learning and improvement. Additionally, partnerships with public health organizations and academic institutions can facilitate the sharing of

best practices and the development of culturally appropriate training materials tailored to the needs of specific communities [64].

2. Simplifying Sterilization Techniques

In resource-limited settings, it is vital to adapt sterilization techniques to match available resources while still ensuring effective pathogen elimination. Traditional methods such as autoclaving, which uses high-pressure steam to sterilize tools, may not always be feasible due to the lack of electricity or appropriate equipment. Therefore, alternative methods should be explored:

- **Chemical Sterilization**: Solutions like 2% glutaraldehyde or hydrogen peroxide can effectively sterilize instruments without the need for thermal energy. While these chemicals require careful handling and specific contact times to ensure efficacy, they can often be stored and transported more easily than bulky autoclave units.
- **Boiling Water**: In situations where electricity is unavailable, boiling instruments for at least 20 minutes can effectively reduce microbial load. However, it is important to recognize that boiling is not a complete sterilization method and should be complemented with thorough cleaning processes and additional treatments whenever possible [65].

3. Establishing Protocols and Guidelines

The development and implementation of standardized protocols and guidelines for sterilization practices is crucial to ensuring consistency and quality in care across healthcare facilities in resource-limited environments. Such guidelines should be evidence-based, culturally appropriate, and adaptable to different levels of resource availability.

Stakeholders, including local health ministries and international health organizations, should collaborate to create these frameworks, ensuring that they address common challenges such as inconsistent supply chains for sterilization materials. Facilities should be encouraged to regularly review and update their protocols to incorporate new evidence and experiences from other regions or organizations [65].

4. Strengthening Supply Chains and Resource Availability

The effectiveness of sterilization practices is inherently linked to the availability of necessary materials and equipment. Strengthening supply chains for sterilization products, such as disinfectants, sterilizing equipment, and personal protective equipment (PPE), is essential in minimizing disruptions to healthcare services [66].

Efforts to build local manufacturing capabilities for critical sterilization supplies can reduce dependency on international supply chains and improve resilience to factors such as price fluctuations or transportation delays. Local governments and NGOs can also work together to establish partnerships with private sector organizations to promote fair access to these materials, ensuring that healthcare facilities are adequately equipped to maintain proper sterilization practices [66].

5. Implementing Monitoring and Feedback Mechanisms

A systematic approach to monitoring and evaluating sterilization practices within facilities is essential for ensuring adherence to established protocols and guidelines. Developing simple monitoring tools that allow healthcare workers to assess and document their sterilization processes can facilitate continuous quality improvement [66].

Feedback mechanisms should encourage open communication between staff and management, allowing for discussions about challenges faced in sterilization efforts and brainstorming potential solutions. Engaging healthcare workers in this dialogue not only enhances accountability but also fosters a sense of ownership and commitment to improving patient safety [67].

6. Utilizing Community Engagement and Education

Community engagement plays a significant role in improving sterilization practices, as public awareness can influence demand for high-quality healthcare services that adhere to sterilization standards. Educating the public about the importance of infection control and the impact of HAIs can foster a culture that prioritizes health and hygiene [67].

Health promotion initiatives may include working with local leaders and organizations to disseminate information about infection prevention. Community members can also be trained to assist in tracking cleanliness and adherence to sterilization standards within local healthcare facilities, creating a

collaborative environment that enhances overall health outcomes [68].

Conclusion:

In conclusion, the challenges surrounding the implementation of sterilization protocols for nurses in low-resource settings are multifaceted and require a comprehensive understanding of both systemic barriers and contextual factors. Limited access to essential supplies, inadequate training, and infrastructural deficiencies significantly hinder adherence to established sterilization practices, which can lead to increased rates of healthcare-associated infections. Additionally, cultural perceptions and community attitudes toward sterilization further complicate compliance and highlight the need for enhanced public education and engagement.

Addressing these challenges necessitates a collaborative approach that involves healthcare organizations, policymakers, and local communities. Developing tailored training programs, improving supply chains, and leveraging technology can empower nurses and enhance sterilization practices in these settings. Ultimately, fostering a culture of safety and promoting best practices in sterilization are crucial steps toward not only improving patient outcomes but also building a resilient healthcare system capable of overcoming the unique challenges faced in low-resource environments. By prioritizing these efforts, we can contribute to a safer healthcare landscape for all patients, regardless of the resources available.

References:

1. Kilpatrick C, Reilly J. The importance of surveillance for hospital-acquired infections. Nurs times. 2002;98(23):56–7.
2. Alicia MJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Hospital infection control practices advisory committee guideline for prevention of surgical site infection. Infec Cont & Hos Epidemiol. 1999 Apr;20(4):247–80.
3. Pankaj P, Maursing P, Ravi K, Kedari S, Viraj K, Sarika K, et al. A study to assess the knowledge and practices of aseptic techniques applied in nursing practices among staff nurses working in selected Hospital Ahmednagar. Vims Helth Sci J. 2014;1(2).
4. National Clinical Guideline Centre. Infection: prevention and control of healthcare-associated infections in primary and community care: partial update of NICE Clinical Guidelines 2. No. 139. London: Royal College of Physicians.
5. Varshney AM, Ahmad S, Bansal R, Sharma S, Parashar P, Shukla A, et al. Awareness about nosocomial infections among nurses and healthcare workers of hospitals in Meerut Up. Asian Pacific J Nurs. 2014;1(2):46–51.
6. Health Science. Aseptic technique learning package. South Gippsland Hospital; Form 690, Issue 3, February 2014.
7. Kesah NF, Vincent KP, Chrysanthus N. Healthcare-associated infections in three hospitals in Dschang, West Region, Cameroon. Ann Trop Med Public Health. 2013;6(1):23–29.
8. Wilson J. Infection control in clinical practices. London: Bailliere Tindall; 2016.
9. Kristeen C, Rachel N. Aseptic technique. Accessed on August 16 2018.
10. Ndipowa JAC, Anchang YK, Ongore D. Availability of resources for infection prevention and control, including constraints, over performance levels in Bamenda Health District, Cameroon. Don J Med Medsci. 2015;2(6):78–85.
11. Knowledge, attitude and practice of standard infection control precautions among health-care workers in a university hospital in Qassim, Saudi Arabia: a cross-sectional survey. Abalkhail A, Al Imam MH, Elmosaad YM, et al. Int J Environ Res Public Health. 2021;18:11831.
12. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Alhumaid S, Al Mutair A, Al Alawi Z, et al. Antimicrob Resist Infect Control. 2021;10:86.
13. Occupational exposure to blood and risk of bloodborne virus infection among health care workers in rural north Indian health

care settings. Kermode M, Jolley D, Langkham B, Thomas MS, Crofts N. Am J Infect Control. 2005;33:34–41.

14. Healthcare-associated infections in Africa: a systematic review and meta-analysis of point prevalence studies. Abubakar U, Amir O, Rodríguez-Baño J. J Pharm Policy Pract. 2022;15:99.

15. Surveillance of antimicrobial resistance in low- and middle-income countries: a scattered picture. Iskandar K, Molinier L, Hallit S, et al. Antimicrob Resist Infect Control. 2021;10:63.

16. Impact of healthcare-associated infections connected to medical devices-an update. Dadi NC, Radochová B, Vargová J, Bujdáková H. Microorganisms. 2021;9:2332.

17. Health care-associated infections among hospitalized patients with COVID-19, March 2020-March 2022. Sands KE, Blanchard EJ, Fraker S, Korwek K, Cuffe M. JAMA Netw Open. 2023;6:0.

18. Knowledge and practices of infection control among healthcare workers in a tertiary referral center in north-western Nigeria. Iliyasu G, Dayyab FM, Habib ZG, Tiamiyu AB, Abubakar S, Mijinyawa MS, Habib AG. Ann Afr Med. 2016;15:34–40.

19. Strategies to prevent healthcare-associated infections: a narrative overview. Haque M, McKimm J, Sartelli M, et al. Risk Manag Healthc Policy. 2020;13:1765–1780.

20. Healthcare-associated infections (HAIs): challenges and measures taken by the radiology department to control infection transmission. Alamer A, Alharbi F, Aldhilan A, Almushayti Z, Alghofaily K, Elbehiry A, Abalkhail A. Vaccines (Basel) 2022;10:2060.

21. Challenges faced by nurses in implementing aseptic techniques at the surgical wards of the Bamenda Regional Hospital, Cameroon. Tambe TA, Nkfusai NC, Nsai FS, Cumber SN. Pan Afr Med J. 2019;33:105.

22. Perception of nursing staff in ICU regarding measures to prevent hospital-acquired infections: a qualitative approach. Dimitriadou I, Pittas S, Sidiropoulos A, Zarkali O. Cureus. 2022;14:0.

23. The role of environmental contamination in the transmission of nosocomial pathogens and healthcare-associated infections. Suleyman G, Alangaden G, Bardossy AC. Curr Infect Dis Rep. 2018;20:12.

24. Local anaesthetics and regional anaesthesia versus conventional analgesia for preventing persistent postoperative pain in adults and children. Weinstein EJ, Levene JL, Cohen MS, et al. Cochrane Database Syst Rev. 2018;6:0.

25. Mortality related to hospital-associated infections in a tertiary hospital; repeated cross-sectional studies between 2004-2011. Koch AM, Nilsen RM, Eriksen HM, Cox RJ, Harthug S. Antimicrob Resist Infect Control. 2015;4:57.

26. Health care-acquired infections in low- and middle-income countries and the role of infection prevention and control. Maki G, Zervos M. Infect Dis Clin North Am. 2021;35:827–839.

27. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Siegel JD, Rhinehart E, Jackson M, Chiarello L. Am J Infect Control. 2007;35:0–164.

28. Centers for Disease Control and Prevention. National hospital discharge survey: 2010 table, procedures by selected patient characteristics-number by procedure category and age. 2010.

29. Kohn W.G., Collins A.S., Cleveland J.L. Guidelines for infection control in dental health-care settings–2003. MMWR Recomm Rep. 2003;52:1–61.

30. Epstein L., Hunter J.C., Arwady M.A. New Delhi metallo-beta-lactamase-producing carbapenem-resistant Escherichia coli associated with exposure to duodenoscopes. JAMA. 2014;312:1447–1455.

31. Rutala W.A., Weber D.J. Disinfection, sterilization and control of hospital waste. In: Bennett J.E., Dolan R., Blaser M.J., editors. Principles and practice of

infectious diseases. Elsevier Saunders; Philadelphia: 2015. pp. 3294–3309.

32. Spaulding E.H. Chemical disinfection of medical and surgical materials. In: Lawrence C., Block S.S., editors. Disinfection, sterilization, and preservation. Lea & Febiger; Philadelphia: 1968. pp. 517–531.

33. Rutala W.A., Weber D.J. Disinfection, Sterilization and Antisepsis: An Overview. Am J Infect Control. 2016;44:e1–e66.

34. Food and Drug Administration. FDA-cleared sterilants and high level disinfectants with general claims for processing reusable medical and dental devices, March 2015.

35. Peery A.F., Dellon E.S., Lund J. Burden of gastrointestinal disease in the United States: 2012 update. Gastroenterology. 2012;143:1179–1187.

36. Rutala W.A., Gergen M.F., Weber D.J. Efficacy of a washer-disinfector in eliminating healthcare-associated pathogens from surgical instruments. Infect Control Hosp Epidemiol. 2014;35:883–885.

37. McDonnell G., Burke P. Disinfection: is it time to reconsider Spaulding? J Hosp Infect. 2011;78:163–170.

38. Sehulster L., Chinn R.Y.W., Healthcare Infection Control Practices Advisory Committee Guidelines for environmental infection control in health-care facilities. MMWR Morb Mortal Wkly Rep. 2003;52:1–44.

39. Rutala W.A., Weber D.J. How to assess risk of disease transmission to patients when there is a failure to follow recommended disinfection and sterilization guidelines. Infect Control Hosp Epidemiol. 2007;28:146–155.

40. Wendorf K.A., Kay M., Baliga C. Endoscopic retrograde cholangiopancreatography-associated AmpC Escherichia coli outbreak. Infect Control Hosp Epidemiol. 2015;36:634–642.

41. Rutala W.A., Weber D.J. Cleaning, disinfection and sterilization. In: Grota P., editor. APIC text of infection control and epidemiology. 4th edition. Association for Professionals in Infection Control and Epidemiology, Inc.; Washington, DC: 2014. pp. 31.1–31.15.

42. Rutala WA, Weber DJ. Disinfection and sterilization in healthcare facilities. In: Han J, editor Practical healthcare epidemiology. 4th edition: University of Chicago Press, in press.

43. Centers for Disease Control and Prevention. Immediate need for healthcare facilities to review procedures for cleaning, disinfecting, and sterilizing reusable medical devices. 2015.

44. Kovaleva J., Peters F.T., van der Mei H.C. Transmission of infection by flexible gastrointestinal endoscopy and bronchoscopy. Clin Microbiol Rev. 2013;26:231–254.

45. Rutala W.A., Weber D.J. Disinfection and sterilization of prion-contaminated medical instruments, reply to Belay. Infect Control Hosp Epidemiol. 2010;31:1306–1307.

46. Rutala WA, Weber DJ. Disinfection and sterilization in healthcare facilities. In: Han J, ed. SHEA practical healthcare epidemiology University of Chicago Press.

47. Ofstead C.L., Wetzler H.P., Snyder A.K. Endoscope reprocessing methods: a prospective study on the impact of human factors and automation. Gastroenterol Nurs. 2010;33:304–311.

48. Weber D.J., Rutala W.A. Lessons learned from outbreaks and pseudo-outbreaks associated with bronchoscopy. Infect Control Hosp Epidemiol. 2012;33:230–234.

49. Rutala W.A., Weber D.J. Disinfection, sterilization and control of hospital waste. In: Bennett J.E., Dolan R., Blaser M.J., editors. Principles and practice of infectious diseases. Elsevier Saunders; Philadelphia: 2015. pp. 3294–3309.

50. Rutala W.A., Gergen M.F., Weber D.J. Microbial contamination on used surgical

instruments. Infect Control Hosp Epidemiol. 2014;35:1068–1070.

51. Alfa M.J., Degagne P., Olson N. Worst-case soiling levels for patient-used flexible endoscopes before and after cleaning. Am J Infect Control. 1999;27:392–401.

52. Weber D.J., Rutala W.A. Role of environmental contamination in the transmission of vancomycin-resistant enterococci. Infect Control Hosp Epidemiol. 1997;18:306–309.

53. Rutala W.A., Weber D.J. FDA labeling requirements for disinfection of endoscopes: a counterpoint. Infect Control Hosp Epidemiol. 1995;16:231–235.

54. Muscarella L.F. Risk of transmission of carbapenem-resistant Enterobacteriaceae and related "superbugs" during gastrointestinal endoscopy. World J Gastrointest Endosc. 2014;6:457–474.

55. Rutala W.A., Gergen M.F., Bringhurst J. Effective high-level disinfection of cystoscopes: is perfusion of channels required? Infect Control Hosp Epidemiol. 2016;37(2):228–231.

56. Pajkos A.V.K., Cossart Y. Is biofilm accumulation on endoscope tubing a contributor to the failure of cleaning and decontamination. J Hosp Infect. 2004;58:224.

57. Rutala W.A., Weber D.J. Gastrointestinal endoscopes: a need to shift from disinfection to sterilization? JAMA. 2014;312:1405–1406.

58. Neves M.S., daSilva M.G., Ventura G.M. Effectiveness of current disinfection procedures against biofilm on contaminated GI endoscopes. Gastrointest Endosc. 2016;83(5):944–953.

59. Roberts C.G. The role of biofilms in reprocessing medical devices. In: WA R., editor. Disinfection, sterilization and antisepsis: principles, practices, current issues, new research, and new technologies. Association for Professionals in Infection Control and Epidemiology; Washington, DC: 2010. pp. 223–229.

60. Rutala W.A., Gergen M.F., Weber D.J. Disinfection of an infrared coagulation device used to treat hemorrhoids. Am J Infect Control. 2012;40:78–79.

61. Tosh P.K., Disbot M., Duffy J.M. Outbreak of Pseudomonas aeruginosa surgical site infections after arthroscopic procedures: Texas, 2009. Infect Control Hosp Epidemiol. 2011;32:1179–1186.

62. Rutala W.A., Weber D.J. Outbreaks of carbapenem-resistant Enteriobacteriaceae infections associated with duodenoscopes: what can we do to prevent infections? Am J Infect Control. 2016;44(5 Suppl):e47–e51.

63. Society of Gastroenterology Nurses and Associates I Standards of infection control and reprocessing of flexible gastrointestinal endoscopes. Gastroenterol Nurs. 2013;36:293–303.

64. Food and Drug Administration. Brief summary of the gastroenterology and urology devices panel meeting, May 14-15, 2015.

65. Rutala W.A., Gergen M.F., Weber D.J. Disinfection of a probe used in ultrasound-guided prostate biopsy. Infect Control Hosp Epidemiol. 2007;28:916–919.

66. 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: 2000. pp. 63–69.

67. Ofstead C.L., Wetzler H.P., Doyle E.M. Persistent contamination on colonoscopes and gastroscopes detected by biologic cultures and rapid indicators despite reprocessing performed in accordance with guidelines. Am J Infect Control. 2015;43:794–801.

68. Rutala W.A., Cole E.C., Thomann C.A. Stability and bactericidal activity of chlorine solutions. Infect Control Hosp Epidemiol. 1998;19:323–327.