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The Role of Physiology Knowledge in Improving Sterilization Outcomes

(TORG-NZ Global CSSD Best Practice Essay Competition 2026 - Third Place Winner)

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ABSTRACT

Sterilization remains a critical component of infection prevention and patient safety in surgical care. Despite advancements in sterile processing systems, surgical site infections (SSIs) continue to pose a significant global health burden, particularly in low-resource settings. This commentary examines the role of physiology knowledge in improving sterilization outcomes by linking biological principles to clinical practice. It highlights how an understanding of infection dynamics, immune responses, and systemic complications can enhance adherence to sterilization protocols and reduce preventable harm. It further examines existing gaps in sterilization practices and proposes practical, low-cost strategies for integrating physiology-based training into Central Sterile Department (CSSD) operations. By bridging the gap between scientific knowledge and routine practice, this approach supports improved patient outcomes and aligns with global efforts to strengthen surgical safety and infection prevention.

Keywords: *Sterilization; Surgical Wound Infection; Infection Control; Decontamination; Patient Safety.*

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MAIN TEXT

Every surgical procedure begins long before the first incision, with the assurance that every instrument is free from harmful microorganisms. Sterilization, a core function of the Central Sterile Services Department (CSSD), plays a critical role in safeguarding patient health and preventing infections. However, beyond protocols and equipment, a deeper understanding of human physiology is essential for improving sterilization outcomes and ensuring effective patient care. Surgical site infections remain a major global health challenge. According to WHO's Global Guidelines for the Prevention of Surgical Site Infection, approximately 2–5% of patients undergoing inpatient surgery worldwide acquire an SSI, with significantly higher rates in low- and middle-income countries (LMICs) where infection prevalence may exceed 10% (1). In LMICs specifically, 11% of patients who undergo surgery are infected during the process (2).

The WHO 2024 Global Report on Infection Prevention and Control estimates that on average, 7% of patients in high-income countries and 15% in LMICs acquire at least one healthcare-associated infection (HAI) during their hospital stay. Patients in LMICs have up to 20 times higher risk of acquiring infections during healthcare delivery than those in high-income countries (3).

In Africa, SSI rates reach levels significantly higher than global averages. The GlobalSurg Collaborative reported that SSI incidence more than doubled from high-income countries (7.4%) to middle-income countries (14.4%) to low-income countries (20.0%), with one in three patients from LMICs suffering an SSI in the most contaminated procedures (4). In Africa specifically, up to 20% of women who have a caesarean section contract a wound infection (5). Approximately one in ten patients undergoing surgery in low-resource settings is at risk of acquiring an infection (5).

Physiology and Infection Dynamics

Physiology, the study of how the human body functions, provides essential insight into how infections occur, spread, and affect body systems. During surgical procedures, the body's primary defense (the skin) is intentionally breached, exposing internal tissues to potential microbial invasion. Once pathogens gain access, they proliferate rapidly in nutrient-rich environments such as blood and interstitial fluids. This invasion initiates complex physiological responses including inflammation, immune activation, and metabolic stress. While these responses are protective, they can cause tissue damage, delayed wound healing, and severe systemic complications such as sepsis (6).

From a physiological standpoint, even minimal contamination of surgical instruments can disrupt the body's internal balance, particularly in patients with weakened immune systems or underlying health conditions. Understanding these processes transforms sterilization from a routine technical procedure into a critical, life-preserving intervention. This perspective highlights how foundational biomedical knowledge directly influences clinical outcomes beyond theoretical learning and reinforces the importance of strict adherence to sterilization protocols.

Gaps in CSSD Operational Practices

Despite the importance of sterilization, significant gaps persist in practice, especially in resource-limited environments. CSSD units face challenges including inadequate infrastructure, outdated equipment, and insufficient personnel training. According to the Central Sterile Services Department Guidelines issued by Namibia's Ministry of Health and Social Services, inadequate decontamination of reusable medical devices continues to lead to HAIs across many settings (7).

The CSSD decontamination life cycle illustrates the critical nature of each step. The cycle begins when dirty medical devices are brought to the CSSD, then cleaned, disinfected, inspected, packed, sterilized, transported, stored, used, and transported back to the CSSD. Each step is crucial, an error during any stage may lead to huge costs, serious suffering, and endangerment of patient and healthcare worker lives.

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Key CSSD operational requirements include:

CSSD Area	Ventilation (ACH)	Pressure	Temperature
Dirty area	10–20	Negative	18–20°C
IAP area	10–20	Positive	18–23°C
Sterile store	10–20	Positive	15–25°C

Table 1. Key CSSD operational requirements. Adapted from the Namibia CSSD Guidelines (7).

The workflow must be unidirectional from dirty to clean, with physical barriers separating these areas. Steam sterilization is the preferred method for sterilizing critical medical devices, requiring saturated steam under pressure at 121°C or above. Quality assurance through biological indicators, chemical indicators, and Bowie-Dick tests must be performed continuously to validate sterilization effectiveness (8, 7).

In parts of Africa, approximately one in ten patients undergoing surgery is at risk of acquiring an infection (5). These challenges are not solely technical but influenced by human factors: fatigue, inconsistent protocol adherence, and limited awareness of physiological consequences of sterilization failure.

A critical issue underlying these gaps is the disconnect between routine sterilization practices and the biological impact of their failure. When sterile processing is perceived merely as a procedural task rather than a determinant of patient survival, compliance diminishes and errors go unnoticed. Addressing this requires integrating physiological understanding into the core of sterilization training and practice. When healthcare workers appreciate how microbial contamination can trigger inflammatory cascades, immune dysfunction, or life-threatening complications such as sepsis, the importance of strict adherence to sterilization protocols becomes more evident and personally meaningful.

Integrating Physiology into CSSD Practice

Integrating physiology into sterilization practices offers a practical and impactful strategy for improving outcomes. Training should move beyond procedural instruction to include clear explanations of biological consequences of inadequate sterilization. This fosters informed responsibility, where actions are guided not only by protocols but by understanding their clinical implications.

CSSD staff qualifications and training requirements, per the Namibia CSSD Guidelines (7):

- Entry-level operators: High school completion certificate
- Nurses: Basic CSSD course (6 months)
- Supervisors: Basic CSSD course plus 2 years' experience
- Managers: Advanced CSSD course plus 5 years' experience

All CSSD staff must receive comprehensive training on decontamination processes, IPC principles, and understanding risks related to their work. Continuous education and periodic competency assessments are essential.
Case-based learning, examining real clinical scenarios through a physiological perspective, can strengthen this connection by illustrating how sterilization lapses translate into adverse patient outcomes.

Practical and scalable innovations can enhance physiology knowledge application within sterile processing systems. Low-cost interventions include:

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- Visual checklists emphasizing infection risks
- Peer-led microtraining sessions
- Continuous professional education
- Mobile-based learning platforms for ongoing training

These approaches are especially relevant in LMICs, where resource constraints require adaptable, sustainable solutions. AORN's updated Guideline for Sterilization provides perioperative nurses with guidance for processing, transporting, and storing reusable medical devices, emphasizing selection of processing methods and quality assurance (9). AAMI ST77 standards establish weight limits of 25 pounds for instrument sets and provide comprehensive sterilization container specifications (10). AAMI ST58 and ST41 guidelines govern gas plasma and ethylene oxide sterilizer conformity, respectively (11).

Global Impact and Collective Commitment

Beyond technical improvement, strengthening sterilization practices contributes to a broader global movement toward safer surgical systems. Knowledge sharing among healthcare professionals, continuous education, and recognition of sterile processing as critical to patient care are essential for driving long-term progress.

When healthcare systems invest in sterile processing personnel development and encourage best practice exchange across regions, impact extends beyond individual institutions to the global healthcare community. Such efforts improve technical outcomes and reinforce collective commitment to patient safety and quality care.

CONCLUSION

Ultimately, sterilization is not merely a technical process but a critical safeguard grounded in human physiology principles. Understanding how infections affect the body transforms sterile processing into a vital component of safe surgical care. As healthcare systems address the SSI burden, particularly in resource-limited environments, integrating physiological knowledge into sterilization practices presents a practical, sustainable solution.

By bridging the gap between science and application, healthcare professionals can improve sterilization outcomes, enhance patient safety, and uphold the fundamental right of every patient to receive carefree from preventable harm.

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CONFLICT OF INTEREST
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