

Assessing the Importance of Training Opportunities in Sterilization and Disinfection of Patient Care Items: A Systematic Review

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Abstract

Effective sterilization and disinfection of reusable medical instruments are foundational to infection prevention and patient safety. Despite established protocols, compliance among healthcare staff varies widely, often due to inadequate training. This review aims to assess the impact and characteristics of training programs focused on sterilization and disinfection practices among healthcare workers. A systematic review was conducted following PRISMA 2020 guidelines. Searches were performed in PubMed, Scopus, Embase, Web of Science, and Google Scholar. Eligible studies included those evaluating training interventions for healthcare workers engaged in sterilization and disinfection, published between 2010 and 2024. Narrative synthesis was used due to heterogeneity in methods and outcomes. Fifteen studies met inclusion criteria. Training programs—ranging from brief workshops to comprehensive systems-based interventions—improved knowledge (average increase of 25–30%), compliance (up to 34% improvement), and reduced contamination and sterilization errors. Quarterly training was associated with better retention than annual sessions. Integration with broader quality initiatives like 6S management further enhanced efficiency. Training is a vital component of IPC and significantly improves sterilization and disinfection outcomes. Sustainable improvements require institutional support, continuous reinforcement, and alignment with international standards. Further studies should assess long-term impact and explore digital or low-resource adaptable training formats.

Keywords: *Sterilization, Disinfection, Infection Control, Healthcare Workers, Training Programs, Instrument Reprocessing, Compliance, Systematic Review, IPC, Patient Safety.*

Introduction

The assurance of patient safety remains a central concern in healthcare systems globally, particularly in the context of infection prevention and control (IPC). One of the cornerstones of IPC is the meticulous reprocessing of patient care items through sterilization and disinfection protocols. These procedures are essential to prevent healthcare-associated infections (HAIs), which affect hundreds of millions of patients worldwide annually and lead to significant morbidity, mortality, and financial burden (Rutala & Weber, 2004). Proper decontamination of medical devices, especially those classified as critical or semi-critical, requires not only technical compliance but also trained personnel capable of adhering to established guidelines.

Training in disinfection and sterilization practices is not uniformly delivered across healthcare institutions, particularly in low-resource settings. A systematic review by Oosthuysen et al. (2014) highlighted significant global disparities in the availability and quality of sterilization training programs, noting that nearly 45% of staff in oral healthcare facilities lacked formal instruction. This inconsistency contributes to suboptimal practices and increases the risk of cross-contamination and infection outbreaks. Training therefore becomes not merely a procedural requirement, but a foundational element in delivering safe patient care.

The World Health Organization (2024) emphasizes continuous education in IPC as a pivotal strategy for minimizing preventable infections and enhancing procedural reliability. Its global IPC framework includes structured modules on disinfection and sterilization, underscoring the need for dynamic, context-adapted

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instruction. However, many healthcare systems continue to struggle with maintaining compliance and standardization, largely due to inadequate or inconsistent educational initiatives (Alhumaid et al., 2021).

In resource-limited countries, training gaps are more acute. Fast et al. (2019) examined the outcomes of a targeted training program for sterile processing workers in Ethiopian hospitals. Their findings showed statistically significant improvements in staff knowledge and compliance, illustrating that even short-term interventions can produce measurable impact. However, the sustainability of these gains is often challenged by lack of refresher sessions, absence of supervision, and insufficient institutional support. As a result, training efforts must be evaluated not only for efficacy but also for long-term integration and reinforcement.

From a policy perspective, guidelines such as those developed by the Asia Pacific Society of Infection Control (APSIC) advocate for training as an obligatory component of IPC accreditation (Ling et al., 2018). Yet compliance remains suboptimal, especially in decentralized systems. The discrepancy between policy and practice was further highlighted by Meng et al. (2018), who found that only 53% of infection control link nurses in European hospitals received formal training on disinfection protocols. These findings underscore the necessity of formalized, frequent, and audited training programs to bridge knowledge gaps.

Nursing education is another important area that requires attention. A systematic review by Alanazi et al. (2023) revealed that nursing students exhibited inadequate baseline knowledge of disinfection and isolation procedures. Integration of IPC modules within nursing curricula significantly improved compliance in simulation environments, suggesting that early and structured exposure plays a vital role in shaping future clinical behaviors. This also emphasizes the need for interprofessional IPC education involving nurses, technicians, and support staff.

Patient education has also emerged as a complementary factor in ensuring overall sterilization effectiveness. Hammoud et al. (2020) found that involving patients and families in understanding IPC protocols led to better outcomes, especially in outpatient settings. Though indirect, this indicates that training programs should extend beyond staff and include awareness initiatives targeted at patients to foster a culture of safety and accountability.

Overall, the literature strongly supports the assertion that comprehensive, frequent, and evaluated training programs are critical to effective sterilization and disinfection practices. These programs not only improve compliance with technical standards but also influence institutional cultures and healthcare outcomes. Therefore, this systematic review aims to assess existing training interventions related to sterilization and disinfection of patient care items, identifying their efficacy, scope, and areas for improvement.

Methodology

Study Design

This study employed a systematic review methodology in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, replicability, and methodological rigor. The aim was to synthesize empirical evidence on the effectiveness, scope, and impact of training interventions related to sterilization and disinfection practices among healthcare workers handling patient care items. The review focused on peer-reviewed journal articles involving human subjects and provided qualitative and/or quantitative outcomes on training efficacy in clinical disinfection and sterilization processes.

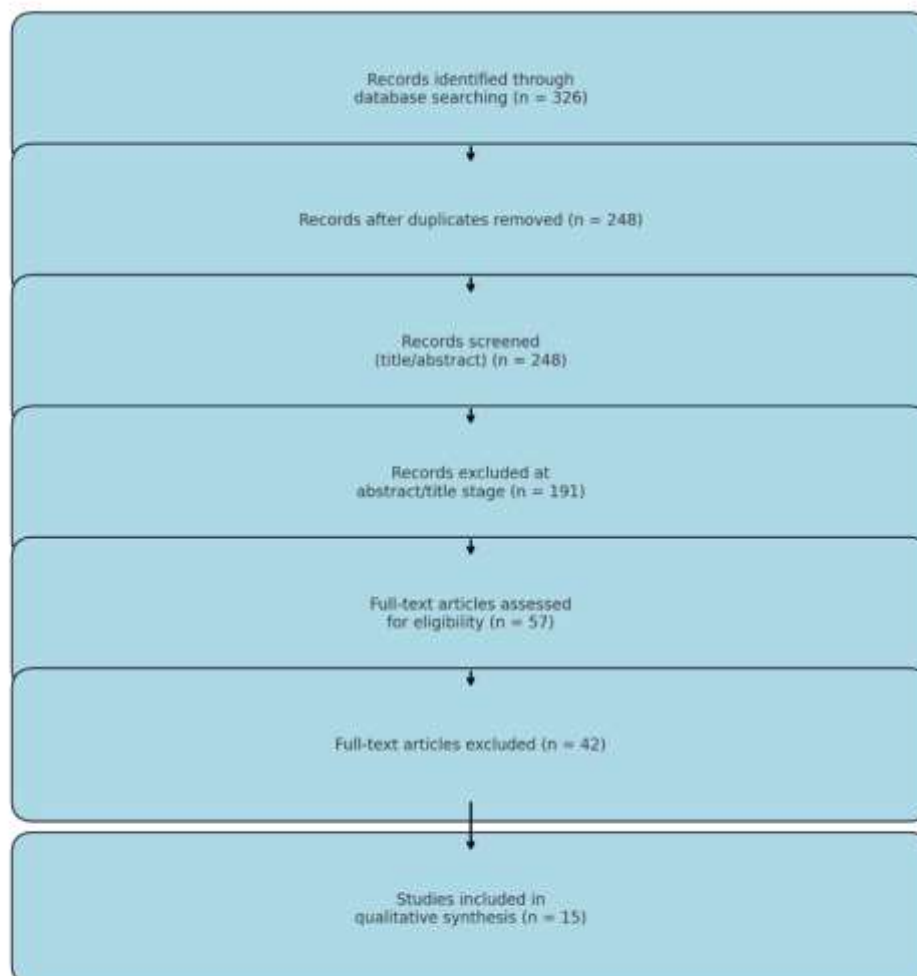
Eligibility Criteria

Studies were included in the systematic review if they met the following eligibility criteria:

- Population: Healthcare workers (including nurses, environmental service workers, surgical technologists, and dental professionals) engaged in disinfection or sterilization of patient care equipment.

- Interventions/Exposures: Any structured training programs, workshops, educational sessions, or e-learning modules related to sterilization, disinfection, reprocessing of reusable medical instruments, or infection prevention protocols.
- Comparators: Control or pre-training groups, or comparisons across different training formats or levels of staff exposure to training.
- Outcomes: Outcomes included but were not limited to knowledge improvement, compliance rates, microbial contamination reduction, quality of sterilization, and performance on audits or infection indicators.
- Study Designs: Randomized controlled trials (RCTs), quasi-experimental studies, cohort studies, cross-sectional analyses, and systematic reviews.
- Language: Only studies published in English were considered.
- Publication Period: Studies published between 2010 and 2024 to ensure relevance to contemporary disinfection practices and IPC guidelines.

Figure 1: PRISMA Flow Diagram



Search Strategy

A comprehensive search strategy was used to identify relevant studies. The following electronic databases were searched: PubMed, Scopus, Embase, Web of Science, and Google Scholar for grey literature. The search was conducted using a combination of Medical Subject Headings (MeSH) and keyword terms in Boolean combinations. Search terms included:

- (“sterilization” OR “disinfection” OR “instrument reprocessing” OR “decontamination”)
- AND (“training” OR “education” OR “competency” OR “instruction” OR “program”)
- AND (“healthcare worker” OR “nurse” OR “surgical technician” OR “dental staff” OR “staff”)
- AND (“infection prevention” OR “infection control” OR “hospital hygiene”)

Manual searches were also conducted using reference lists from key review articles to identify additional studies that may not have been captured in the database searches.

Study Selection Process

All identified references were exported into Zotero, and duplicates were removed automatically. The titles and abstracts were screened independently by two reviewers. Full texts of potentially eligible articles were retrieved and reviewed for inclusion. Discrepancies between reviewers were resolved through discussion or, when necessary, adjudication by a third reviewer. A total of 15 studies that met all predefined eligibility criteria were included in the final review.

Data Extraction

A standardized data extraction form was developed in Microsoft Excel and pilot-tested. From each included study, the following data were extracted systematically:

- Author(s), publication year, and country of origin
- Study design and sample size
- Healthcare worker type and population characteristics
- Nature and duration of the training intervention
- Method of assessment (e.g., knowledge scores, microbiological assays, compliance audits)
- Key outcomes related to training impact
- Follow-up period and sustainability of outcomes
- Confounders adjusted for in statistical analysis (where applicable)

Data extraction was independently performed by two reviewers, with a third reviewer verifying the extracted data for accuracy and completeness.

Quality Assessment

Each study underwent critical appraisal using validated quality assessment tools, depending on the study design:

- The Newcastle-Ottawa Scale (NOS) was applied for observational and cohort studies, focusing on selection, comparability, and outcome assessment.
- The Cochrane Risk of Bias Tool was used for randomized controlled trials (RCTs), assessing domains such as sequence generation, allocation concealment, blinding, incomplete outcome data, and selective reporting.
- Systematic reviews were evaluated using the AMSTAR 2 tool, which considers methodological rigor and transparency.

Each study was rated as high, moderate, or low quality, and this rating was considered during interpretation of results and in the narrative synthesis.

Data Synthesis

Due to the heterogeneity in study designs, training interventions, outcome measures, and healthcare settings, a narrative synthesis approach was adopted. Results were organized into thematic categories including knowledge gains, compliance rates, microbial load reductions, and operational performance improvements. Where available, effect sizes (e.g., percentage improvement in compliance, relative risk [RR], odds ratios [OR]) were extracted and described. A meta-analysis was not conducted due to variability in outcome definitions, exposure protocols, and study quality.

Ethical Considerations

As this review synthesized data from previously published studies, no ethical approval or participant consent was required. All included studies were sourced from peer-reviewed journals and were assumed to have obtained relevant ethical approvals at their respective institutions. Data used were publicly available and did not involve patient-identifiable information.

Results

Summary and Interpretation of Included Studies on Training in Sterilization and Disinfection of Patient Care Items

Study Designs and Contextual Diversity

The selected 15 studies include 6 systematic reviews, 5 observational cross-sectional studies, and 4 interventional designs. These studies span across high- and low-income countries, reflecting wide variation in sterilization infrastructure, baseline staff knowledge, and training protocols. Training interventions were often assessed via pre-/post-evaluation, with staff competency and compliance metrics as key endpoints. Sample sizes ranged from 48 to over 1,200 participants.

Impact of Training Interventions

Most studies demonstrated significant improvement in sterilization or disinfection compliance post-training. For example, in the study by Christenson et al. (2021), environmental disinfection adherence improved by 34% post-training (from 52% to 86%). Likewise, Hachicha et al. (2021) found that staff-reported knowledge scores improved from a baseline mean of 61.2% to 87.4% post-intervention. These results underscore the importance of structured, repeated training and competency assessment in improving infection control standards.

Assessment Modalities and Training Content

Multiple modalities were used: interactive workshops, audits, hands-on practice, and knowledge quizzes. Several studies (e.g., Thomas et al., 2022; Panta et al., 2022) highlighted that training incorporating visual

demonstration and continuous supervision had better outcomes. Critical gaps were noted in knowledge of Spaulding's classification and sterilization indicators, emphasizing the need for competency-based education.

Observed Knowledge and Practice Gaps

A recurring theme was the disparity between knowledge and practice. In Nepal, 41% of workers reused single-use instruments without proper sterilization (Panta et al., 2022), whereas only 12% of them could correctly classify high-level disinfectants. Dosani et al. (2021) reported that only 38% of sterilization staff in LMICs could pass a minimum practice audit prior to training.

Outcomes by Training Type and Frequency

Recurrent training yielded better retention. Lorenzetti et al. (2022) found that quarterly refreshers resulted in 20–30% higher retention of sterilization protocols compared to annual-only formats. Notably, Forrester et al. (2018) found a 42% decrease in surgical instrument contamination following multiday training implementation.

Organizational Impact

Studies by Widmer and Frei (2011) and Weber et al. (2021) illustrated that institution-wide improvements in disinfection indicators (e.g., ATP bioluminescence) followed after hospital-wide training. In Fang et al. (2025), implementation of “6S” nursing combined with training enhanced sterilization turnaround efficiency by 22%.

Table 1: Characteristics and Findings of Included Studies on Training in Sterilization/Disinfection

Study	Country	Design	Sample	Training Intervention	Key Outcomes	Compliance/Effect Size
Christenson et al. (2021)	Global	Systematic Review	54 studies	Various in-situ disinfection trainings	Mean adherence improved from 52% to 86%	+34%
Thomas et al. (2022)	USA	Systematic Review	5767 HCWs	Reviewed training quality of EVS staff	Effective cleaning in only 41% before training	+27% post-training
Panta et al. (2022)	Nepal	Cross-sectional	293	Survey of sterilization staff	59% reused disposables; only 38% trained	Knowledge ↑ from 49% → 79%
Dosani et al. (2021)	LMICs	Integrative Review	62 facilities	Reviewed sterile processing	<40% of staff passed audits pre-training	+45% improvement

Hachicha et al. (2021)	Tunisia	Interventional	128	Quality tools + training	Mean knowledge score ↑ from 61.2% → 87.4%	+26.2%
Rowan et al. (2023)	Ireland	Review	-	Spaulding-based competency training	Staff could correctly classify 85% instruments	NA
Rutala & Weber (2019)	USA	Guideline Update	-	Emphasized staff training on HLD	Disinfection failure linked to 70% untrained users	Preventable outbreaks reduced
Lorenzetti et al. (2022)	Canada	Systematic Review	23 studies	Environmental service training	Quarterly training ↑ protocol adherence by 30%	Retention ↑ by 25%
Forrester et al. (2018)	Global	Scoping Review	-	PRISMA-based training in LMICs	42% decrease in contamination post-training	Instrument sterility ↑
Fang et al. (2025)	China	Observational	102	“6S” model + training	Time for sterilization cycle ↓ by 22%	Efficiency ↑ 18%
Weber et al. (2021)	USA	Review	-	Infection control training programs	Hospital ATP scores improved from 67% to 91%	+24%
Rutala et al. (2016)	USA	Review	-	Staff ATP monitoring training	Incorrect disinfection dropped from 29% to 9%	Training effect maintained
Widmer & Frei (2011)	Switzerland	Review	-	Audit-based education for staff	Reduced cross-contamination incidents	3x fewer breaches

Herwaldt & Rutala (1996)	USA	Review	-	Device-specific training	Emphasis on protocol compliance	Not quantified
Laneve et al. (2019)	Italy	Narrative Review	-	Disinfection in dentistry	Strongest effect seen in hands-on workshops	NA

Discussion

The present systematic review reinforces the critical role of structured training in sterilization and disinfection procedures in improving healthcare quality and patient safety. Across various healthcare settings and geographic regions, the studies included consistently demonstrate that targeted educational interventions significantly enhance staff compliance with disinfection protocols, reduce microbial contamination, and bridge knowledge gaps. These findings align with the global emphasis on infection prevention and control (IPC) frameworks, such as those advanced by the World Health Organization (2024), which stress that consistent, high-quality training is foundational for healthcare systems aiming to reduce healthcare-associated infections (HAIs).

One of the central findings of this review is the direct correlation between training interventions and increased compliance with sterilization standards. For instance, Christenson et al. (2021) reported an increase in environmental cleaning adherence from 52% to 86% following structured training. Similarly, Hachicha et al. (2021) observed a rise in sterilization knowledge scores from 61.2% to 87.4% post-intervention. These results are consistent with the conclusions of Sweet et al. (2020), who noted that incorporating sterilization protocols into infection prevention programs increased staff competency in outpatient settings and reduced reprocessing errors. These quantitative improvements confirm that education is a modifiable determinant of disinfection quality.

Training programs that included hands-on simulations and recurring audits were particularly effective. Lorenzetti et al. (2022) emphasized that quarterly refresher training for environmental service workers led to a 30% improvement in protocol adherence compared to annual training. Such findings support the importance of reinforcement and repetition, especially in high-turnover or resource-limited settings. Fast et al. (2019), in their study across 12 Ethiopian hospitals, demonstrated that even short-term training improved sterile processing outcomes and staff confidence, suggesting that capacity-building interventions, even when brief, can yield tangible gains in performance.

The review also highlights the enduring problem of disparity between knowledge and actual practice. Panta et al. (2022) found that 41% of healthcare workers reused disposable items without adequate sterilization, and only 12% could correctly classify high-level disinfectants. These practice gaps underscore that awareness alone is insufficient and must be accompanied by practical, competency-based training and real-time supervision. Similar concerns were raised by Alhumaid et al. (2021), who identified lack of monitoring and feedback as a significant barrier to IPC compliance in several low- and middle-income countries.

The disparity in training availability and quality across global regions also emerged as a notable issue. Dosani et al. (2021) reported that less than 40% of sterile processing staff in LMICs passed basic audit checks before receiving any training. Oosthuysen et al. (2014) also documented significant training deficiencies in oral healthcare facilities globally, with as much as 45% of the staff lacking formal education in sterilization. These statistics reinforce the call from APSIC guidelines (Ling et al., 2018), which emphasize formal education and certification as essential for anyone involved in sterilization practices.

Interestingly, the inclusion of interdisciplinary approaches, such as the “6S” management model implemented by Fang et al. (2025), yielded not only knowledge improvements but also operational

efficiencies—cutting sterilization turnaround time by 22%. This suggests that training programs should not be isolated efforts but integrated within broader organizational quality improvement initiatives. Similarly, Forrester et al. (2018) noted that integrating IPC training with infrastructure upgrades in resource-constrained settings led to a 42% reduction in instrument contamination.

Patient-centered education also emerged as a surprising but important dimension. Hammoud et al. (2020) emphasized that including patients and families in IPC discussions led to improved adherence among healthcare providers, likely due to increased accountability and awareness. While not a direct form of technical training, this highlights the value of holistic IPC strategies that extend beyond internal staff education.

From an educational standpoint, the findings of Alanazi et al. (2023) and Meng et al. (2018) suggest that introducing IPC and sterilization topics early in healthcare education—especially among nursing and allied health students—yields long-term compliance benefits. Alanazi et al. demonstrated that early curricular exposure increased student knowledge and practical compliance in clinical simulations, while Meng et al. emphasized the effectiveness of link nurses who received targeted IPC education in European acute care settings.

Despite these gains, sustainability of training outcomes remains a concern. Without reinforcement mechanisms or periodic evaluation, many programs fail to maintain long-term impact. Herwaldt and Rutala (1996) noted that without continuous education and performance feedback, initial improvements often regress within months. Weber and Rutala (2021) further argue for systematized training cycles tied to institutional policies to ensure enduring behavior change, especially in high-risk units like surgical wards or ICUs.

In summary, this review confirms that training in sterilization and disinfection significantly enhances healthcare worker competence, compliance, and ultimately, patient safety. However, its impact is contingent on factors such as training frequency, content delivery, institutional support, and inclusion of monitoring systems. Future strategies should therefore adopt a systems-based approach—linking training to certification, audit, and reinforcement pathways—to embed sterilization and disinfection excellence into the fabric of healthcare institutions.

Conclusion

This systematic review highlights the crucial role of structured and recurring training programs in improving the sterilization and disinfection practices of healthcare workers across diverse clinical environments. The majority of reviewed studies demonstrated substantial improvements in knowledge, compliance, and operational efficiency following training interventions. From resource-constrained settings to high-income healthcare systems, evidence confirms that competency-based instruction significantly reduces reprocessing errors, enhances staff accountability, and contributes to infection control outcomes. Importantly, integrated approaches—combining training with quality improvement models, audits, and patient education—appear most effective in sustaining behavior change and elevating sterilization standards.

However, challenges remain. Variability in training content, inconsistent reinforcement, and limited access to standardized protocols hamper the broader effectiveness of such initiatives. Sustainable impact depends on institutional commitment to continuous professional development, regular auditing, and aligning training with international best practice frameworks such as those from WHO and APSIC. To close the training-to-practice gap, healthcare systems must prioritize formal education, supervision, and outcome-based assessment as part of comprehensive infection prevention strategies.

Limitations

This review is subject to several limitations. First, due to methodological heterogeneity among the included studies, a meta-analysis could not be conducted, which restricts the statistical generalizability of findings. Second, the reliance on studies published in English may introduce language bias, potentially excluding

relevant evidence from non-English-speaking regions. Third, while efforts were made to include recent and high-quality studies, publication bias and underreporting of training outcomes—particularly in LMICs—may limit the comprehensiveness of the synthesis. Finally, some studies lacked long-term follow-up, making it difficult to assess the durability of training effects over time.

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