



Improving sterile processing practices in Cambodian healthcare facilities

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SUMMARY

Background: Sterile processing practices in low-resource countries contribute to greater post-operative infection rates compared to high-resource countries. Provision of a sterile processing training program in Tanzania and Ethiopia demonstrated statistically significant improvements in sterile processing practice, a key requisite for safe surgical care.

Aim: To determine if a sterile processing program in a South East Asia country would result in improved conditions and practice in urban and rural healthcare facilities.

Methods: In 2019, a mixed-methods study was conducted with two cohorts in Cambodia, involving a total of eight healthcare facilities and 43 healthcare workers. Quantitative data were collected using a sterile processing assessment tool and a multiple-choice test pre- and post-training. Qualitative data in the form of interviews were obtained several months post-training.

Findings: Test results showed statistically significant and sustained effect of training over a four-six month period, as well as a large positive effect on SP knowledge in both cohorts. Analysis of hospital assessment data revealed an aggregate improvement of 36% in sterile processing benchmarks. While all participants reported increased knowledge and confidence (quantitative), rural participants conveyed a lack of support (qualitative) to implement practice changes.

Conclusion: The training course produced improvements in both rural and urban facilities. Findings highlight the importance of informing administrators of the rationale for needed improvements, ensuring funding is available to implement recommendations, and for governments to hold administrators accountable for improvements aligning with universally recommended sterile processing standards.

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Introduction

Surgical site infections (SSIs) are the most common health-care associated infection. Low-resource countries (LRCs), however, have a greater prevalence of SSIs and higher rates of antibiotic resistance than high-resource countries (HRCs). [1–3] As an example, Biccard *et al.* [4] reviewed surgical outcomes of over 11 422 patients from 247 hospitals in 25 African nations. The authors report a post-operative infection rate of 10.2%, with a mortality rate twice as high as the global average, despite patients having lower risk profiles, being younger, and experiencing fewer post-operative complications. Other studies focus on use of appropriate antibiotic prophylaxis in LRCs as a means of decreasing SSIs. [5].

A few studies however, looked beyond antibiotics. Allegranzi *et al.* [5] conducted a study in four African nations focused on six infection control practices, including pre-operative patient bathing, avoiding preoperative removal of hair, hand preparation, antibiotic prophylaxis, and operating room discipline. Forrester *et al.* [6] identified barriers to effective perioperative infection prevention practices, including skin irritation from alcohol-based rubs, inconsistent prophylactic antibiotic administration, lack of confirmatory sterility measures of surgical instruments, and inappropriate staffing, guidelines, and training.

This manuscript reports on one aspect of infection control, sterility of surgical instruments. Safe re-processing of reusable surgical instruments and medical devices involves multiple steps – steps that when not followed result in use of instruments that remain contaminated and increase the probability of patients developing a post-operative infection. [7] Initiatives to improve surgical outcomes in LRCs frequently overlook or simply do not address the sterility of surgical instruments, despite it being an aspect of the WHO's safe surgery checklist. [8] The inability of operating theater nurses in LRCs to confirm sterility of surgical instruments due to lack of access to chemical indicators, applied to every re-used surgical instrument pack in HRCs, highlights the need for greater attention to infection control globally. [9–11] The likelihood of using unsterile instruments during surgery is significantly higher in LRCs due to numerous factors, including a lack of: standard operating procedures, education and training on the fundamentals of reprocessing, access to resources, and access to evidence-based resources. [10].

One organization that has worked to provide training programs in sterile processing (SP) is Sterile Processing Education Charitable Trust (SPECT). Training programs for healthcare workers (HCWs) in Tanzania and Ethiopia [9,11] resulted in significant improvements in practice. While the value of SPECT's training has been identified in African nations, it is unknown if SP practices and conditions are similar in other LRCs, such as in a Southeast Asian country, or if SP training would be as impactful. Also of interest to the authors was if rural and urban healthcare facilities (HCFs) would have similar outcomes following SPECT's training program.

Methods

To address this gap in knowledge, as in Ethiopia and Tanzania, a mixed-methods study was conducted in Cambodia from February to December 2019, with data collected prior to

and following SPECT's training program. In collaboration with a large public hospital in Phnom Penh, the Ministry of Health, and Safe Surgery 2020, [12] SPECT provided a four-day course for two cohorts, identified as C1 and C2. Administrators from HCFs designated HCWs involved in some aspect of sterile processing to attend training. C1 participants attended from 3/06/2019 to 6/06/2019, while C2 participants attended from 16/09/2019 to 20/09/2019. C1 attendees were from four rural HCFs and one urban HCF. C2 attendees were all from urban HCFs. Several of the C1 attendees participated in teaching during the C2 training program. In total 60 HCWs from nine HCFs (one HCF was in Vietnam and therefore attendees were not invited to participate in the research) attended classes. Eight HCFs received two follow-up visits and mentoring sessions from SPECT. One round of mentoring visits occurred during the week following classes and then again three months post classes. Twenty-nine of the 60 individuals who attended training participated in an additional one-day training-of-trainers (ToT) course that provided strategies for educating colleagues at places of employment. Reinforcement of content was provided through an online platform in monthly 80-minute sessions from 06/2019 to 12/2019. All HCWs who attended SPECT's training were invited to participate.

Data collection

Data were gathered using a SP assessment tool, pre- and post-tests, and interviews. Pre-training assessments of SP practices at HCFs in C1 were done using the HCF SP Assessment Tool (Appendix A) in February 2019. Pre-assessments of three HCFs in C2 were done in August of 2019. Attendees were informed of the research study and invited to participate prior to the course and informed consent was obtained. Participants from C1 and C2 wrote individual knowledge tests (Appendix B) at the beginning and end of the four training days (Pre-test and Post1). Three (C2) to four (C1) months following the last mentoring visit HCF assessments were again conducted and participants rewrote the knowledge test (Post2). Forty-five semi-structured interviews of participants were conducted by SC in person or over the phone, depending on participants' availability.

The participating HCFs were assessed for compliance with SP practices based on thematic areas (Appendix C). Variables captured in each area are shown in Appendix C. Each HCFs performance of individual SP variables was assessed on a three-point ordinal scale, later coded as: no = 0, sometimes = 1, always = 2. Pre- and post-tests and hospital assessment data were aggregated and tested for statistical significance using the Wilcoxon signed-rank test after testing for symmetry.

Data analysis – quantitative

The research reported here tested the hypothesis that the training would have significant positive effects on the attendees, as well as on HCFs' SP practices in both rural and urban settings. Quantitative data were analyzed using the IBM Statistical Package for Social Sciences Statistics (SPSS) version 25. The test scores and hospital assessments provide indicators of impact of mentorship and education on sterile processing in HCFs. Frequencies and proportions of responses received are reported in Appendix A (HCF Assessment Tool), and for each of the forty questions in Appendix B (knowledge test). Non-

parametric statistical tests were completed for the nominal and ordinal data in the HCF Assessment Tool.

To test the hypotheses that the treatments (training) had significant effects on HCWs of HCFs in C1, we conducted paired sample t-tests because the pre- and post-training data sets passed the Shapiro-Wilk normality test. To determine the clinical significance of the training intervention on SP knowledge of individuals working in HCFs, an analysis was completed using the Cohen's d effect size. The 'minimal clinically important differences' (MCID) [13] were computed as follows: MCID = change in treatment values/pooled standard deviation of pre-and post-treatment. In our analysis, we compared the clinical effectiveness of the treatment based on the pre- and post-tests by computing the percentage difference in the MCID between first and second tests for C1 and C2 respectively.

Data analysis – qualitative

In terms of interview data analysis, a structured qualitative research approach has been taken aligning with phenomenology. [14] The analytic method employed interpretive thematic analysis, an iterative and inductive process involving decontextualization and recontextualization [15] and integration, involving inductive and deductive reasoning. Various strategies were employed to ensure rigour. First, it was important to gather data from a variety of sources (i.e., in this case data was collected from eight HCFs). This process assisted in the internal validation of the data through triangulation between sources. [16] Demonstrating consistent findings between multiple data sets increases the confidence level in the credibility of study findings. [17] In keeping with the mixed-methods design, findings from the qualitative analysis were compared to quantitative data and integrated to corroborate and elaborate on findings. [18].

Findings

Rural HCFs (A–D) conducted an average of 21 surgeries per week while urban HCFs (E–H) conducted an average of 66 surgeries per week. Rural HCFs performed mostly caesarean sections while urban HCFs performed a number of general surgeries in addition to caesarean sections. Overall, urban HCFs had more structured cleaning procedures and practices than rural HCFs. For example, in rural HCFs, some HCWs responsible for cleaning surgical instruments did not have formal education (e.g., one HCW could not read or write and was included through the use of verbal interpretation) but received informal training in SP from their immediate supervisors. In contrast, in urban HCFs, nurses who had more formal training and a post-secondary education were responsible for cleaning instruments.

Quantitative analysis

In C1, involving HCFs A, B, C, D, and E, the paired sample T-test showed $p < 0.05$ for the Pre-test vs Post1 ($t = -11.443$; Sig - .000) and for the Pre-test vs Post2.

Table I
Percentage improvement (deterioration) on individual SP elements

Sterile processing thematic area	Percentage improvement		
	Rural HCFs	Urban HCFs	Combined
Environment cleaning and general information	5.97	67.80	36.89
Point of use preparation	20.44	105.88	63.16
Transport of items from point of use to dirty area	51.89	111.22	81.55
Cleaning instruments and medical devices	23.23	63.64	43.43
Disinfection	-70.00	86.67	8.33
Inspection, assembly & packaging in clean area	0.42	66.80	33.61
Instrument maintenance	4.99	93.50	49.24
Sterilization	-7.29	54.02	23.36
Sterile storage	71.43	43.75	57.59
Aggregate improvement	11.23	77.03	44.13

($t = -7.489$; Sig - .000). The results also showed statistically significant and sustained effect of the training over the six-month period between Post1 and Post2 tests.

For C2, involving three HCFs (F, G, H), where some of the trainees in the C1 cohort served as trainers, the Pre-, Post1 and Post2 tests had mean values of 12.57, 22.04, and 19.57 respectively. These results indicate a good level of improvement (75.38%) between the Pre- and Post1 tests, but not as much between the Pre- and Post2 tests (55.69%). The Wilcoxon signed-rank test showed a statistically significant effect ($p < 0.05$) of training on health workers' SP knowledge. There were 21 positive ranks (improvements) in knowledge between Pre- and Post1; however, only 17 positive ranks were recorded between Pre- and Post2, while two individuals had the same scores (Pre- and Post2). The Z score for the Pre-Post1 tests was -4.018 and -3.668 for the Pre-Post2 tests. The two tailed p-value (Asymp. Sig.) was 0.000 for both.

The detailed Cohen's computations are contained in [Appendices D and E](#). The summary results of the clinical significance tests show a large positive clinical effect of training on SP knowledge in both cohorts. The effect was slightly higher by 26.67% (Pre-Post1) in C1 over C2, where the ToTs were involved in the training; however, C1 had a drop in sustained effectiveness of training (10.82%) compared with C2, which had a slight positive aggregate sustained effectiveness (1.3%). A statistically significant improvement ($p < 0.005$) was found in adherence to SP practices at HCFs following training. The overall rates of improvement (or otherwise) in the nine thematic areas for the entire group and for the dichotomized data of rural and urban HCFs were determined ([Table I](#)).

Quantitative analysis of hospital assessment data revealed an aggregate improvement of 44% in SP benchmarks post training, largely influenced by urban HCFs. Rural and urban HCFs demonstrated 11% and 77% improvement respectively in SP benchmarks post training. Urban HCFs showed noticeable levels of improvement in all benchmarks except inspection, assembly and packaging in clean areas, while rural HCFs

Table II
Qualitative findings

Theme*	Findings and participants' quotations
Changes in SP practice	<p>Workflow changes included the implementation of a three-step manual cleaning process for surgical instruments, one-way flow between point of use and decontamination areas, and entry restrictions to sterilization areas. Procedural changes included cleaning instruments immediately after use, improved arrangements of packaged instruments within sterilization machines to maximize exposure, and instrument inspections and function testing prior to packaging. Improvements in the organization of procedural areas and storage of instruments were commonly reported. In addition, participants reported more frequent and appropriate use of personal protective equipment (PPE) while cleaning and sterilizing surgical instruments. Several participants discussed improvements in quality assurance, including the use of internal and external chemical indicators and more frequent checking of autoclave functionality.</p>
Increased knowledge and confidence	<ul style="list-style-type: none"> • "The outside and inside [class I and IV chemical indicators for sterilization] are now used for all departments." (03C2) • "I feel completely [different] from what we knew and practiced in the past. After I attended the training with SPECT, I have a better understanding about the correct technique for instrument cleaning and sterilization in our hospital." (12C1) • "I feel completely [different], especially in my knowledge and skills. Now I see a lot of gaps in my work in the past. I have changed and improved and I feel more confident than before." (8C2)
Connection of SP practice quality to patient and staff safety	<ul style="list-style-type: none"> • "In the past, I did not have any idea that what I did was correct or not, and I did not have a way to protect myself, but after I received training from SPECT, I understand the cleaning and sterilization process, and how ... my job can improve patient safety." (21C1) • "After training I am clearer and have a better understanding of both theories and practices of instrument cleaning and the sterilization process to ensure my self-protection and patient safety." (24C1) • "I did change my technique of instrument cleaning, ensuring all the parts of surgical instruments are cleaned. When we have correctly cleaned the instruments, it will be more effective in reducing infection or contamination." (12C2)
Mentorship from the SPECT team	<ul style="list-style-type: none"> • "I have good teamwork and good communication with SPECT, we also have been working together to address the problem and solve it." (14C1) • "We work together [with SPECT] to share and provide training to other departments." (02C2) • "Following the visit from SPECT, we have changed as they advised and we also requested some materials and activities from hospital leadership. A number of requests have been agreed to and some are still being considered." (06C2)
Training others	<ul style="list-style-type: none"> • "I am able and confident to share my knowledges with other staff in my hospital, especially the benefit of using internal and external indicator tests to measure ... surgical instrument sterilization." (05C2) • "In order to [respond] to the new process and requirements from the training, we have created a team for [the hospital] to provide training and share knowledge with other departments." (10C2) • "We also provide training to other department staff who did not join the training with SPECT." (14C2)
Improvements in instrument integrity	<ul style="list-style-type: none"> • "The instruments look cleaner and [have] no rust." (13C1) • "I have a better understanding about using different types of solution to clean, to ensure instruments [maintain] good quality for a long time." (17C2)
Changes in perception of work and recognition by others	<ul style="list-style-type: none"> • "In the past, it seems the cleaning and sterilization department were not valued, but after training ... the cleaning and sterilization department has been recognized as an important department in the hospital" (14C1) • "I can see clearly about the values and the importance of instrument cleaning and sterile tasks/department in our hospital." (19C1)
Identification of remaining gaps	<ul style="list-style-type: none"> • "I feel completely changed from the past including knowledge and skill and hospital staff behaviors, and instrument cleaning and sterilization zone in each department; however, it still has not met the 100% according to the SPECT recommendation." (15C1) • "Since we have limited spaces and building at this point in time, we are not able to change the flow in the Operation Theater. We will change the flow ... according to the guidelines once the new buildings are built." (16C2)

Table II (continued)

Theme*	Findings and participants' quotations
Barriers to implementing changes	<p>Common barriers across many healthcare facilities included limitations in infrastructure and budgets as well as resistance to practice changes. In terms of infrastructure, participants reported not having enough room to separate cleaning and sterilization rooms, a lack of space for a central sterile supply department (CSSD), and a lack of storage space for surgical instruments and other SP equipment.</p> <ul style="list-style-type: none"> • "We also have lack of supplies for cleaning and sterile instruments as recommended from SPECT, we have requested them to admin department but [they] seem [slow to] respond." (21C1) • "It is difficult to change the behaviors or perception of some staff and they seem not to support our new ideas." (04C2) • "I have difficulty in changing the perception of other staff as they do not listen to me as I am just normal staff." (09C2)
Varying degrees of administrative support	<ul style="list-style-type: none"> • "No support from hospital leadership team due to ... difference [in] view or perception from SPECT" (11 C1) regarding SPECT's recommendation for air conditioners in cleaning and sterilization rooms • "There is active participation and commitment from hospital directors to change the cleaning and sterilization zones." (14C1) • "Since this hospital was built and sponsored by [another] organization, we are required to obtain approval from them for any changes to infrastructure ... it will be a long process." (07C2)
Gaps between guidelines, policy, and practice	<ul style="list-style-type: none"> • "There are some requests still not accepted by hospital leadership as they have a different perception or idea. For example, some types of detergent for cleaning instruments, which were not clearly mentioned in the national guidelines, were not approved." (06C2)

* The process of decontextualization and recontextualization involves the researchers independently reviewing participants' interview transcripts, reducing the information to significant statements or quotes, combining the statements into themes, and writing a textual description of the experiences of participants, a structural description (the conditions, situations, or context in which they experienced the phenomenon), and a combined statement of textural and structural descriptions to convey the essence of the experience (i.e., code the data into clusters of meaning) [14].

deteriorated in two thematic areas: disinfection and sterilization.

Qualitative analysis

Eleven emergent themes were identified in 45 semi-structured interviews with participants (Table II). Themes included changes in SP practice, increased knowledge and confidence, connection of SP practice quality to patient and staff safety, mentorship from the SPECT team, training others, improvements in instrument integrity, changes in perception of work and recognition by others, identification of remaining gaps, barriers to implementing changes, and varying degrees of administrative support.

Discussion

The challenges faced by workers in rural and urban HCFs related to implementation seemed to differ, potentially explaining the disparity in SP benchmark improvement between rural and urban HCFs. In contrast to urban workers, who experienced a broad range of barriers to implementing practice changes, including resource constraints and resistance from colleagues, workers from rural HCFs consistently conveyed a structural lack of support for practice changes from leadership. This lack of support was evident in slow or no response from leadership to recommended changes as well as supply requests, which rural workers often attributed to budgetary constraints. Two rural workers (11C1, 12C1) stated that their administrative committees' perspectives

differed from those of SP educators regarding practice recommendations. One rural worker (13C1) identified high workloads as impeding the ability of staff to attend on-site training provided by SPECT trainees. Three rural workers (20C1, 21C1, 24C1) reported that barriers, primarily a lack of response from hospital leadership and budgetary constraints, hindered more significant practice changes, including building a three-sink system for cleaning surgical instruments.

It appears that systemic barriers faced by rural workers, including unsupportive HCF leadership and lack of funding and support for SP practice, are factors in the disparity in improvements in SP benchmarks. Systemic barriers may also contribute to observed regression in disinfection benchmarks in rural HCFs, as well as regression in sterilization and instrument inspection/assembly benchmarks. These areas depend on supplies (e.g., chemical indicators and instrument wrappers) and rural participants described their supply requests as consistently being unfulfilled by rural HCF administration. Although SPECT recommendations aligned with Cambodia's published national infection control guidelines, these guidelines were not adhered to by administration in some of the rural hospitals.

It is noted that urban HCFs had higher and more varied caseloads, more structured cleaning processes, and HCWs who had more formal training. Rural HCFs had lesser caseloads (mostly C-sections) and their SP staff generally had informal training. Staffing organization and education, therefore, could also be a factor in the variability between rural and urban results.

The test results for both C1 and C2 showed statistically significant effects of the training and sustained effect of the training over the four–six month period between the pre- and post-tests. These findings are similar to data collected from the previously mentioned studies in Tanzania and Ethiopia. [9,11] While it was not possible to correlate individual test scores with HCF SP assessment results, the training had significant effects on SP practices at both individual and institutional levels.

The difference in timing for data collection between C1 (four months post training) and C2 (three months post training) suggest a decrease in participants' knowledge over time, and therefore a subsequent need for reinforcement of knowledge. The likelihood of culture, language, and socialization, with respect to the local healthcare system, impacting knowledge retention and knowledge application in practice may explain some of the difference in sustained effectiveness (i.e., slightly positive aggregate in C2), as Cambodian HCWs from C1 helped teach C2 sessions.

Our findings speak to the complexity of the global surgical ecosystem. DeVries and Rosenberg [19] conceptualize this ecosystem as being made up of interconnected human and community resources, professional networks, material resources, and infrastructure. In particular, surgical teams work within nested systems consisting of hospital administration, local supports, district health systems, government ministries, and global organizations. Given this complexity, the WHO recommends that infection prevention and control (IPC) initiatives use multimodal strategies that combine components such as system and supply changes, education and training, leadership engagement, and monitoring and evaluation. [20,21] Leadership support is a strong determinant in the overall success of initiatives because it contributes to the removal of barriers and promotion of culture change. [22] Furthermore, the involvement of actively engaged champions and role models, who build organizational support, address barriers, and promote culture change, has contributed to the success of numerous initiatives. [21,23].

Education is well recognized as imperative to increase surgical capacity in LRCs. [24] Initiatives that aim to engage and empower front-line workers, such as SPECT's training and mentoring programs, are ultimately affected by broader factors that influence the feasibility and sustainability of practice and system changes. One of the objectives of this study was to examine the state of IPC and SP in Southeast Asia through the first implementation of SPECT training outside of Africa. Although the training was delivered in collaboration with a large private hospital in Phnom Penh, the Cambodian Ministry of Health, and Safe Surgery 2020, one of the most salient findings was the varying degree of administrative support for patient safety initiatives (e.g., adherence to national IPC guidelines) and practice changes at individual HCFs. Based on these findings, it is advisable that future IPC and SP initiatives in Southeast Asia include a particular focus on engaging HCF leadership within the surgical ecosystem.

Conclusion

A review of the literature related to infection control practices highlights the lack of attention paid to sterile processing practices by physicians, surgeons, and administrators.

The little research that has been done in LRCs related to infection control and SSIs seems to make assumptions that instruments are sterile, and therefore not one of the aspects of infection control to be considered. As in most HCFs worldwide, in LRCs sterile processing is performed outside the operating theater and what is not seen is too often overlooked. The lack of responsiveness by administrators, as evidenced in this study, is indicative of a lack of understanding of the impact improperly cleaned and therefore unsterile instruments have on patients who undergo surgery. This is a finding that has been observed in several LRCs [8,9,11], and therefore not isolated to Cambodia.

Attention to participants' concerns for improvement were noted. The impact of a focused SP training program varied between urban and rural facilities, and much of that variation stemmed from administrative support for change and budget availability. The study's findings highlight the importance of ensuring administrators are aware of needed improvements, have funding to implement those improvements, and are held accountable to ensure improvements reflect universal standards for decontamination and sterilization practices. Ensuring accountability and funding to maintain equipment, provision of appropriate supplies, and supportive infrastructure for safe SP practices are areas that need greater attention in Cambodia. Further research and work to address the concerns found in this study is required to decrease surgical risk for patients.

Credit author statement

CRedit roles are as follows:

Olive Fast: Conceptualization and design of the study, analysis and interpretation of data, drafting the article and revising, final approval of the version to be submitted. Funding acquisition, project administration, supervision

Aliyah Dosani: Analysis and interpretation of data, drafting the article and revising, final approval of the version to be submitted.

Faith-Michael Uzoka: Analysis and interpretation of data, drafting the article and revising, final approval of the version to be submitted.

Alexander Cuncannon: Analysis and interpretation of data, software, drafting the article and revising, final approval of the version to be submitted,

Samphy Cheav: Acquisition of data, data curation, investigation, resources, article revision and final approval of the version to be submitted.

Ethical approval

Ethical approval was obtained from Mount Royal University Human Research Ethics Board (101620) January 10th, 2019, and Cambodia's National Ethics Committee for Health Research (027) February 17th, 2019.

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Conflict of interest statement

Olive Fast is Chair of Sterile Processing Education Charitable Trust (SPECT), and Christina Fast is her daughter, providing a potential perception of conflict of interest. No other conflict of interest has been identified on the part of other authors.

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Appendix A. Supplementary data

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