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Evaluating the Efficacy of Training and Education on Lowering Blood Culture Contamination Rates in a Tertiary Care Hospital

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ABSTRACT

Introduction: Blood culture remains the gold standard for diagnosing bloodstream infections. Contamination during the collection, transport, or processing of blood culture samples can obscure the true pathogens with contaminant growth, thereby complicating or delaying the diagnosis of bacteremia. This study assesses the effectiveness of an educational intervention aimed at reducing blood culture contamination rates in a tertiary care hospital. **Methods:** This single-center study, aimed at quality improvement, included two phases: an observational phase from December 2022 to February 2023, and an interventional phase from March to May 2023. During the interventional phase, healthcare workers underwent comprehensive training in aseptic blood sample collection techniques. The study involved 980 patients, with 470 blood samples collected during the observational phase (December 2022–February 2023) and 510 during the interventional phase (March–May 2023), all processed using standard microbiological techniques. Blood cultures yielding commensal organisms without corresponding clinical symptoms were classified as contaminants. **Results:** The contamination rate of blood cultures dropped from 12.1% (57/470) during the observational phase to 8.6% (44/510) post-intervention; however, this reduction was not statistically significant ($P = 0.34$, chi-square test). Contamination rates during the observational phase were highest in the ward at 16.2%, followed by 13% in the outpatient department, and lowest in the intensive care unit at 7.1%. The predominant contaminants identified were *Staphylococcus hominis*, followed by *Staphylococcus haemolyticus*, highlighting common sources of contamination. **Conclusion:** Although the educational intervention did not yield a statistically significant decrease in blood culture contamination rates, the study underscores the need for multifaceted strategies, including enhanced training, environmental controls, and standardized protocols, to meet international benchmarks for contamination control.

INTRODUCTION

Blood cultures remain the definitive method for diagnosing bloodstream infections and sepsis; however, they are prone to contamination during collection or processing, which can result in false positives [1-3]. According to the Clinical Laboratory Standards Institute (CLSI), a contaminant in blood cultures is defined as a microorganism introduced during specimen collection or processing, which might not be pathogenic to the patient. Commonly identified contaminants include Coagulase-Negative Staphylococci (CoNS), Aerobic spore-bearing bacilli (ASB), *Diphtheroids*, *Bacillus spp*. (excluding *Bacillus anthracis*), *Micrococcus* species, Viridans group streptococci, *Corynebacterium* species, *Propionibacterium* species, and *Clostridium perfringens,* among others [4-8].

Distinguishing true bacteremia from contamination is crucial for precise diagnosis and effective patient management [9]. True bacteremia is typically defined by microbial growth within 48 hours and the presence of the same organism in multiple blood culture sets [4]. In contrast, contamination is suggested by delayed time to positivity, polymicrobial growth typical of skin flora, or

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growth during antibiotic therapy. The clinical relevance of an isolate can be assessed by correlating it with clinical signs (fever (>38°C), chills, rigors, hypotension (systolic BP <90 mmHg), tachycardia (>90 bpm)), medical conditions (diabetes mellitus, hypertension, immunosuppression, chronic renal failure, malignancy), treatment factors (use of prolonged broad-spectrum antibiotics, chemotherapy, parenteral nutrition), device presence (central venous catheters, indwelling urinary catheters, ventilators), and laboratory data (total leukocyte count, complete blood count, previous culture reports, and other diagnostic tests) [5, 10].

The precision and promptness of diagnosing bloodstream infections depend critically on blood cultures. Yet, contamination not only delays appropriate treatment but also risks misdiagnosis by obscuring the actual causative pathogen [11]. Misdiagnosis can arise from several procedural errors including inadequate skin preparation, suboptimal blood volume, too few blood culture bottles, and sampling post-antimicrobial initiation [8, 12]. The primary contributor to blood culture contamination is inadequate technique by insufficiently trained health personnel, including interns, nurses, and residents on rotational duties. Essential to mitigating this issue are comprehensive induction and reorientation training on correct blood collection techniques, the critical importance of blood cultures, and optimal timing for sample collection relative to antibiotic therapy. Breaching aseptic technique during blood collection stands as the leading cause of contamination. Studies underscore that strict adherence to asepsis can significantly lower contamination rates [1, 2].

Guidelines from the American Society for Microbiology (ASM) and the CLSI stipulate that blood culture contamination rates should not exceed 3% [12, 13]. However, research indicates that contamination rates vary widely, from 0.6% to 6%, depending on hospital settings, collection techniques, and laboratory processing methods [1, 14].

Prior to this study, the blood culture contamination rate was calculated at 14.6% over the previous two years, significantly exceeding the recommended threshold of 3% by nearly five times. Recognizing the critical role of contamination rates in infection diagnosis, severity assessment, and treatment guidance, this study aimed to evaluate the effectiveness of educational interventions on reducing blood culture contamination rates across hospital settings (wards, ICUs, and outpatient departments) by comparing an observational phase (December 2022–February 2023) with an interventional phase.

MATERIAL AND METHODS

Study design. Conducted at a tertiary care hospital in Delhi, India, this single-center interventional study aimed at quality improvement spanned six consecutive months from December 2022 to May 2023.

Ethical considerations. This study was classified as a quality improvement initiative, focusing on the enhancement of infection control practices through the analysis of existing microbiological surveillance data. Consequently, formal approval from an ethics committee was not required, in line with our institution's policy where such projects, utilizing de-identified data from routine clinical activities, are exempt from the review process. This exemption is based on the premise that these initiatives aim to improve service delivery without directly involving human subjects in a manner that would necessitate ethical oversight beyond standard clinical consent.

Although formal ethical review was not mandated, the principles of ethical research were upheld. All patients were provided with comprehensive information about the study's objectives, the use of their blood samples, potential risks, and their rights, including the option to withdraw. Written consent was obtained from all patients before any sample collection (supplementary file). All data were anonymized to safeguard patient privacy. Blood samples were obtained by skilled personnel employing standardized techniques to minimize discomfort and risk. Blood culture results were reported as part of standard patient care protocols, ensuring that the study did not interfere with clinical management.

Study population. Participants were patients aged 24 to 79 years, suspected of having a bloodstream infection (BSI), which was indicated by at least two of these clinical criteria: fever (>38°C), chills, rigors, hypotension (systolic BP <90 mmHg), or tachycardia (HR >90 bpm). Recruitment occurred across the hospital's OPD, ICU, and inpatient wards. Exclusion criteria encompassed patients diagnosed with conditions such as malignancy, autoimmune disorders, or immunosuppression that could manifest similar symptoms, thereby confounding the diagnosis of BSI.

Patients' demographics. The study cohort had a mean age of 49.17 years (SD ± 14.98), spanning from 24 to 79 years. Blood culture contaminants were identified in patients with an almost even distribution by gender: 50.88% (29 out of 57) were male, and 49.12% (28 out of 57) were female.

Sample size calculation. The sample size was determined with reference to Shaj *et al*. (2022) [2], who reported a 9.5% decrease in blood culture contamination rates post-intervention. To replicate this finding with a statistical power of 80%, a two-tailed test margin of error of 2%, and a significance level of 5%, the study required a minimum of 902 patients.

Blood sample collection and processing. Blood samples for culture, 8-10 mL per bottle, were collected from patients suspected of having a bloodstream infection (BSI), diagnosed when at least two clinical signs were present: fever (>38°C), chills, rigors, hypotension (systolic BP <90 mmHg), or tachycardia (HR >90 bpm),

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following CDC criteria. These samples were inoculated into the Automated BACTEC 9160 system upon receipt in the laboratory. Subcultures from positive blood culture bottles (PBCs) were plated on 5% sheep blood agar and MacConkey agar, then incubated at 37°C for 18-24 h. Identification and antimicrobial susceptibility testing were conducted using the Vitek II compact system. Contamination was identified by the isolation of organisms such as CoNS, Aerobic spore-bearing bacilli (ASB), Diphtheroids, *Bacillus* spp. other than *B. anthracis*, *Micrococcus* species, *Viridans group streptococci*, *Corynebacterium* species, or *Propionibacterium* species from PBCs, with criteria for contamination supported by references [4, 15].

Study phases

Phase 1: Observational study

From December 2022 to February 2023, the initial phase involved direct observation of blood sample collection practices. This was carried out by an infection control nurse along with staff from the Microbiology Department, specifically postgraduate residents and senior residents. Observations focused on:

1. Patient particulars: Name, age, sex, sample ID number, case record file (CRF) number, and location (ward/OPD/ICU);
2. Compliance with hand hygiene protocols prior to the procedure;
3. Proper donning of sterile gloves;
4. Adequacy of skin preparation at the collection site;
5. Whether vein palpation was avoided post-cleaning;
6. Volume of blood collected, ensuring 8-10 ml per sample.

These observations were systematically recorded to evaluate the adherence to established blood culture collection protocols among the hospital's clinical and technical staff.

Phase 2: Interventional study

From March to May 2023, the study entered its interventional phase where Infection Control Nurses (ICNs), overseen by medical residents from the Microbiology Department, conducted training sessions for nurses, medical residents, and technical staff involved in blood sample collection. These sessions, lasting 15-20 minutes, were conducted at the bedside and included:

1. Hand hygiene practices;
2. Proper use of sterile gloves;
3. A two-step decontamination process involving the application of 70% alcohol followed by 0.5% chlorhexidine-based antiseptics;
4. Maintaining adequate contact time for decontamination (30 seconds to 1 min);
5. Ensuring collection of 8 to 10 mL of blood per sample;
6. The significance of obtaining blood samples prior to the administration of antibiotics, whenever possible.

The training aimed to reinforce best practices in blood culture collection to minimize contamination rates.

Post-intervention data collection. Following the training and education phase, the blood sample collection techniques of medical residents, nurses, and technical staff were re-evaluated. Observations were documented using the same predefined proforma utilized during the initial observational phase to ensure consistency in data collection.

Calculation of contamination rate. Contamination rates for blood cultures were calculated for both the pre-intervention and post-intervention periods across different hospital settings: OPDs, ICUs, and inpatient wards. The contamination rate was defined as the percentage of contaminated cultures out of the total cultures taken, calculated using the formula: (Total contaminated cultures / Total cultures performed) × 100%, following the method outlined in reference [15].

Statistical analysis. The blood culture contamination rates were compared between the pre-intervention and post-intervention phases using the chi-square test. A *P*-value of less than 0.05 was considered statistically significant. No additional statistical analyses were performed beyond the comparison of contamination rates between the two phases.

RESULTS

Throughout the six-month study, a total of 980 blood samples, meeting the study's inclusion criteria for suspected bloodstream infection (BSI), were collected: 470 during the observational phase and 510 following the educational intervention.

Observational phase. From the 470 samples collected during the observational phase, 12.1% (57 samples) were contaminated, 13.4% (63 samples) exhibited pathogenic growth, and 74.5% (350 samples) showed no microbial growth.

Interventional phase. In the interventional phase, contamination was found in 8.6% (44/510) of the samples overall, with setting-specific rates of 8.5% in the OPD, 11.1% in the ward, and 6.1% in the ICU (Table 1). Pathogenic growth was present in 15.5% (79/510), and no microbial growth was observed in 75.9% (387/510) of the samples (Figure 1).

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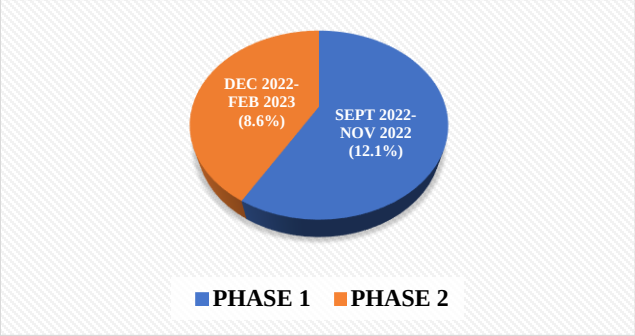

Fig. 1. Comparison of blood culture contamination rates between the pre-intervention and post-intervention phases

In the study's setting, prior to the intervention, the inpatient wards exhibited the highest blood culture contamination rate at 15.2%, with the OPD following at 13%, and the ICU at 7.1%. Table 1 shows the impact of training interventions on blood culture contamination rates across hospital settings.

Table 1. Comparison of blood culture contamination rates (%) before and after intervention across hospital settings

Setting	Observational phase (%)	Interventional phase (%)	*P*-value
OPD	13.0	8.5	0.2487
Ward	16.2	11.1	0.300
ICU	7.1	6.1	0.774
Total	12.1	8.6	0.34

The contamination rate decreased from 13.0% in the observational phase to 8.5% post-intervention. Although this represents a notable reduction, the change did not reach statistical significance (*P*-value = 0.2487), suggesting that other factors might still influence contamination rates in this setting or that the sample size might not be sufficient to detect a significant effect.

A similar trend was observed in the ward setting, where the contamination rate dropped from 16.2% to 11.1%. Here too, the *P*-value of 0.300 indicates that this decrease, while clinically interesting, did not achieve statistical significance. This could imply that while the intervention has a positive trend, there might be ward-specific challenges or variability in practice adherence that need addressing.

In the ICU, the smallest reduction in contamination rates was observed, from 7.1% to 6.1%. The high *P*-value of 0.774 suggests that the intervention had the least measurable effect in this critical care environment. This could be due to the complexity of care in the ICU, where the risk of contamination might be inherently higher due to more frequent interventions and the severity of patient conditions.

When considering the hospital as a whole, the total contamination rate was reduced from 12.1% to 8.6%. Despite this overall decrease, the P-value of 0.34 indicates that this change was not statistically significant across the entire study population. However, this overall trend towards reduction suggests that the educational interventions might be moving in the right direction but might require further refinement or a larger study to confirm their effectiveness statistically.

The study observed a reduction in blood culture contamination rates from the observational to the interventional phase, although this decrease was not statistically significant as determined by a chi-square test ($P = 0.34$). The profile of contaminant organisms in both phases is shown in Figures 2 and 3, detailing the observational and interventional periods, respectively.

During the observational phase (Phase 1), CoNS were the predominant contaminants at 70.1% (40/57), followed by aerobic spore-bearing bacilli at 22.8% (13/57), and *Micrococcus* species at 7.0% (4/57). Within the CoNS group, *S. hominis* was identified in 29.8% (17/57) of contaminated cultures, with *S. haemolyticus* accounting for 26.3% (15/57) (see Figure 2 for species distribution).

During the interventional phase (Phase 2), *CoNS* continued to dominate as contaminants at 72.7% (32/44), followed by aerobic spore-bearing bacilli at 27.3% (12/44). Within CoNS, *S. haemolyticus* was identified in 31.8% (14/44) of contaminated cultures, closely followed by *S. hominis* at 29.5% (13/44) (Figure 3).

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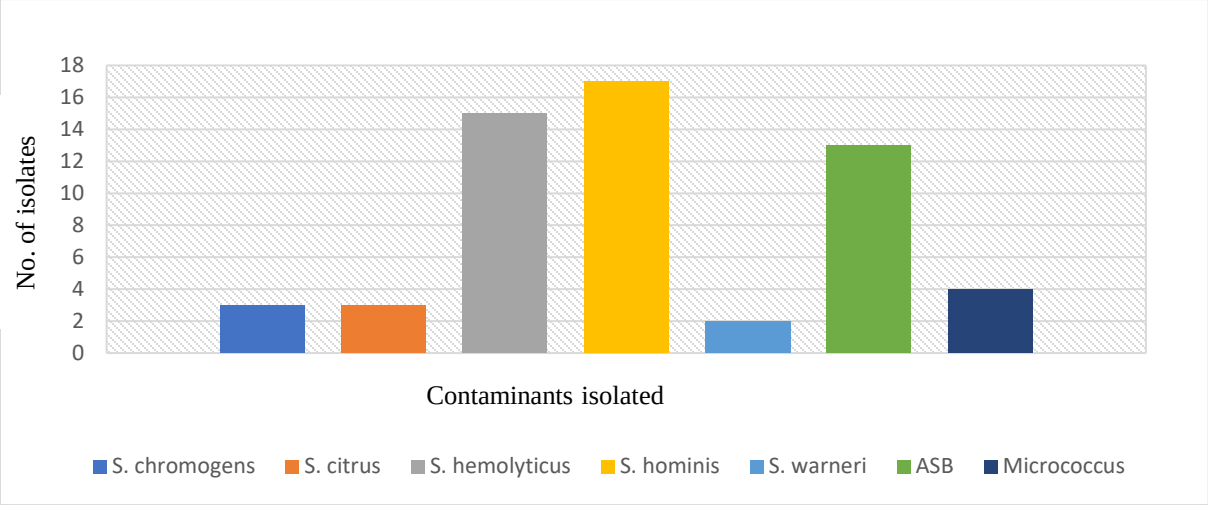

Fig. 2. Frequency and types of contaminants in blood cultures during the observational phase

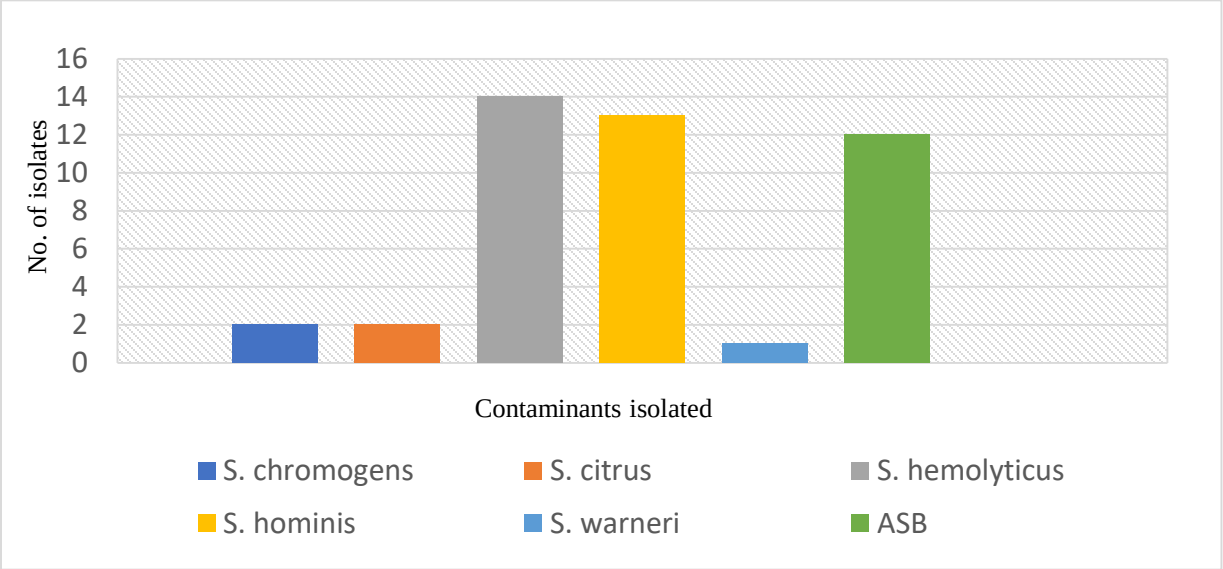

Fig. 3. Types and frequencies of contaminants in blood cultures post-intervention

Table 2. Distribution of blood culture contaminants across different clinical settings

Contaminant	OPD	WARD	ICU	Total
S. chromogenes	1	1	1	3
S. citreus	0	2	1	3
S. haemolyticus	2	6	7	15
S. hominis	4	7	6	17
S. warneri	0	1	1	2
ASB	7	5	1	13
Micrococcus spp.	2	2	0	4
Total	16	24	17	57

The OPD exhibited a diverse range of contaminants with *S. hominis* and Aerobic Spore-Forming Bacteria (ASB) being the most prevalent. This suggests that skin flora contamination, particularly from staphylococcal species, remains a challenge in less controlled environments like the OPD, where patients are not as critically ill but still undergo numerous procedures that could introduce contaminants.

In the ward setting, there was a higher total number of contaminants, with *S. hominis* and *S. haemolyticus* being predominant. The increased presence of these contaminants might reflect the longer patient stays and more frequent medical interventions, which could increase the opportunities for contamination. The presence of ASB also indicates possible issues with sterilization or environmental sources of contamination.

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The ICU showed a slightly different contaminant profile, with *S. haemolyticus* being the most common, closely followed by *S. hominis*. The lower total count of contaminants compared to the ward might be attributed to stricter aseptic techniques due to the critical nature of care in the ICU. However, the persistence of *S. haemolyticus* suggests that even with enhanced protocols, certain resistant strains or biofilm-forming bacteria might pose ongoing challenges.

The total distribution indicates that *S. hominis* and *S. haemolyticus* are the leading contaminants across all settings, pointing towards these species as primary targets for contamination control strategies. The relatively high number of ASB across settings, particularly in the OPD, suggests environmental or handling issues that might not be directly addressed by standard skin preparation techniques.

DISCUSSION

Diagnostic stewardship, which aims to reduce the inappropriate use of antimicrobials, heavily depends on preanalytical factors like sample collection techniques [16, 17]. This is particularly critical in blood cultures, where the presence of contaminants can result in inappropriate treatment, thereby increasing morbidity and mortality in sepsis patients [6, 17, 18]. Given these implications, our study was designed to evaluate baseline contamination rates in blood cultures and to identify effective interventions for reducing these rates.

Blood culture contamination can result in false-positive results, impacting both sample collection and processing stages, which leads to several adverse outcomes. It results in the wastage of hospital resources through additional testing and can cause contaminants to be misinterpreted as true pathogens, leading to unnecessary antimicrobial treatment. This not only contributes to the emergence and spread of antimicrobial resistance, a critical public health issue, but also increases healthcare costs due to the superfluous use of antibiotics and extended hospital stays. Consequently, reducing contamination rates is essential for improving care quality, minimizing healthcare expenditures, and enhancing antimicrobial stewardship [7, 18].

This study recorded a decrease in blood culture contamination rates from 12.1% in the observational phase to 8.6% in the interventional phase. While this suggests a potential positive impact of the intervention, the lack of statistical significance (P-value = 0.34) suggests that the intervention's effectiveness might require further validation or optimization. It is possible that the study did not have sufficient power to detect a smaller, yet clinically significant, difference. A reduction from 12.1% to 8.6%, although not statistically significant, may have clinical relevance, potentially reducing unnecessary antibiotic prescriptions and costs, warranting further investigation.

In line with prior studies [19, 20], CoNS emerged as the predominant contaminants during both phases of this study. The distribution of these contaminants varied by setting, with the highest contamination rate in the inpatient ward at 16.2%, followed by the OPD at 13%, and the ICU at 7.1%. Despite staff training on optimal blood sample collection techniques, the reduction in contamination rates did not reach statistical significance. The absence of statistically significant reduction might be attributed to several factors: partial adherence to the new protocols, ongoing contamination from sources not targeted by the intervention, or inherent limitations in how the intervention was designed or executed. These findings suggest a need for enhanced training, broader contamination control measures, or a refined intervention approach.

In both study phases, CoNS were identified as the most common contaminants in blood cultures. Interestingly, the intervention did not significantly alter the profile of contaminant species between the two study phases. The continued prevalence of CoNS underscores the difficulty in reducing contamination from skin flora despite targeted interventions. This persistence suggests that factors other than sample collection practices, such as skin preparation or environmental controls, might need to be addressed to further reduce CoNS contamination.

Guidelines from authoritative bodies like the ASM and CLSI set a benchmark where blood culture contamination rates should not exceed 3% [1, 2, 14]. However, a significant portion of the literature reports contamination rates that are considerably higher across various clinical settings, with numerous studies documenting rates from 2% to 14% [2, 21]. This gap between the recommended standards and actual contamination rates underscores the necessity for continuous quality improvement initiatives and rigorous adherence to best practices in clinical microbiology labs to approach these benchmarks.

Archibald *et al*. (2006) conducted a three-year study that revealed a notable disparity in contamination rates between inpatient and emergency room settings, with rates of 2.5% and 7.8%, respectively [6]. This discrepancy might be linked to the high-pressure environment of emergency departments, where adherence to proper blood culture collection techniques can falter. Additionally, medical crises can increase the likelihood of protocol deviations irrespective of the setting. In contrast to Archibald *et al*. (2006), our study found the lowest contamination rates in the ICU (6.1%) and the highest among inpatients (11.1%), suggesting different operational dynamics at play. Several factors might explain these observations: dedicated staffing in ICUs versus frequent rotations in wards, variations in patient acuity, and the nature of procedures conducted in each setting. Moreover, adherence to protocols might be more stringent in the critical care environment of ICUs [12]. These findings highlight the need for department-specific contamination control strategies that address the unique

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operational and procedural challenges within each healthcare setting.

Numerous interventions have been aimed at reducing blood culture contamination rates. One study showed a significant decrease in contamination through strict adherence to aseptic skin cleansing protocols, improved venipuncture techniques, and a two-step decontamination process: first with 70% isopropyl alcohol, followed by a 1-2% tincture of iodine [6]. Additionally, Bekeris *et al*. (2005) found that employing dedicated phlebotomists or medical technologists for blood culture collection markedly reduced contamination rates [22]. These studies underscore the critical role of strict adherence to aseptic techniques and suggest that training specialized personnel for blood culture collection can significantly minimize contamination rates.

Hall *et al*. (2013) observed a significant drop in peripheral blood culture contamination from 3.9% at baseline to 1.6% post-intervention [23]. Likewise, Shaji *et al*. (2022) documented a decline in contamination rates from a pre-intervention level of 13.7% to 4.2% in the regular group and 3.2% in the phlebotomist group during the intervention [2]. Both studies underscore the effectiveness of targeted interventions like enhanced collection methods, staff education, and specialized phlebotomy teams in significantly reducing contamination rates, thereby enhancing the reliability of blood culture diagnostics [2, 23].

Although there was a reduction in contamination rates from 12.1% to 8.6% between the observational and interventional phases, this indicates that the interventions had some effect, yet it underscores the necessity for a broader, multifaceted strategy to significantly lower contamination rates to below 4% (achieving statistical significance with a *P*-value of 0.03 by chi-square test), especially in high-risk settings like inpatient wards.

During the intervention, there was a notable trend: as contamination rates decreased, there was a corresponding increase in cultures identified as 'true positives' or 'sterile.' Blood culture contamination can lead to both false-positive results, where non-pathogenic organisms are misidentified as pathogens, leading to unnecessary treatments and prolonged hospital stays [15], and less commonly, false-negatives in rare cases, where true pathogens are obscured, potentially delaying critical treatment decisions [15]. These errors significantly impact patient care [2, 5]. These observations highlight the critical need to minimize contamination in blood cultures to enhance diagnostic accuracy, thereby ensuring effective antimicrobial stewardship and improving patient outcomes [24].

Throughout the study, CoNS were identified as the most prevalent contaminant, followed by ASB and micrococci. These findings align with previous research where CoNS and ASB have similarly been identified as leading contaminants in blood cultures [2, 4-6, 11]. The persistence of CoNS and ASB as contaminants highlights the need for ongoing rigorous skin decontamination, enhanced hand hygiene, and stringent environmental controls to reduce contamination [2].

The prevalence of specific organisms contributing to blood culture contamination remained consistent between the observational and interventional phases. CoNS were the predominant contaminants, accounting for 40 out of 57 contaminated cultures in the observational phase and 32 out of 44 in the interventional phase. This consistent pattern underscores the need for ongoing efforts to target these specific organisms through focused training initiatives and strict adherence to aseptic protocols during blood culture collection procedures. To effectively reduce contamination by CoNS, it is crucial to implement and reinforce targeted interventions like rigorous skin decontamination and comprehensive hand hygiene training. These measures are vital for maintaining the integrity of microbiological diagnostics [14, 19, 25].

This research was undertaken in a tertiary care hospital in Delhi, India, focusing on patients with suspected BSIs, which might influence the study's outcomes due to regional healthcare practices and patient demographics. The specific demographic profile, healthcare infrastructure, and clinical practices of this Delhi-based tertiary care hospital may limit the generalizability of our findings to other settings where these factors might significantly differ. When considering these findings for other contexts, one must account for the distinctive attributes of this study's setting and its patient cohort. Therefore, these results should be interpreted with consideration of the study's specific environmental context, and caution is advised when applying these findings to different healthcare environments characterized by varied patient demographics, resource availability, and clinical protocols.

Cultural norms and practices, as well as setting-specific contextual factors, can significantly affect both the implementation success of interventions and the incidence of blood culture contamination. For example, differing levels of adherence to infection control protocols, diverse patient demographics, and varying healthcare provider behaviors influenced by cultural contexts can directly affect contamination rates. Understanding the impact of cultural and contextual factors is essential for evaluating the transferability of study results [15]. Future studies should specifically investigate how these cultural and contextual elements alter intervention outcomes across various healthcare environments, guiding the creation of culturally adapted contamination control strategies. This approach would not only deepen our understanding of contamination dynamics but also enable the design of intervention strategies that are sensitive to the cultural and contextual nuances of different healthcare settings.

Despite the reduction in contamination rates lacking statistical significance (P = 0.34), this outcome underscores the necessity for further exploration of or

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adjustments to current intervention strategies. This suggests that refining the existing interventions or adopting a comprehensive strategy might be essential for achieving a statistically significant reduction in contamination rates. Creating a culture of change among healthcare staff through active hospital administrative support, regular interdepartmental reviews, and continuous monitoring could significantly enhance intervention effectiveness. Ongoing research and comprehensive initiatives are imperative to develop robust protocols that safeguard public health by minimizing contamination. Operational enhancements should include orientation programs for new staff on sample collection, reinforced training on aseptic techniques, routine, unannounced audits in wards and ICUs, and direct observation and correction of staff to enforce adherence to sample collection and hygiene protocols.

Our study underscores the ongoing challenge of blood culture contamination in our hospital, primarily driven by CoNS. Although not statistically significant, the modest reduction in contamination rates post-intervention suggests that targeted measures have the potential to be effective. However, these results reveal the multifaceted nature of contamination control, where interventions did not uniformly succeed across all departments, with inpatient wards still showing elevated contamination rates despite the measures taken.

To effectively reduce contamination, adopting a multifaceted approach is essential, encompassing training programs customized to address the distinct contamination challenges of each clinical area, with ongoing monitoring, feedback systems to ensure protocol adherence, and rigorous enforcement of standardized collection procedures. Moreover, fostering a culture of heightened awareness and accountability in healthcare staff is crucial for sustaining the behavioral shifts needed to keep contamination rates low. Effective mitigation of blood culture contamination demands a unified effort from all relevant parties, encompassing clinicians, nursing staff, microbiologists, and administrative leadership. By implementing comprehensive and contextually tailored interventions, we can aim for substantial and sustained reductions in contamination rates, thereby enhancing diagnostic accuracy, improving clinical outcomes, and optimizing resource use in our healthcare setting.

The study's six-month duration limited evaluation of the long-term effects of training initiatives on blood culture contamination rates. While the study provided insights into the immediate impact of the interventions, an extended study period is crucial for determining whether the reductions in contamination rates are sustainable over time. Moreover, a prolonged study would better capture the cumulative benefits of ongoing training on reinforcing best practices and driving behavioral change in healthcare staff.

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Each author contributed substantially: WW, SG, MJ, PL, AS, and ST participated in study design, data collection, analysis, and manuscript preparation, and all have reviewed and approved the manuscript for submission.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest associated with this manuscript.

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