An-Najah National University

Faculty of Graduate Studies

THE EFFECTIVENESS OF MULTIMODAL INTERVENTIONS ON REDUCING BLOOD CULTURE CONTAMINATION RATE IN GOVERNMENTAL HOSPITALS: A PRE- AND POST-STUDY

By

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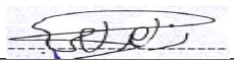
Dr. Zaher Nazzal	
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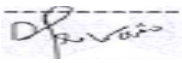
Dr. Fekri Samara	
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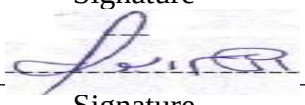
Prof. Adham abo taha	
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Dedication

I dedicated this thesis to the sake of Allah and my great teacher and messenger, Mohammed (may Allah bless and grant him), who taught us the purpose of life.

To those who are incomparable in the universe, to those whom Allah has commanded us to be dutiful to, to those who have given so much and offered what cannot be repaid, and to you, my dear mother and father, for you have been my greatest supporters throughout my academic career.

To those who are my refuge and a symbol of my pride and honour, I am one of them, and they are one of me, my dear brothers and sister.

To the adornment and joy of my life, to the smile that bestows hope upon me, to the one who always trusted in me, hoping to God that I will always be a source of pride and strength for him and a good role model, to my little child

To those who carried the most sacred message in life, to those who paved the way for us, the path of knowledge and science, to our distinguished teachers.

To all of them I dedicate this work; may Allah guide me and you to goodness, and I hope that Allah Almighty has benefited me with what I taught it, that He will teach me what I do not know, and that He will make it an argument for me, not against me.

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Thank you to everyone who gave me moral support for completing this task.

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

THE EFFECTIVENESS OF MULTIMODAL INTERVENTIONS ON REDUCING BLOOD CULTURE CONTAMINATION RATE IN GOVERNMENTAL HOSPITALS: A PRE- AND POST-STUDY

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **Mariam Zaid**

Signature: 

Date: **14-8-2025**

List of Contents

List of Tables

List of Figures

List of Appendices

THE EFFECTIVENESS OF MULTIMODAL INTERVENTIONS ON REDUCING BLOOD CULTURE CONTAMINATION RATE IN GOVERNMENTAL HOSPITALS: A PRE- AND POST-STUDY

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Abstract

Background: Blood Culture (BC) is a diagnostic standard for detecting bloodstream infections, which contribute substantially to hospital morbidity and mortality. However, even with modern medical technology, contamination rates remain a persistent challenge, potentially compromising diagnostic accuracy and clinical decision-making.

Objective: This study aimed to assess the effectiveness of a multimodal intervention in reducing the blood culture contamination (BCC) rate to below 3%, in line with the Clinical and Laboratory Standards Institute (CLSI) guidelines, as well as to enhance nurses' knowledge, practice, and adherence to proper BC collection practices.

Method: We conducted a six-months pre-post intervention study at secondary governmental hospital in the northern of the Palestine, assessing four primary outcomes in the pre and post intervention phases: (1) BCC rates, (2) nurses' knowledge, (3) nurses practice, and (4) procedural compliance for both peripheral and central venous access device (CVAD) collections. The intervention package comprised six key components: introducing the standard procedure of the BC collection, structured education sessions, a standardized bundle checklist, visual reminders, performance feedback, and on-site corrections that were used for two months. Bloom's criteria were used to evaluate the total knowledge, practice, and compliance for the procedure of BC collection. SPSS version 21 was used for statistical analysis, with significance set at p-value ≤ 0.05.

Results: The study demonstrated significant improvements across all measured outcomes. Post intervention, nurses' knowledge increased substantially from 55.48% (poor knowledge) to 92.54% (good knowledge) ($p < 0.001$), and nurses' practice

improved significantly from 25.36% (poor practice) to 40.19% (bad practice) ($p < 0.001$). Procedural compliance showed statistical enhancement for both, peripheral collections (80.4% (good compliance) to 96.43% (good compliance)) and CVAD collections (68.25% (bad compliance to 94% (good compliance)), with ($p<0.001$) for both. Most importantly, the BCC rate declined from 9.4% to 2.4%, achieving the study's target of falling below the 3% CLSI benchmark.

Conclusion: This study demonstrated that targeted multimodal interventions can effectively reduce BCC rates to meet clinical standards while substantially improving both theoretical knowledge and practical compliance among nursing staff. These findings underscore the value of combined educational and operational strategies in optimizing diagnostic microbiology quality, ultimately enhancing patient care through more reliable bloodstream infection detection.

Keywords: Multimodal intervention, Blood culture contamination, Nurses' compliance, Nurses' knowledge and practice.

Chapter One

Introduction

1.1 Background

Bloodstream infections (BSI), which include bacteremia, fungemia, and severe sepsis, are a significant cause of morbidity and mortality for hospitalized patients worldwide (1). BC is a standard method for identifying BSI, which can be used to guide antimicrobial therapy. This approach helps patients with serious infections receive safe and rapid treatment (1).

Although the BC is one of the most accurate and sensitive tests conducted in clinical microbiology laboratories, advancements in technology and medical equipment may still yield false-positive results or contaminated BCs when microorganisms are misidentified as contaminants. This common issue in hospitals can have significant financial and clinical implications (1,2).

A contaminant is defined as a microbe that may not be harmful to the patient but is present in the culture as a result of poor blood collection methods, through a patient's skin, contaminated surroundings, the hands of medical workers, and equipment used to collect or transfer blood (2,3).

The most common microorganisms that cause BC contamination (BCC) are present on the skin as flora, such as *coagulase-negative staphylococci* (CONS), *Micrococcus species, Propionibacterium species, Streptococci viridians, Bacillus species,* other than *Bacillus anthracis, and Corynebacterium* (4–6).

Based on the recommendations of the Clinical and Laboratory Standards Institute (CLSI), the acceptable rate of BCC in health institutions is less than 3% (5). However, several studies have reported that the contamination rate in adults varies from 0.6 to 12.5% (7–14). Additionally, studies in neonatal populations have demonstrated that BCC occurs at rates ranging from 2.6% to 18%(15–18). The difficulty of drawing blood is the reason for the higher contamination rates in newborns (15,19). In particular, a single retrospective study conducted at a tertiary care facility in Palestine found that the BCC ranged from 3.8% to 4.8% (20).

Inappropriate sampling, noncompliance with aseptic procedures, low staff experience, inadequate training in withdrawing the BC sample, staff education disparities, heavy traffic and crowding in the blood collection areas, difficulties with taking blood from elderly and pediatric patients, and workload levels all affect the accuracy of the BC results (3,20–22).

Hence, best practice guidelines for specimen collection emphasise the importance of obtaining samples using aseptic methods before administering antibiotics and before other laboratory tests. It is preferable to use a direct venous puncture. The process for BC collection from peripheral veins involved performing proper hand hygiene, putting on sterile gloves, applying alcohol-based products to disinfect the skin, allowing it to dry, and then performing septal disinfection of the top of the BC bottles. It is crucial to collect the blood samples for culture in the proper order and with an adequate volume.

To confirm the presence of bacteria, it is recommended to collect a second set of BCs from another venipuncture site within 15–30 minutes after the first collection. In addition, if the BC sample is collected from a central venous access device (CVAD), the healthcare worker (HCW) should wear a face mask, the catheter hub should be disinfected before and after collection of the first sample, and a new cap should be aseptically attached after collection(3,5,22,23).

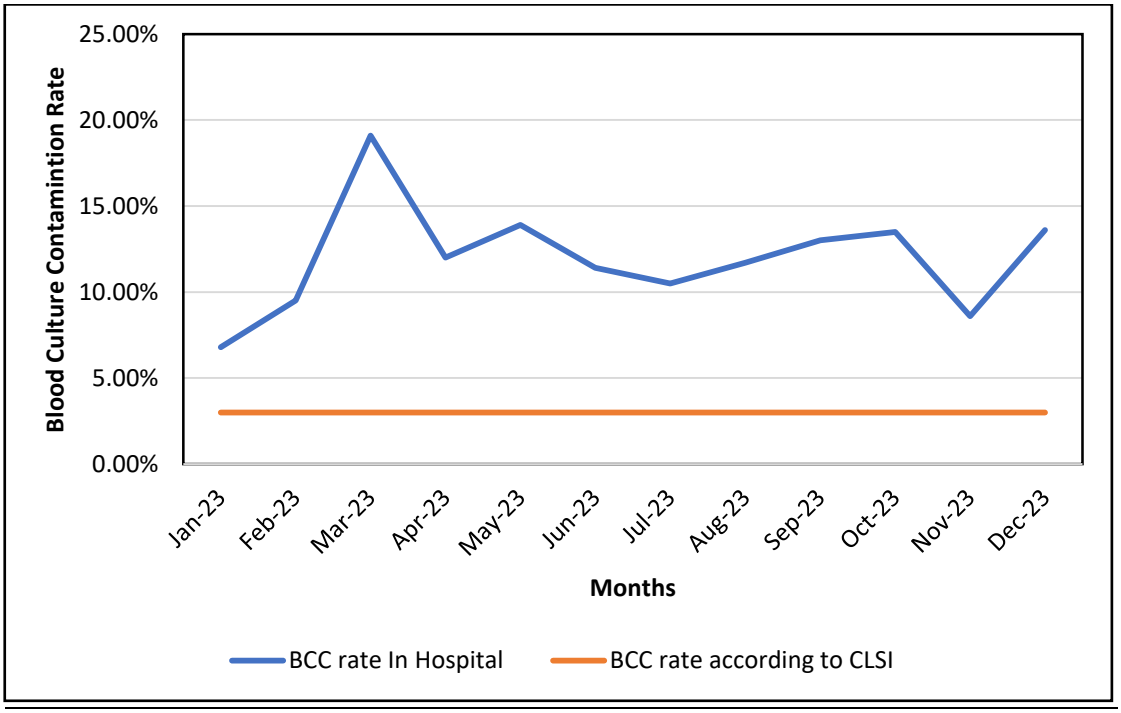
At each step, precautions need to be taken. A contaminated sample could result from a missed step at any of these stages. Therefore, adherence to standard protocols for BC collection, evidence-based practices, and staff training is crucial for ensuring the implementation of appropriate procedures (24,25).

1.2 Problem statement

In March 2023, nurses who withdrew the BC samples expressed concern about the BCC rate. An analysis of the organisms cultivated in the BC test indicated that a more significant issue probably causes BCC episodes. Following an assessment of all positive BCs, it was found that in 2023, the total BCC rate exceeded the accepted BCC rate in healthcare settings, as shown in Figure 1, which is less than 3%, according to CLSI(5). Despite the hospital's efforts to lower the BCC rate, which included providing education to nurses only, the rate did not drop below the approved rate during that time, as reported by the infection control and prevention officer of the selected hospital.

Figure 1

The blood culture contamination in the hospital in 2023 before conducting the study



Initially, BCC negatively impacts analytical testing and laboratory efficiency, increasing technologists' workloads when there is a lack of HCWs in microbiology laboratories. Contaminated cultures divert efforts from other critical samples, and time spent on false-positive BC is diverted from other critical samples. This disruption affects not only the laboratory but also nurses and physicians. High BCC rates can also give users a negative perception of clinical laboratory services, as they tend to think that contamination results from unsatisfactory procedures. (26–28).

Contaminated BC can also have significant financial consequences for the laboratory si nce it requires expensive and unnecessary further testing. This includes repeat BC, ancillary site cultures, and nonmicrobiological tests like therapeutic drug monitoring and complete blood count tests (11).

Additional organism identification techniques, media utilisation, and unnecessary antimicrobial susceptibility testing are all possible in a microbiology laboratory. The median patient charges for negative and false-positive events increased by 47%, to $8,720 per contaminant, according to research by Gander et al. (27).The overall microbiological charges associated with contaminated BC increased by 80%,

according to Bates et al. This rise included a 30% increase in normal culture charges and a 40% increase in BC charges. (26) Alahmadi et al. found a 4-fold increase in microbiology charges per contaminated culture compared to a negative culture (29).

Moreover, contaminated cultures can lead to increased antibiotic exposure, with intravenous antibiotic charges being 39% higher for contaminant BC episodes compared to culture-negative patients (26). Forty-one percent of BCC episodes due to CONS were treated with antibiotics, with 34% receiving unnecessary vancomycin(11). Furthermore, 41% of the 178 patients who had contaminants were given unnecessary intravenous antibiotics (30). Many patients start on antibiotics for contamination events and receive prolonged therapy, with a median antibiotic course of 7 days and a mean duration of 6.5 days for CONS contamination episodes (30).

Increased exposure to antibiotics can result in adverse side effects, including drug-drug interactions, allergic reactions, antibiotic resistance, and alterations to the host microbiome, which may lead to an infection with Clostridium difficile (3).

On the other hand, the burden of adverse effects associated with contaminated BC is not well-documented. According to a previous study, patients with contaminated BC who were treated with antibiotics had greater crude mortality rates; however, this finding was complicated by the fact that patients who received antibiotics were more ill and had more comorbidities, and their deaths were not directly caused by the overuse of antibiotics (31).

Numerous studies have investigated the economic impact of contaminated BC and the associated costs. A retrospective case series study found that the average cost for the care of patients with contaminated BC was $928 per patient, incurred due to hospital admissions, re-evaluation in the ED, and antimicrobial susceptibility testing (32). Patients with contaminated BC and those with negative BC have been compared economically in a number of studies. According to a retrospective case-control study conducted in Ireland, individuals with contaminated BCs spent more time in the hospital and paid $7,502 more for care overall. Laboratory prices rose by $61, and pharmaceutical costs per patient rose by $95 (29). Hospitalisation, antibiotic, and laboratory expenses were considerably greater for patients with contaminated BCs, according to another comparative study conducted in St. Louis (13).

A study in Boston found that 94 out of 1,191 hospitalized patients (7.9%) with BC had contaminated results, leading to longer hospital stays and increased hospital charges(26). According to a retrospective cohort research conducted in Denver, patients who received contaminated BC spent three more days in the hospital overall, which led to an increase in hospital expenses of $8,756. The anticipated 1,455 to 2,200 additional hospital days annually could result in $1.8 million in increased annualized expenditures due to BC contamination (33).

The economic benefits of routinely using therapies to lower BCC costs have been evaluated in two studies. Self et al. discovered that, compared to the standard BC collection process, the regular use of sterile collection kits and phlebotomy teams for drawing blood produced net annualized savings of $483,219. Training phlebotomists saved $288,980 per year by collecting blood samples (34). According to Skoglund et al., regular use of an initial specimen diversion device to avoid contamination would save the hospital $272 for each BC collected in the emergency room (28). The cost-effectiveness of interventions, as demonstrated by cost-benefit studies, is effectively shown to result in lower BCC.

BCC events can lead to various clinical consequences, including the need to maintain venous access for parenteral antibiotics, which may result in mechanical complications, thromboembolic disease, and infection, generate unnecessary consultation requests, and necessitate additional diagnostic testing (35).

Indwelling devices, such as pacemakers or implanted cardioverter defibrillators, may become problematic as a result of the search for the cause of the bacteremia.

Additionally, the initial focus on BC results may result in "anchoring bias," a cognitive bias that can delay the correct diagnosis and appropriate therapy, resulting in a delay in obtaining the correct diagnosis (3).

According to researchers at Vanderbilt University Medical Center, the annual impact of CONS contamination occurrences is expected to be 900 extra bloodstream infections, 350 antibiotic treatments, 30 catheter removals, echocardiograms, and subspecialty visits (30).

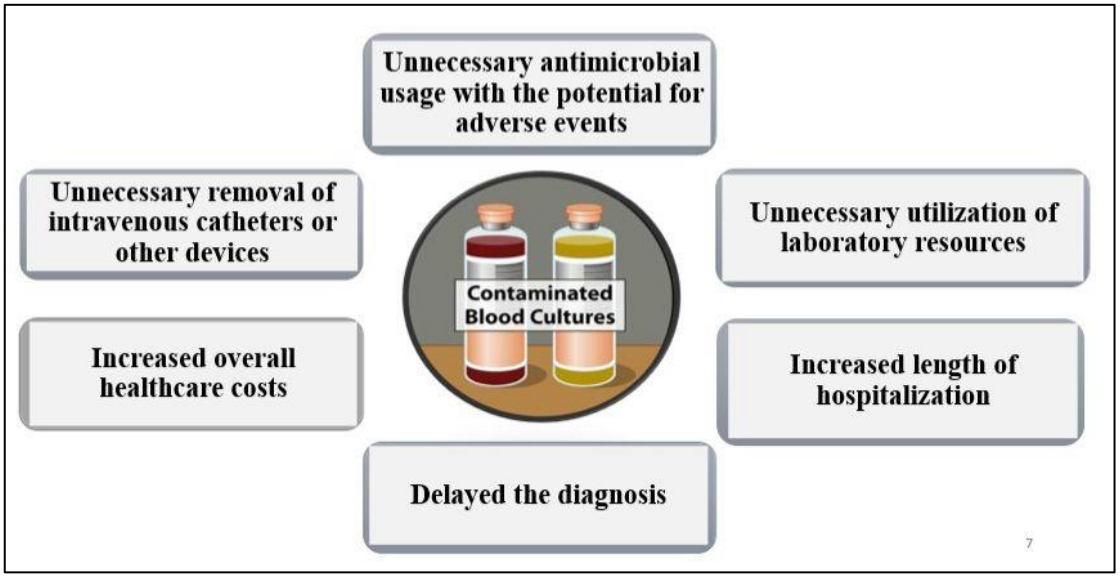
Furthermore, fifteen surgical procedures would be delayed annually due to contamination incidents, potentially leading to longer hospital stays. Consequently, BCC can considerably lengthen hospital stays. Compared to controls, contaminated BC was linked to a 5.4-day increase in hospital stay (29).

The risk of hospital-acquired adverse events, including healthcare-associated infections, drug-related mistakes, falls, decubitus ulcers, and thromboembolic complications, rises with each extra hospital day brought on by BCC. Every extra night spent in the hospital increases a patient's risk of developing pressure ulcers by 0.5%, hospital-acquired infections by 1.6%, and adverse drug reactions by 0.5%, according to Hauck and Zhao's estimation. (36)

The negative effects of the contaminated BC are summarized in the following figure(3).

Figure 2

Negative consequences of the contaminated blood culture



Every hospital should routinely check its BCC rates by monitoring the contamination source through a bundle checklist, supporting educational and training interventions, receiving staff and ward feedback about their BCC rate, assessing the competency of the staff who taking BCs, and setting a threshold for an acceptable contamination rate because low BCC statistics are a crucial indicator of procedure and laboratory quality (9,18,21,22,24,25,36–53).

As far as the researcher knows, no research has been conducted on the BCC in Palestinian government hospitals regarding how to reduce contamination when the rate exceeds the permitted threshold, despite the significance of data demonstrating the detrimental effects of incorrectly obtained BCC.

Therefore, this study was conducted to mitigate the consequences of the BCC, which had a negative impact on patients, healthcare workers, and the hospital in various aspects.

1.3 Literature Review

In clinical microbiology labs, the BC test is one of the most significant and possibly life-saving tests performed. (3). The process of withdrawing a blood sample for culture is technically challenging. Therefore, preanalytical errors in BC collection lead to contamination and mask the actual BSI, creating confusion for both physicians and laboratory technicians (54,55). The problem with lowering BCC in the healthcare setting is that numerous factors within the BC collection process have been identified as contributing to the increased BCC rate, rather than a single cause (56).

Contaminants from the patient's skin, staff skin, the equipment used for collection, and the environment are all possible sources of BCC (3). Whether the blood for culture was drawn from a peripheral vein or a CVAD, these contaminants arise from not adhering to all the instructions in the blood collection process for culture. Consequently, this suggests that a multimodal strategy and various practice changes may be necessary to reduce BCC rates.

1.3.1 Interventions to reduce blood culture contamination

To improve patient safety in healthcare settings, a number of measures were implemented to increase HCW compliance with BC collection and lower BCC rates. These included the introduction of BC collection pack techniques, equipment, education, training, monitoring, individual feedback on contamination rates, bundled approaches, and implementation of an effective aseptic approach (9,18,21,22,24,25, 36–40,42–51,53,57–61)

1.3.1.1 Educational Interventions on the procedure of BC

One of the most important components, as well as recent evidence-based guidelines for BC collection, is the continued use of an effective aseptic approach. Common antiseptic agents used in clinical settings include alcohol, chlorohexidine gluconate (CHG), and iodine products. The efficacy of antiseptics is directly correlated with the application technique, i.e., making sure the skin is properly cleansed and allowed to dry without re-palpation. When re-palpation is necessary, the use of sterile gloves has been shown to help maintain a sterile procedure. Data from previous work has shown that this method reduces false positives by 50% (5,54,62–64).

A descriptive one-year correlational study focused on a specific change in equipment for reducing BCC rates, which involved replacing alcohol preparation pads with a CHG swab, a broad-spectrum antiseptic. The study demonstrated that CHG products significantly decreased BCC rates from 4.5% to 1.5% (65).

Furthermore, quality improvement interventions and an interrupted time series design at two community hospitals showed that switching from the widely used non-sterile approach to a sterile process for BC collection led to significant decreases in BCC. The study found that the BCC rates at both sites have improved. It is possible that this study discovered that an emphasis on clean technique can lower BCC rates just as well as a completely sterile procedure. As with previous research, it was observed that ongoing observation and interaction with nursing and medical personnel are critical components of implementing change and sustaining it (66).

Additionally, a unique collection system can significantly decrease the BCC rate and is designed to augment, rather than replace, the standard phlebotomy protocol already in use in most hospitals. When compared to the conventional method, the novel specimen collection methodology was found to reduce false positives by 82.8% (67).

According to the collection by BC, venipuncture has generally been linked to lower contamination rates compared to indwelling intravenous catheters (22,68,69). Numerous studies found that BCC rates were greater for samples taken using catheters (range: 3.4%–13%) compared to blood acquired by venipuncture (range: 1.2%–7.3%) (69–73). Furthermore, according to the administration of antibiotics, BC collection should not

occur during antibiotic therapy, as this is associated with a notable reduction in pathogen identification (74).

However, it is essential to achieve a higher yield of pathogen isolation in culture. Among sepsis patients not receiving antibiotics, the study found a BC positive rate of 50.6% (78/154), whereas among those receiving antibiotics, the rate was 27.7% (112/405) ($p < 0.001$) (74). Moreover, the study found that intravenous antibiotics significantly reduce the chance of a positive BC, but not during the first hour of administration (75). Also, a study discovered that an increase in HCW compliance with collecting BCs before the start of antibiotics could be somewhat responsible for the improvement in pathogen isolation rate in emergency wards, both in intervention and phlebotomist groups (39).

One of the most important aspects of infection prevention is practising good hand hygiene. By ensuring that appropriate hand hygiene is practiced before blood collection processes, the risk of contaminating blood collection bottles with bacteria is reduced. The Centers for Disease Control and Prevention (CDC) guidelines include recommendations for HCW professionals who collect BC. These include decontaminating hands before direct patient contact, before the insertion of peripheral vascular catheters or other invasive devices that do not require surgery, after contact with a patient's intact skin, after contact with bodily fluids, after contact with inanimate objects, and after glove removal (76).

An ecological study investigated the relationship between BCC and hand hygiene compliance at a tertiary care hospital affiliated with a university. The investigation was conducted in emergency rooms and the critical care unit (ICU). Hand hygiene and BCC were found to be significantly correlated in the IU, but not in the emergency room, because of a lack of power (77).

While it is generally recognized that the majority of contaminants arise during the preanalytical stage of laboratory testing, particularly during specimen collection, the use of sterile gloves as a preventive measure is not covered by any standard or recommendation. A single hospital's medical wards and ICU were the sites of the sole study examining this intervention, which was a cluster-randomised, assessor-blinded crossover experiment. After the skin site was decontaminated, interns who took blood

by venipuncture were randomised to wear either sterile gloves for all procedures or optional sterile gloves for re-palpating the vein. The contamination rates varied significantly: 1.1% when sterile gloves were optional and 0.6% when sterile gloves were used regularly (62).

The use of sterile gloves in BC collection from CVADs or other intravascular devices has not been thoroughly investigated, despite their essential role as an integral component of aseptic technique. (22).

According to the use of masks during BC collection, there are currently no guidelines or other publications that discuss the use of masks during this process. In theory, when a blood sample is being taken, organisms from the patient's mouth might be transported from the physician onto a CVAD access port or the patient's skin. There is proof that this doesn't happen (22).

A pre- and post-study in the neonatal intensive care unit (NICU) in St. Michael's Hospital in Bristol, UK, used a sterile collection bundle as an intervention, which included sterile gloves and a surgical mask. It was found that the number of false-positive BC reduced from 4.6% to 0.6% ($p < 0.001$) (18).

Additionally, many studies have demonstrated the effect of disinfecting the rubber septa of the BC bottles (7). One leading manufacturer of BC bottles specifies that the tops of the bottles should be disinfected, providing illustrated instructions that emphasize this point in the collection process (3,5). The CLSI’s guideline recommends that 70% isopropyl alcohol be used for disinfection (5). Many other expert organisations also support disinfecting the tops of the BC bottles. Using an antiseptic on bottle tops was linked to a significantly lower incidence of contamination (2.3%) compared to institutions that did not utilize this technique (3.4%), according to the CAP Q-Probes investigation, which was conducted in 640 hospitals (10). Because iodine products have the potential to degrade the stopper material and introduce contaminants into the solution, they should not be utilised (7).

To reduce the incidence of BCC and maximize the yield of true pathogens, the most important factor is drawing an adequate volume of blood (5,8,78,79). In relation to the volume of blood collected, the number of pathogens recovered rises (79,80). A survey of people who take blood for culture, however, revealed that a sizable portion were

unaware of the ideal volume of blood that should be drawn (81). The CLSI recommends that adults inoculate two sets of BCs (a set including one anaerobic bottle and one aerobic bottle) and draw 20–30 mL from at least two different venipuncture sites (5). No more than 1% of the patient's total blood volume should be used for neonates, infants, and children(5). Additionally, contamination may be impacted by inadequate volumes. According to a retrospective analysis of newborns and kids who had at least one BC obtained, smaller blood volumes were associated with a higher rate of contamination (79).

According to the collection of blood samples for culture from CVAD, it is a usual practice to discard the first volume of blood to minimize dilution by infusion or contamination by other substances, such as potassium or dextrose (82). However, the current guidelines do not address their purpose in reducing BCC (61,83,84).

Numerous studies have examined the theory that bacteria that could lead to contamination are eliminated when samples are taken by venipuncture or intravenous catheterization using the discard volume method. The BCC rates in paediatric oncology patients with CVADs were the same for the 5-mL trash samples and the second sample collected for diagnostic culture (85).

The study found that the contamination rates in 10-mL discard aliquots inoculated into aerobic bottles were compared with those in 20-mL samples split into two 10-mL aliquots inoculated into anaerobic BC bottles and aerobic (standard vial) samples collected from adult oncology patients via peripherally inserted central catheters or Hickman catheters. According to the total BCC rates of 10.9% and 10.5% for the standard and discard vials, respectively, it appears that discarding the first sample of blood drawn using an intravascular catheter does not decrease contamination rates (86).

Additionally, it was found that educational programs were both cost-effective and successful in reducing BCC rates (37). Following the implementation of an educational intervention program that included posters and a 13-minute video to raise staff awareness of BCC and the correct technique for administering BC, the BCC rates at an ICU in a hospital in Northern Ireland decreased from 9.5% to 3.7% (38). Furthermore, a tertiary care hospital's eight-month prospective study revealed that educational intervention can reduce the prevalence of BCC. In the intervention and control wards,

the baseline BCC rates were 5.7% and 7.1%, respectively, and 1.95% and 6.7%, respectively, following the intervention (37).

Through the use of a BC collection teaching tool introduced in staff meetings, poster presentations, newsletters, and flyers in the emergency department, a five-year quality improvement initiative employed an educational approach to reduce BCC. BCC rates are lowered from 5.7% to 1.76% using this method. Notably, BCC rates rise when staff members are distracted and when monthly rates are not visible to them (87).

1.3.1.2 Other interventional tools to decrease blood culture contamination

Studies report that educational interventions have only a limited effect on BCC rates (65) and that the reduction is more effective if the BCC feedback is given directly to the phlebotomist(51). Several studies have found that education strategies are supported by strong feedback mechanisms for reducing BCC rates (25,51,58).

A study conducted in a medical centre in northern Taiwan found that educational interventions and one-on-one feedback were more effective in decreasing BCC rates than educational interventions alone. BCC rates decreased from 3.4% to 2.67% after a month-long course of infection control education and practical training in the emergency department. Additionally, the BCC rate was further reduced to 2.0% for 6 weeks when this educational intervention was combined with one-on-one feedback to ensure the correct individual technique was used (51).

In various hospital settings, venipuncture and the use of phlebotomy teams are effective strategies for reducing BCC rates, as demonstrated through a comprehensive review and meta-analysis. These procedures have a strong overall body of evidence and significant effect size ratings, making them evidence-based recommendations (14**).** Also, when dedicated phlebotomists are replaced by clinical personnel for blood specimen collection, BCC rates are further decreased (27). Additionally, a prospective research carried out at Parkland Memorial Hospital revealed that contamination rates were reduced to suggested levels by using phlebotomists to collect BC in the emergency department, with an estimated $4.1 million in annual patient charge reductions (27).

Additionally, a study aimed to examine how monthly monitoring and feedback of BC results affected the rates of contamination. It found that monthly reports of BC contamination rates were sent to the ED in 2017. The ED staff responded by holding more intensive instructional workshops, private counselling, and competency evaluations for nurses who had collected tainted BCs. In February and March of 2017, twelve instructional sessions were held. The contamination rate was reduced by more than 60% as a result of the intervention, from the baseline level of 8.6% to less than 3%. Of 1318 patients in 2017, 128 (4.8%) of the 2660 BC sets obtained were contaminated, making up 39.5% of all positive cultures (60).

Both the internal medicine and emergency care settings participated in a blinded clinical investigation. Participants in this 12-month trial received personalised information updates every month, and the results showed an 89% decrease in BCC rates (88).

According to a comprehensive analysis of BCC prevention techniques, all studies have shown a decrease in BCC rates, regardless of the strategies employed, including equipment, education, feedback, packaged methods, and stakeholder engagement. However, the bundled strategy was found to be useful, affordable, and flexible, and it produced the most notable effects (58).

The idea that education does not help people modify their behaviour has been supported by a study that did not particularly employ education as an intervention. The implementation of focused education and practice checklists during a two-month skill fair revealed initial improvements followed by an increase in the BCC rate, indicating that education alone was unable to sustain practice change (65).

A study was conducted in the NICU to increase the BCC rate by utilising a sequence of Plan-Do-Study-Act cycles. It was discovered that by creating a checklist, standardizing equipment, and specifying a collection technique, the BCC rates could be decreased from 4.74% to 2.0% (42).

Another study investigated the bundled strategy in a pediatric emergency room over a two-year period. Similar results from the study showed that BCC rates dropped by 61%, as supported by statistical data. Additionally, it was the only study to report a 27% drop in sample requests after implementing a practice adjustment to BC ordering procedures.

During the study period, a decrease in BCC was found to result in a $300,070 cost savings (89).

Furthermore, a study that used the bundle to target environmental and skin contaminants, teamwork, education, and feedback reported that BCC rates decreased from 1.96% to 0.3% during the initial eight-week pilot program. This program was then extended and continued for a year, during which time sustained BCC rates of less than 2% were observed. Additionally, this packaged strategy is straightforward to use and can be applied to multiple departments (45).

Before the HIV era, BC was frequently obtained using a two-needle technique because the needle used for venipuncture could become contaminated; it was shown that the BCC decreased after applying the double-needle technique. However, due to concerns regarding needlestick injuries, the double-needle transfer technique has fallen into disfavor, and instead, it is recommended that equipment be used that allows for the direct collection of blood into culture vials (3).

Moreover, a multifactorial BCC in the ICU was discovered by a one-year before-and-after analysis. Through work environment optimisation, skill training within two months, reinforcement of the online learning programme, weekly departmental feedback, and individual feedback, they were able to enhance nurses' adherence to the standard protocol for BC collection and successfully lower BCC to a sustainable low rate. They achieved this through questioning ICU nurses about the challenges they faced with protocol adherence and by observing how they performed during blood collection (25).

Also, it was detected that the implementation of multimodal intervention through conducting a standard protocol for BC collection by using the BC requisition form, educational sessions, and dedicated phlebotomists for a one-year study divided into two phases, the preintervention phase and the intervention phase, led to a decrease in BCC, an improvement in staff compliance with the BC collection protocol, and the filling of various parameters in the BC requisition form after intervention, thus improving the overall effectiveness of BC testing (39).

Furthermore, multimodal interventions were found to significantly lower BCC rates and enhance staff adherence to BC protocols, which include evaluating staff members' knowledge, attitudes, and practices regarding various aspects of sample collection, educating nursing staff about BC collection through the use of a structured, pre-made checklist, and highlighting best practices for BC collection (46).

The introduction of a BC pack, training activities, revisions to guidelines, and frequent data monitoring and feedback were all components of a multimodal intervention used in a trial that focused on nursing staff. BCC dropped after the intervention, from 6.8% (Phase 1) to 3.9% (Phase 2). Prior to the intervention, the chance of contamination was almost four times higher in the first culture, according to a comparison analysis for this study (90).

Additionally, a pre- and post-study that employed a multidisciplinary intervention discovered that it enhanced BC efficiency and minimized the use of antibiotics. It comprised the creation of a multidisciplinary team to carry out the intervention, role definition, standardisation of practices, ongoing enhancement of instruction and feedback, and incentive systems. Regular quality control evaluations of the accountable departments are carried out. In terms of knowledge, practice, and attitude concerning BC collection in the hospital, awareness and compliance significantly improved after the intervention. Following the intervention, hospital-wide antibiotic consumption dropped by 10.7%. The median submission time for BC specimens decreased from 2.2 hours to 1.3 hours. Positive rates (9.9% vs. 8.6%), accurate timing (98.7% vs. 89.6%), accurate processing (98.1% vs. 92.3%), decreased contamination rates (0.9% vs. 1.4%), and disqualification rates (1.3% vs. 1.7%) were also significantly higher in the intervention group (57).

1.4. Aims and objectives

The primary aim of this study is to evaluate the effectiveness of a multifaceted intervention strategy designed to reduce the rate of BCC. Specifically, the objective is to achieve a BCC rate below the 3% threshold recommended by CLSI. Concurrently, the study aimed to evaluate the intervention's impact on enhancing nurses' knowledge of standardized BC collection protocols and improving their adherence to these protocols during procedures involving both peripheral veins and CVADs.

1.5 Research questions

This study is guided by the following primary and secondary research questions:

1.5.1 Primary Questions

- To what extent does the implementation of a multimodal intervention strategy affect the overall rate of BCC within the selected hospital wards?

1.5.2 Secondary Questions

- What is the impact of the multimodal intervention on the rate of nursing compliance with established protocols for peripheral BC collection?
- What is the impact of the multimodal intervention on the rate of nursing compliance with established protocols for BC collection via CVADs?
- How does the introduction of the multimodal intervention influence nurses' documented knowledge and observed practices related to BC collection procedures?
- What are the most common causes of BCC in the study setting?

Chapter Two

Methods

2.1 Study Design

This study utilized a quasi-experimental, single-group, pre-test/post-test design. This methodological approach involved assessing the primary dependent variable within a single cohort of participants at two distinct time points: prior to the introduction of the independent variable (pre-intervention) and after its implementation (post-intervention).

2.2 Study setting

This study was conducted in a governmental hospital, which is affiliated with the Ministry of Health and serves as a secondary healthcare facility in Palestine. The research setting involved specific hospital wards selected due to the high volume of BC tests originating from them: the emergency department, the paediatric ward, the NICU, and the combined surgical and medical wards**.**

2.3 Study period

The study was conducted over six months, systematically divided into three distinct phases. The initial phase, designated as the pre-intervention period, spanned two months (August and October 2024). This was followed by a two-month intervention phase (December 2024 and January 2025). The final two months (February and March 2025) constituted the post-intervention phase.

2.4 Study population and sample

The target population for this study comprised nursing staff who withdrew the BC samples in the hospital; the study sample was nurses who were employed within the emergency, pediatric, NICU, and combined surgical and medical wards at a secondary governmental hospital.

2.4.1 The inclusion criteria

Participation in the study was limited to nurses actively working in four designated wards who were responsible for collecting BC via peripheral venipuncture or from a CVAD.

2.4.2 The exclusion criteria:

Nurses were excluded from the study if they met either of the following criteria:

1. Nurses not employed within the selected study wards.
2. Nurses who did not perform BC collection procedures through peripheral veins or CVADs.

2.5 Sampling method and sample size

All nurses working on the selected ward were included in the study. Following completion of data collection, a post hoc power analysis was conducted to assess the adequacy of the achieved sample size. For the outcome of nurses' adherence to peripheral blood culture collection protocols, the pre- and post-intervention mean scores were 80.4 ± 8.69 and 96.4 ± 5.22, respectively, among 57 paired participants. This yielded a very large effect size (Cohen's d ≈ 2.0), with an observed power exceeding 99.9% at $\alpha = 0.05$. This finding suggests that the sample size was more than adequate to evaluate changes in nurses' adherence.

2.6 Variables

The study examined several dependent and independent variables.

2.6.1 Dependent variable

1. **BCC Rate:** This rate was operationally defined as the total number of contaminated BCs divided by the total number of BCs performed, expressed as a percentage. An acceptable BCC rate in hospital settings is generally considered to be below 3%, as per guidelines established by the CLSI (5).

A BC was classified as contaminated if it met specific criteria, including:

- Isolated Microorganism Type: Identification of bacteria typically considered contaminants, such as *coagulase-negative Staphylococcus spp., Corynebacterium species, Bacillus species (excluding Bacillus anthracis), Micrococcus species, or Propionibacterium acnes* (5).

- Number of positive cultures: Isolation of the microorganism in only a single BC bottle or set when two or more sets were collected within 24 hours. Conversely, isolation from two or more sets was not considered contamination (91).

- The clinical Context: Consideration of the patient's clinical status, medical history, and laboratory findings, such as fever, leukocytosis or leukopenia, and elevated C-reactive protein level (92).

2. **Overall Competency Rate for BC Collection Procedures:** These rates separately measured the total procedural competency for peripheral vein and CVAD collections. They were calculated by summing the total points achieved by all nurses for each complete method, dividing by the maximum possible score for that method, and multiplying by 100% by utilizing the tool presented in Appendices E and F. In the same part, competency rates for each selected variable in the procedure of the BC collection were evaluated; these rates assessed proficiency for individual components of the BC collection process for both peripheral vein and CVAD methods. The calculation involved summing the points achieved by all participating nurses for each specific variable within each technique, dividing this sum by the maximum possible score for that variable, and then multiplying by 100%, every variable in the tools had a value that was evaluated so that it was one if there was a commitment and zero if there was not. Additionally, Bloom's criteria were used to classify compliance for the procedure of blood culture collection into categories(93), as shown in Table 1.

3. **Overall, Nurses' Knowledge:** The nurses' understanding of the BC collection procedure was evaluated. The total score for each participant was used to calculate the overall knowledge. This was assessed by adding up all the points each participating nurse received for each question in the knowledge section of the questionnaire, dividing the total by the highest possible score, and then multiplying the result by 100% to calculate the percentage. In the same section, we also evaluated the nurses' knowledge of each variable. To do this, we added up all of the points that the participating nurses had earned for each variable, divided that total by the highest possible score for that variable, and then multiplied the result by 100%. Every variable in the tool had a value that was evaluated so that it was one if the

answer to the question was yes and zero if the answer was no. Also, Bloom's criteria were used to assess the knowledge level, that presented in Table 1.

4. **Overall nurses' practice:** The practice of the BC collection procedure among nurses was also evaluated. The total score and percentage for each participant were used to determine the overall practice. The calculation of this score and the evaluation were done as the knowledge score.

Table 1

Bloom's cutoff categories for the total knowledge, practice, and compliance for the procedure of blood culture collection

Item	Score (%)
Total knowledge	
Good	7-8 (80-100%)
Moderate	5-6 (60-79%)
Bad	<5 (<60%)
Total practice	
Good	11-13 (80-100%)
Moderate	8-10 (60-79%)
Bad	<8 (< 60%)
Total compliance for BC collection from peripheral veins	
Good	5-6 (80-100%)
Moderate	5 (60-79%)
Bad	<4 (<60%)
Total compliance for BC collection from CVAD	
Good	7-8 (80-100%)
Moderate	5-6 (60-79%)
Bad	<5 (<60%)

2.6.2 Independent variables

1. **Adherence to Peripheral BC Collection Protocol Elements**

This included assessing compliance with specific procedural steps:

- Timing of BC collection relative to antibiotic administration (i.e., prior to dose)(75,94):yes/no.
- Performance of hand hygiene (3,76): yes/no.
- Utilization of sterile gloves (5,54,62): yes/no.
- Correct skin disinfection technique for venipuncture site (application of iodine for 1.5-2 minutes followed by 70% isopropyl alcohol, with a 30-second drying time). (5): yes/no.

- Appropriate disinfection of BC bottle tops (removal of flip-off caps, disinfection with 70% isopropyl alcohol pad per vial, allowing adequate drying time) (5,23): yes/no.
- Type of skin disinfectant used (e.g., alcohol, povidone-iodine, chlorhexidine)(5).
- Adherence to recommended disinfectant contact times (30 seconds for 70% isopropyl alcohol; 1.5–2 minutes for iodine) (5,63,64): yes/no.
- Collection of appropriate blood volume based on patient age (8–10 ml for adults; 1-3 ml for children) (5): yes/no.

2. Commitment to various elements of the protocol of BC collection from CVAD

- Performance of hand hygiene (96): yes/no.
- Wearing a mask during the procedure (18,96): yes/no.
- Donning sterile gloves (62,66,97): yes/no.
- Correct disinfection technique for BC bottle tops (as described above(5,23): yes/no.
- Proper scrubbing technique for the catheter hub prior to collection (15 seconds with antiseptic, followed by drying) (61,98): yes/no.
- Correct technique for blood withdrawal from CVAD (avoiding aspiration of a discard volume) (5,23): yes/no.
- Use an appropriate scrubbing technique for the catheter hub subsequent to collection (15 seconds with antiseptic, followed by drying) (61,98): yes/no.
- Aseptic attachment of a new cap (61): yes/no.

3. Background Variables of Nurses

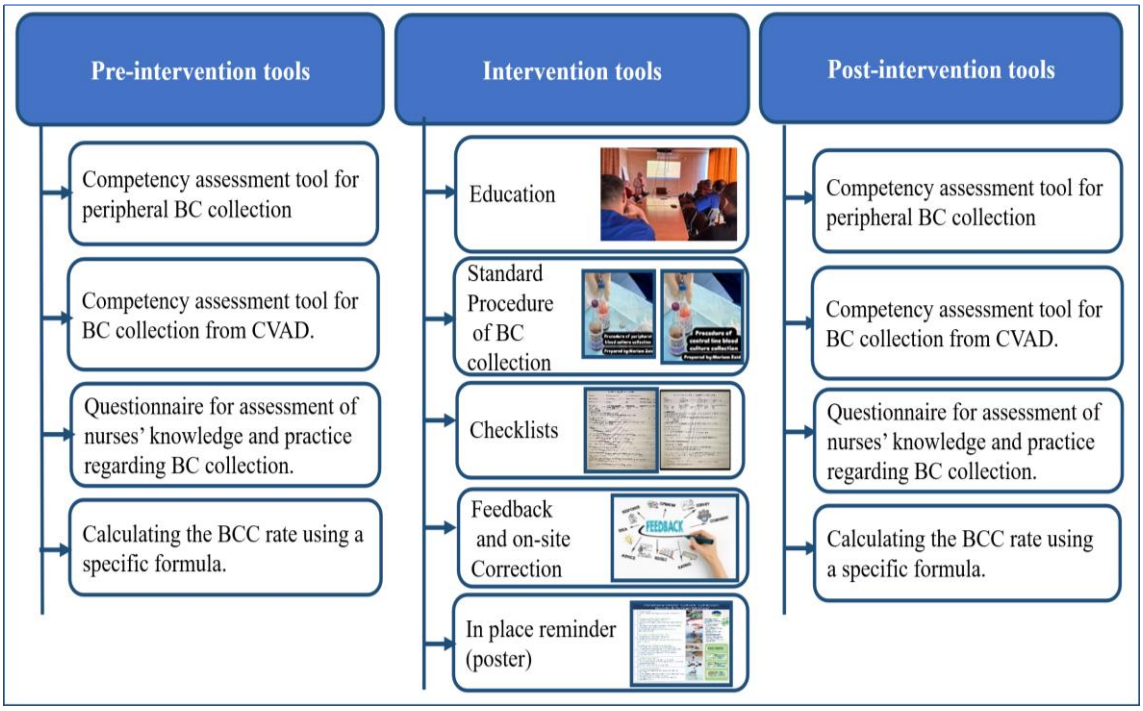
- Educational Level: Categorized as a diploma, bachelor's, or master's degree.
- Prior Training: Documented as yes or no.
- Years of Experience: Grouped as 1-5 years, 6-10 years, or more than 10 years.
- Assigned Ward: Surgical and medical, NICU, pediatric, or emergency.
- Perceived Workload Level: Defined as the number of patients requiring medical attention relative to the available staff on duty, reported as yes or no.
- Perceived Overcrowding: Defined as a condition impairing departmental function due to patient volume exceeding physical or staffing capacity, recorded as yes or no.
- Working in High-Traffic Areas: Characterized as locations with frequent passage of numerous individuals, recorded as yes or no.

2.7 Data collection tools

The study's data were collected throughout the pre-intervention and post-intervention phases. To assess key variables before and after the intervention, particular tools and techniques were used. Additionally, the instruments used to implement the study's modifications throughout the intervention phase are summarized in Figure 3.

Figure 3

Overview of study phases and activities



2.7.1 Preparation phase

An intensive literature review was conducted to design a questionnaire and competency tools for BC collection from peripheral veins and CVAD to be used in the pre- and post-intervention phases. Additionally, a presentation, a 3-minute locally produced video, a checklist for peripheral and CVAD collections, and a poster were prepared for use during the intervention phase of the study to encourage regular compliance with the procedure for BC collection.

All tools were designed for brevity, simplicity, and conceptual clarity. Moreover, to improve the reliability and validity of the study tools, all tools used in the study, both those employed before, during, and after the study intervention were derived from reliable resources, including the CDC, the CLSI, Infectious Diseases Society of

America (IDSA), and relevant prior research (3,5,14,22,23,58,98). Secondly, those tools underwent content validation by a panel of three infection control and prevention specialists, who approved their use with some recommending modifications before their use. Finally, A preliminary pilot study was undertaken to evaluate and refine the methodological instruments intended for use in the main investigation. Functioning as a scaled-down iteration of the proposed research, the pilot study aimed to enhance the overall methodology prior to full-scale implementation. This pilot phase replicated the core elements of the main study design, employing analogous participant characteristics but a different sample from the final study, the same hospital setting (specifically, the ICU), identical intervention protocols, and congruent data collection and analysis techniques**.**

The pilot study was conducted over a concentrated one-month period within the ICU ward. This timeframe was structured to encompass distinct phases: one week dedicated to establishing baseline data (pre-intervention), two weeks allocated for implementing the study interventions, and a final week for collecting post-intervention data. The primary objectives of this pilot phase were to assess the clarity and comprehensibility of the data collection tools, specifically the questionnaire, checklist for peripheral and CVAD, and competency assessment instruments, also for peripheral and CVAD. Additionally, the pilot aimed to assess the effectiveness of the instructional materials provided to participants, verify the completeness of the response sets obtained, determine the average time required for participants to complete each tool, and evaluate the overall feasibility and success of the planned data collection procedures.

Feedback was actively solicited from pilot study participants regarding the perceived applicability and appropriateness (content validity) of the questionnaire, checklist, and competency assessment tools.

At the end of this phase, the questionnaire included some additional choices for certain questions, modifications to others, and revisions or removals of some questions. Also, regarding the competency tools for peripheral and CVAD collection, at the start of the pilot, the assessment tools were long lists that included all the steps of the procedures. However, following the initial assessment, the researcher found that the assessment was lengthy and contained a lot of unnecessary information unrelated to contamination. As a result, the researcher shortened the assessment tools and retained only the steps related

to BCC that were already identified as defective and were the focus of the study intervention.

2.7.2 Pre intervention phase: (2 month)

During the initial two-month pre-intervention phase (August and October 2024), baseline data were collected to identify existing knowledge gaps, establish pre-intervention performance levels, and guide the development of the subsequent intervention. Assessment focused on four primary areas related to BC collection practices and potential contributors to BCC:

2.7.2.1 Assessment of Nurses' Knowledge and Practice

A structured questionnaire in Appendix G was utilized to evaluate nurses' baseline knowledge and self-reported practices concerning BC collection. This self-administered instrument, written in the English language, was distributed to all participating nurses. It comprised four sections: an introductory section confirming voluntary participation, a second section gathering demographic information (assigned ward, educational level, prior training, years of experience), a third section containing items related to the nurses' knowledge related to the BC collection (collection method, types of the disinfectants used in the disinfection the venipuncture area and the top of the BC bottles, contact time of the disinfectants, volume of the blood collected in adult and pediatric for culture, how to withdraw BC from multiple sites, knowing the consequences of the BCC). The last section contains items related to the nurses' practice, specifically the BC collection (tools that help nurses adhere to the correct method of blood sample collection), causes that prevent nurses from performing hand hygiene when required, and receiving feedback about BC contamination in your ward.

2.7.2.2 Assessment of Compliance with Peripheral BC Collection Protocol:

Nurses' competency in performing peripheral BC collection was evaluated using a standardized competency assessment tool as presented in Appendix E. This assessment involved direct observation of one BC collection procedure per participating nurse assigned to the selected wards who performed peripheral collections. The tool incorporated specific procedural items, nurse background information, assessment coding, methodology details, and defined performance criteria outlining the requisite knowledge and skills for competency (taking BC before the antibiotic dose, hand

hygiene, donning sterile gloves, correct technique for cleaning the venipuncture area, and the top of bottles, and collecting the BC first if blood is being taken for other tests).

Competency rates for each procedural element were calculated as follows: (Total points achieved for the item across all observations / Maximum possible score for the item) * 100%. The overall competency rate for the peripheral BC collection procedure was calculated by summing the total points achieved by all nurses, dividing by the maximum possible score for the procedure, and then multiplying by 100%.

2.7.2.3 Assessment of Compliance with Blood Culture Collection Protocol from Central Venous Access Device

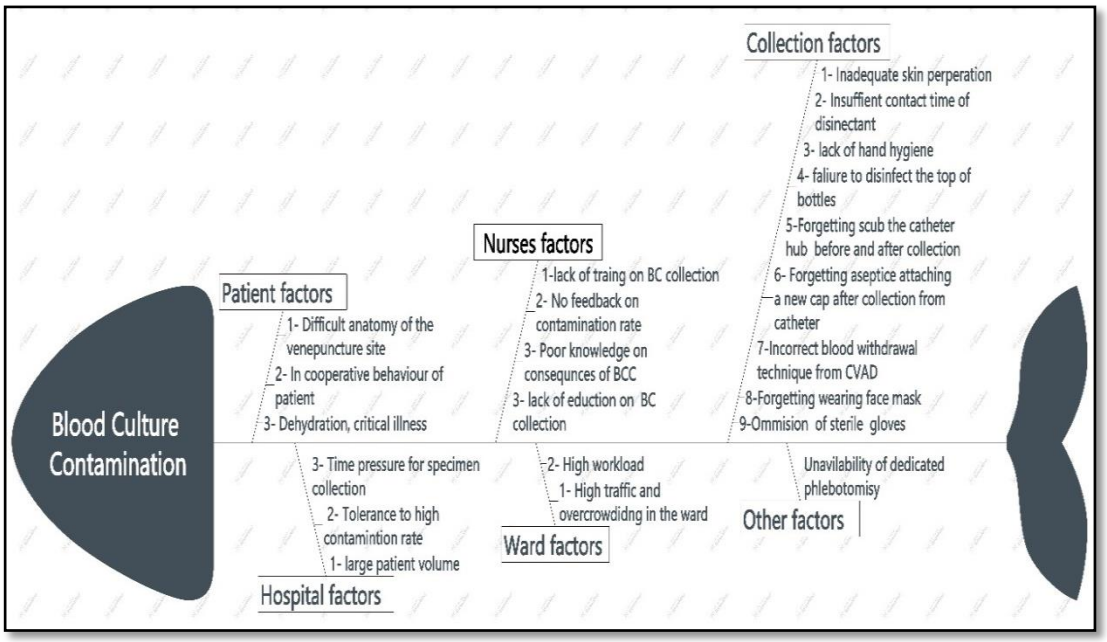
Similarly, competency in BC collection from CVADs was assessed via direct observation using a dedicated competency assessment tool, as shown in Appendix F. One CVAD BC collection procedure was observed for each participating nurse in the designated wards who performed this task. This tool mirrored the structure of the peripheral collection tool, including procedural items, background data, coding, methodology, and performance criteria (wearing a mask, sterile gloves, performing hand hygiene, the proper method for disinfecting bottle tops, scrubbing the catheter hub before and after collection, the proper technique of collecting a sample from a CVAD and aseptic attachment of a new cap). Competency rates were calculated using the same formulas as for peripheral collection.

2.7.2.4 Determination of Baseline Blood Culture Contamination Rate

The pre-intervention BCC rate was calculated using the formula: BCC Rate = (Number of contaminated cultures / Total number of cultures performed) * 100%. All BC results (positive and negative) processed from the selected wards during this phase were aggregated. Positive BCs were further analysed using standard laboratory protocols to differentiate between true bacteraemia and contamination. Findings from this pre-intervention assessment, particularly identified risk factors for BCC within the selected wards, were synthesized and visually represented using a fishbone diagram (Figure 4).

Figure 4

The risk factors of blood culture contamination



This analysis revealed that non-standardized BC collection protocols and deficiencies in nurses' knowledge were primary risk factors, thus becoming the focus of the intervention. Significant variations in practice were noted. Key deficiencies observed in peripheral collection included inconsistent hand hygiene, the omission of sterile gloves, improper skin preparation techniques, inadequate disinfectant contact time, and failure to disinfect bottle tops prior to inoculation. For CVAD collections, similar issues with hand hygiene and disinfection of the bottle tops were observed, along with failure to scrub the catheter hub before and after collection, incorrect blood withdrawal technique, omission of face masks, and failure to attach a new sterile cap post-procedure.

2.7.3 Intervention phase: (2months)

Based on the risk factors identified during the pre-intervention phase and summarized in the fishbone diagram, a multimodal intervention strategy was implemented over two months (December 2024 and January 2025). This intervention comprised the following components, summarized in Figure 3.

2.7.3.1 The standard procedure for collecting blood culture

Standardized protocols for BC collection from both peripheral vein and CVAD were developed and implemented. Key modifications emphasized consistent adherence to hand hygiene (76). Mandatory use of sterile gloves (54,62) and disinfection of the top of

the BC bottle using separate alcohol wipes prior to needle insertion(5,23). For peripheral collections, the nurses used a double-needle method to collect the BC because of the hospital facility, which required the use of a first sterile needle for venipuncture. Then, before inoculating the BC vials, the needle was removed. A second sterile needle was attached to the syringe for inoculating blood into the culture bottles, a two-step skin disinfection process (10% povidone-iodine followed by 70% alcohol) (5), with strict adherence to contact times (30 seconds for alcohol and 30 seconds to 2 minutes for povidone-iodine) was implemented (5).

For CVAD collections, key changes included mandatory scrubbing of the catheter hub with antiseptic for 15 seconds (allowing drying time) both before and after collection(61,98), collection of the BC sample without aspirating a discard volume (5), and aseptic attachment of a new sterile cap post-procedure (61).

2.7.3.2 Educational Intervention

An educational program was delivered to nurses in groups through one-hour sessions led by the researcher. Each session included a lecture, a brief instructional video, and a demonstration utilizing the bundle checklists. Topics covered included the clinical significance of BC tests, common sources of contamination, criteria for identifying BCC, the multifaceted impact of BCC (on patients, staff, and hospitals), best practice recommendations, and detailed procedural steps for both peripheral and CVAD collection. The procedures were reinforced by a 3-minute, locally produced video developed under specialist guidance, referencing CDC, CLSI and IDSA guidelines. Each session concluded with a question-and-answer period.

2.7.3.3 Implementation of Bundle Checklists

The implementation phase commenced with detailed instructions provided to the nursing staff regarding the peripheral and CVAD bundle checklists during a dedicated lecture session. This educational component focused on elucidating the specific components within each bundle and outlining the correct procedure for completing the checklists to ensure practical application. The primary function of these checklists was to serve as a cognitive aid, assisting nurses in recalling each critical step of the BC collection procedure immediately prior to its execution**.**

To foster consistent adherence to the protocol, the utilization of the checklists during BC collection was actively encouraged in collaboration with departmental leadership. Upon completion, the checklists were submitted alongside the BC order form to the microbiology department for integration into the sample processing workflow.

As indicated in appendix I, the procedural checklist designed for peripheral BC collection incorporated several key data points. These included essential patient demographic information, the identification of the staff member performing the collection, the precise time and date of the procedure, and the ward from which the procedure originated.

Furthermore, the checklist provided specific recommendations pertinent to peripheral BC collection and meticulously outlined every step of the process. This encompassed the thorough assembly of all necessary equipment, the performance of rigorous hand hygiene, and a detailed skin preparation sequence involving repeated cleansing with iodine for a duration of 30 seconds to 2 minutes, followed by the application of 70% isopropyl alcohol centrifugally from the intended puncture site outwards, allowing for a subsequent drying period of 30 seconds. The protocol continued with the cleaning of BC bottle tops using separate alcohol swabs, ensuring complete drying time, followed by re-performing hand hygiene and wearing sterile gloves. The aerobic bottle was designated for initial inoculation. Accurate labelling of the bottles with patient details was mandated to occur in the patient's presence, taking care not to obscure or remove any pre-existing barcodes.

Finally, the checklist required that the transport of the collected BC specimens to the laboratory should be done within a two-hour timeframe, utilizing biohazard bags, for incubation at 37°C. The procedure was required to be repeated at a distinct anatomical site, with a temporal separation of 30 to 60 minutes between collections.

Similarly, the checklist governing BC collection from a CVAD detailed required information, such as patient background data, the name of the collecting staff member, collection time and date, and ward location. It also included specific recommendations for CVAD-drawn cultures and delineated the comprehensive procedural steps. These steps began with the complete assembly of required equipment and adherence to hand hygiene protocols. A sterile towel was placed beneath the central line access point, and

all active infusions through the line were paused for a minimum of one minute before the sample was acquired.

After performing hand hygiene again and putting on sterile gloves, the injection cap was meticulously disinfected with 70% alcohol and allowed to air dry completely. Employing a non-touch technique, the injection cap was removed from the catheter hub. The catheter hub itself was then scrubbed vigorously for 15 seconds using 70% alcohol with a rotating motion. The necessary volume of blood for culture was subsequently drawn, crucially without aspirating a discard volume beforehand. A sterile needle attached to the filled syringe was used to inoculate the BC bottles. Following inoculation, the catheter hub was disinfected again by scrubbing with 70% alcohol for 15 seconds, after which a new sterile cap was connected to the hub. As with peripheral collections, bottles were labelled with patient details at the bedside, ensuring barcodes remained visible, and transported in biohazard bags to the laboratory within two hours for incubation at 37 °C, as shown in Appendix J.

2.7.3.4 Monitoring and feedback

Ongoing monitoring and feedback mechanisms were established. Direct observation of nurses' performance using the checklists occurred regularly, with immediate on-site correction provided as needed during daily morning shifts through one-on-one interactions. Additionally, information regarding BC collection personnel was tracked via the hospital's Avicenna System and the microbiology department logbook. Staff nurses associated with more than two contaminated BC episodes during the intervention period were flagged for compliance reassessment, required to re-attend the educational lecture, and offered further individualized counseling if necessary.

2.7.3.5 Visual Reminder (poster)

As mentioned in Appendix H, posters were developed and displayed prominently at locations where BC collection typically occurred, serving as visual reminders of the standardized BC collection procedures and key recommendations.

2.7.4 Post-Intervention Phase: (2 months)

Following the two-month intervention period, data collection was repeated during the post-intervention phase (February and March 2025) to evaluate the effectiveness of the multimodal strategy. The BCC rate was recalculated using the identical formula employed in the pre-intervention phase. Nurses' compliance rates with the standardized protocols for both peripheral and CVAD collection were reassessed using the same direct observation competency tools. Finally, nurses' knowledge and self-reported practices were re-evaluated using the same questionnaire administered pre-intervention (excluding the demographic section) to measure changes following the intervention.

2.8 Ethical consideration

Before initiating the data collection process and implementing study interventions, formal ethical approval was obtained from the relevant Institutional Review Board (IRB), as shown in Appendix C. To safeguard participant confidentiality, rigorous confidentiality measures were instituted; specifically, the names of participating nurses and the identities of patients were anonymized through a coding system. Access to the collected data was strictly limited to authorized members of the research team and confined solely to the purposes of this investigation**.**

Furthermore, as presented in Appendix B, informed consent was obtained from patients before creating an instructional video detailing the peripheral and CVAD BC collection methodologies, tailored to the specific resources and protocols of the participating hospital. Data pertaining to BC results, subsequent to laboratory analysis, were retrieved from the established Avicenna hospital information system. Prospective participants were personally contacted by the researcher, provided with a comprehensive explanation of the study's objectives, and subsequently invited to volunteer. Written informed consent, as indicated in Appendix A, was formally solicited and obtained from all individuals prior to their enrollment in the study.

2.9 Data analysis plan

Data management commenced with the entry of data into Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA), followed by comprehensive statistical analysis using IBM SPSS Statistics for Windows, version 21 (IBM Corp., Armonk, NY, USA). The analytical approach involved initial descriptive statistics to summarize

participant demographics, pertinent clinical characteristics, identified causative microbial organisms, and the sources of BCC. Categorical variables were characterized using frequencies and percentages, while continuous variables were presented as mean values accompanied by their standard deviations (mean ± SD)**.**

Prior to inferential testing, the assumption of normality for continuous variables was assessed through visual inspection of data distributions and the application of the Shapiro-Wilk test. Based on the outcomes of these normality assessments, appropriate statistical tests were selected for comparing outcomes before and after the study interventions within the same participant group. Specifically, for normally distributed continuous data, the paired t-test was employed; for non-normally distributed continuous data, the Wilcoxon signed-rank test was utilized. Comparisons involving categorical variables were conducted using the McNemar test. Statistical significance for all inferential analyses was predetermined at a p-value ≤ 0.05.

2.10 Budget

This study was conducted without dedicated external or institutional funding.

Chapter Three

Results

This chapter presents the findings derived from the study, encompassing participant demographics, assessments of nursing knowledge and practice regarding BC collection both before and after the intervention, compliance rates with procedural steps, and the overall impact on BCC rates.

3.1 Participants' Characteristics

Initially, sixty nurses were approached to participate in the study. Of these, fifty-seven consented and completed all study requirements, yielding a high response rate of 95%. The reasons for excluding the three nurses from the study were that two of them were on vacation, and one of them declined to participate.

The demographic profile of the participating nurses revealed an almost equal distribution between males (50.9%) and females (49.1%). Participants drawn from various hospital wards, with the largest contingents originating from medical and surgical wards (29.8%), followed by paediatric wards (28.1%), the NICU (22.8%), and the emergency unit (19.3%).

Regarding educational background, the majority of participants (71.9%) possessed a bachelor's degree. A smaller proportion held diplomas (19.3%) or master's degrees (8.8%). In terms of clinical experience, over half of the nurses (54.4%) reported having more than ten years of professional experience. Despite this level of experience, a significant majority (59.6%) indicated they had not received prior formal training specifically focused on BC collection techniques. Furthermore, environmental factors potentially influencing practice were noted; a large proportion of nurses perceived their workload as excessive relative to staffing levels (80.7%) and reported experiencing high traffic and overcrowding within their respective wards (86.0%). Detailed participant background characteristics are presented in Table 2.

Table 2

Participants' background characteristics

Variables	Frequency (%)
Sex	
Male	29(50.9)
Female	28(49.1)
Education level	
Diploma	11(19.3)
Bachelor	41(71.9)
Master	5(8.8)
Ward	
Surgical and medical	17(29.8)
NICU	13(22.8)
Emergency	11(19.3
Pediatric	16(28.1)
Experience (Years)	
1-5	18(31.6)
6-10	8(14.0)
More than 10	31(54.4)
Previous training on the BC collection	
Yes	23(40.4)
No	34(59.6)
Perceived Workload Level that is appropriate for the staff	
Yes	11(19.3)
No	46(80.7)
Nurses perceived that there was high traffic and overcrowding in the wards	
Yes	49(86)
No	8(14)

3.2 Nurses' Knowledge Regarding Blood Culture Collection

The study evaluated nurses' knowledge concerning BC collection protocols during both the pre-intervention and post-intervention phases**.**

3.2.1 Pre-Intervention Knowledge

In the baseline assessment, all participating nurses (100%) correctly identified the peripheral method as the standard approach for BC collection. However, knowledge gaps were evident in specific procedural aspects. While 70.2% were aware of the correct sequence for skin disinfection (povidone-iodine followed by 70% alcohol applied centrifugally), only 14.0% demonstrated awareness of the required contact time for these disinfectants. Knowledge regarding disinfection of BC bottle tops with alcohol was limited, with only 24.6% reporting awareness. Concerning appropriate blood

volumes for culture, 59.6% knew the correct volume for adult collections (8-10 ml per bottle), and 89.5% knew the volume for paediatric collections (1-3 ml). Only 24.6% knew to draw from different sites with a 15–30-minute interval when multiple BC sets were required. Finally, 61.4% of nurses indicated awareness of the potential negative consequences associated with BCC**.**

3.2.2 Post-Intervention Knowledge

Following the implementation of the multimodal intervention, significant improvements in knowledge were observed across several domains. All nurses (100%) demonstrated knowledge of the correct skin disinfection sequence and the required contact time for disinfectant. Awareness regarding the disinfection of BC bottle tops increased substantially to 87.7%. Knowledge of correct blood volumes improved, with 93.0% correctly identifying the adult volume and 100% identifying the paediatric volume. Awareness of drawing multiple sets from different sites increased to 59.6%, although this change did not reach statistical significance (p-value =0.063). Notably, post-intervention, all participating nurses (100%) reported awareness of the adverse consequences of BCC. Specific item comparisons between pre- and post-intervention knowledge are detailed in Table 3.

Table 3

The results of the knowledge-based questions in the pre- and post-intervention phases

Items	Pre intervention	Post intervention	p-value*
	Correct answer Percentage(frequency)		
The BC test should be collected using the peripheral method.	100% (57)	100% (57)	---
The antiseptic agent should be used in disinfecting the skin according to the hospital facility: povidone iodine and 70% alcohol	70.2% (40)	100% (57)	0.004
You should wait for the disinfectant's contact time.	14.0% (8)	100 % (57)	<0.001
Seventy percent alcohol should be used to disinfect the top of the bottle	24.6% (14)	87.7% (50)	<0.001
The volume of blood collected in adult cases should be 8- 10 mL for each bottle	59.6% (34)	93.0% (53)	0.002
The volume of blood collected in pediatric cases should be 1-3 mL for each bottle	89.5% (51)	100% (57)	0.250
If you draw several sets of BCs, you should withdraw from two separate sites approximately 15-30 minutes apart	24.6% (14)	59.6% (34)	0.063
Knowing the consequences of BC contamination	61.4% (35)	100% (57)	<0.001

*McNamar test.

3.2.3 Overall Knowledge Comparison

A quantitative comparison of overall knowledge, derived from the knowledge-based questionnaire, revealed a statistically significant improvement following the intervention. The mean knowledge increased from 55.48% (bad knowledge) (SD ±15.49) in the pre-intervention phase to 92.54% (good knowledge) (SD ±8.13) in the post-intervention phase (p-value < 0.001). This improvement is summarized in Table 4.

Table 4

Comparison of the overall knowledge during the pre- and post-intervention phases

	Pre-intervention Mean ±SD	Post-intervention Mean ±SD	p-value*
Overall knowledge	55.48 ±15.49	92. 54±8.13	<0.001

*Wilcoxon rank test

3.3 Nurses' Practices and Perceptions Regarding Blood Culture Collection

Self-reported practices and perceptions related to BC collection were also assessed before and after the intervention**.**

3.3.1 Pre-Intervention Practices and Perceptions

Prior to the intervention, nurses reported limited use of aids for BC collection; none used visual reminders (posters) or pre-made checklists. Guidance primarily came from self-reliance on existing knowledge (75.4%), with smaller proportions reporting assistance from educational sessions (17.5%) or senior colleagues (3.5%). Regarding hand hygiene barriers, cited reasons included time constraints (22.8%), forgetfulness (26.3%), and allergy to hand rub products (10.5%). A significant gap in feedback mechanisms was identified, with 77.2% of nurses reporting they never received feedback regarding BCC rates in their unit, while 19.3% received it occasionally, and only 3.2% received it consistently**.**

3.3.2 Post-Intervention Practices and Perceptions

Post-intervention, substantial shifts in reported practices and perceptions were observed. A large majority of nurses reported that the provided pre-made checklists (93.0%) and visual reminders (42.0%) helped them adhere to the correct protocol. Reliance on educational sessions as a guide increased significantly to 100%, while reliance on personal knowledge remained high (77.2%), and guidance from seniors improved significantly (70.2%). Reported barriers to hand hygiene shifted over time, with time constraints remaining a significant factor (21.1%), but forgetfulness decreased significantly (3.5%). Allergy remained a minor factor (5.3%). Significantly, the frequency of receiving feedback on BCC improved markedly; 26.3% reported consistently receiving feedback, 59.6% reported receiving it sometimes, and only 31.6% reported never receiving it. Detailed comparisons are provided in Table 5.

Table 5

The results of the practice-based questions from the pre- and post-interventional stage

Item	Pre intervention Percentage(frequency)	Post intervention Percentage(frequency)	p-value*
Which of the following aspects helps you adhere to the correct method of blood sample collection?			
Visual reminders like posters	0% (0)	42% (24)	<0.001
Observing seniors	3.5% (3)	70.2% (40)	<0.001
Educational sessions	17.5% (10)	100% (57)	<0.001
Provision of a pre-formed checklist	0%	93% (53)	<0.001
Personal knowledge	75.4% (43)	77.2% (44)	<0.001
What makes you not perform hand hygiene when required?			
Inadequate availability of hand rub products	0	0	---
Lack of motivation	0	0	---
Allergy to hand rub product	10.5% (6)	5.3% (3)	0.250
Forgetfulness	26.3% (15)	3.5% (2)	0.001
Lack the time	22.8% (13)	21.1% (12)	1.000
Have you ever received feedback about the BC contamination in your ward?			
Always	3.2% (2)	26.3% (15)	0.180
Sometimes	19.3% (11)	59.6% (34)	<0.001
Never	77.2% (44)	31.6% (18)	<0.001
*McNamar test.			

3.3.3 Overall Practice Comparison

A quantitative comparison of overall practice, derived from the practice-based questionnaire, revealed a statistically significant improvement following the intervention. The mean practice improved significantly from 25.36% (bad practice) (SD ±9.06) in the pre-intervention phase to 40.19% (bad practice) (SD ±4.43) in the post-intervention phase (p-value < 0.001). This improvement is summarized in Table 6.

Table 6

Comparison of the total practice during the pre- and post-intervention phases

	Pre-intervention Mean ±SD	Post-intervention Mean ±SD	p-value*
Total practice	25.36 ±9.06	40.19±4.43	<0.001

*Wilcoxon rank test

3.4 Compliance Rates with Peripheral Blood Culture Collection Procedures

Direct observation was used to assess compliance with key steps in the peripheral BC collection process**.**

3.4.1 Pre-Intervention Compliance (Peripheral)

Baseline compliance varied across different procedural elements. Compliance rates for collecting BC before laboratory tests were 84.2%, and for donning sterile gloves were 89.5%. Additionally, compliance with collecting BC before antibiotic administration was 57.9%, and using the correct technique for disinfecting the venipuncture site was 56.1%. Additionally, the compliance rates for performing hand hygiene were 26.3%, and for correctly disinfecting bottle tops, they were 19.3%.

3.4.2 Post-Intervention Compliance (Peripheral)

Significant improvements in compliance were observed for all assessed elements following the intervention. Perfect compliance (100%) was achieved for collecting BC before antibiotics, collecting before lab tests, donning sterile gloves, and using the correct venipuncture site disinfection technique. Compliance with hand hygiene increased substantially to 71.9%, and compliance with correct bottle top disinfection rose dramatically to 84.2%. All observed improvements were statistically significant, which means they were less than the significance level of the study. These findings are detailed in Table 7.

Table 7

The compliance for various elements in the peripheral blood culture collection procedure in the pre- and post-intervention phases

Step	Pre intervention (%)	Post intervention (%)	p-value*
Take a BC before the antibiotic dose	89.5%	100%	0.031
Hand Hygiene	26.3%	71.9%	<0.001
Donning sterile gloves	89.5%	100%	0.031
Correct technique for disinfecting the venipuncture area.	56.1%	100%	<0.001
Correct technique for disinfecting the tops of bottles	19.3%	84.2%	<0.001
Collect BC before laboratory tests	84.2%	100%	0.004
*McNamar test			

3.4.3 Overall Compliance comparison (Peripheral)

The overall compliance for the entire peripheral BC collection procedure demonstrated a statistically significant increase from a mean of 80.4 (good compliance) (SD ± 8.7) pre-intervention to 96.4 (good compliance) (SD ± 5.2) post-intervention (p-value < 0.001). This is summarized in Table 8.

Table 8

The overall compliance of peripheral BC collection in the pre- and post-intervention phases

	Pre-intervention *Mean ±SD*	Post-intervention *Mean ±SD*	p-value*
Compliance with the procedure of peripheral BC collection	80.4 ±8.69	96.43±5.22	<0.001
*Wilcoxon rank test			

3.5 Compliance with Blood Culture Collection from Central Venous Access Devices

Compliance with key steps for BC collection via CVADs was also assessed through direct observation**.**

3.5.1 Pre-Intervention Compliance (Central Venous Access Device)

Baseline compliance for CVAD procedures showed considerable variability. High compliance was observed only for donning sterile gloves (96.0%). Moderate compliance was noted for scrubbing the catheter hub before collection (60.0%). Lower compliance rates were recorded for properly cleaning bottle tops (40.0%), using the correct technique for sample collection (avoiding discard volume) (36.0%), attaching a new cap aseptically (20.0%), performing hand hygiene (16.0%), scrubbing the hub after collection (16.0%), and wearing a mask (8.0%).

3.5.2 Post-Intervention Compliance (Central Venous Access Device)

Following the intervention, significant improvements were observed in most assessed elements. Perfect compliance (100%) was achieved for donning sterile gloves, scrubbing the catheter hub correctly before collection, and collecting the sample correctly (without discard volume). Compliance increased significantly for wearing a mask (to 60%), performing hand hygiene (to 76%), cleaning bottle tops (to 84%), scrubbing the hub after collection (to 72%), and attaching a new cap aseptically (to 48%). All these improvements were statistically significant after the intervention, which means their p-value ≤ 0.05, except the improvement in putting on the sterile gloves was not significant (p-value =0.317). Detailed results are presented in Table 9.

Table 9

The compliance with various elements in the procedure of blood culture collection from a central venous access device in the pre- and post-intervention phases

Step	Pre intervention (%)	Post intervention (%)	p-value*
Wearing mask	8%	60%	<0.001
Put on sterile gloves	96%	100%	0.317
Perform hand hygiene	16%	76%	<0.001
The proper method for disinfecting the top of the bottle	40%	84%	0.001
The correct method of scrubbing the catheter hub before collection	60%	100%	0.002
The proper technique of collecting a BC sample from a CVAD	36%	100%	<0.001
The proper method of scrubbing the catheter hub after collection	16.0%	72%	<0.001
Attach a new cap aseptically	20%	48%	0.008

*Wilcoxon rank test

3.5.3 Overall *Compliance* with Blood Culture Collection from Central Venous Access Devices

The overall compliance rate for the BC collection procedure from CVADs showed a statistically significant improvement. The mean compliance increased from 68.3(moderate compliance) (SD ± 11.1) before intervention to 90.0(good compliance) (SD ± 7.2) after intervention (p-value < 0.001). This is summarized in Table 10.

Table 10

The compliance with the procedure of blood culture collection from central venous access devices in the pre- and post-intervention phases

	Pre-intervention *Mean ±SD*	Post-intervention *Mean ±SD*	p-value*
Compliance with the procedure of BC collection from the CVAD	68.25±11.11	90±7.21	<0.001

*Wilcoxon rank test

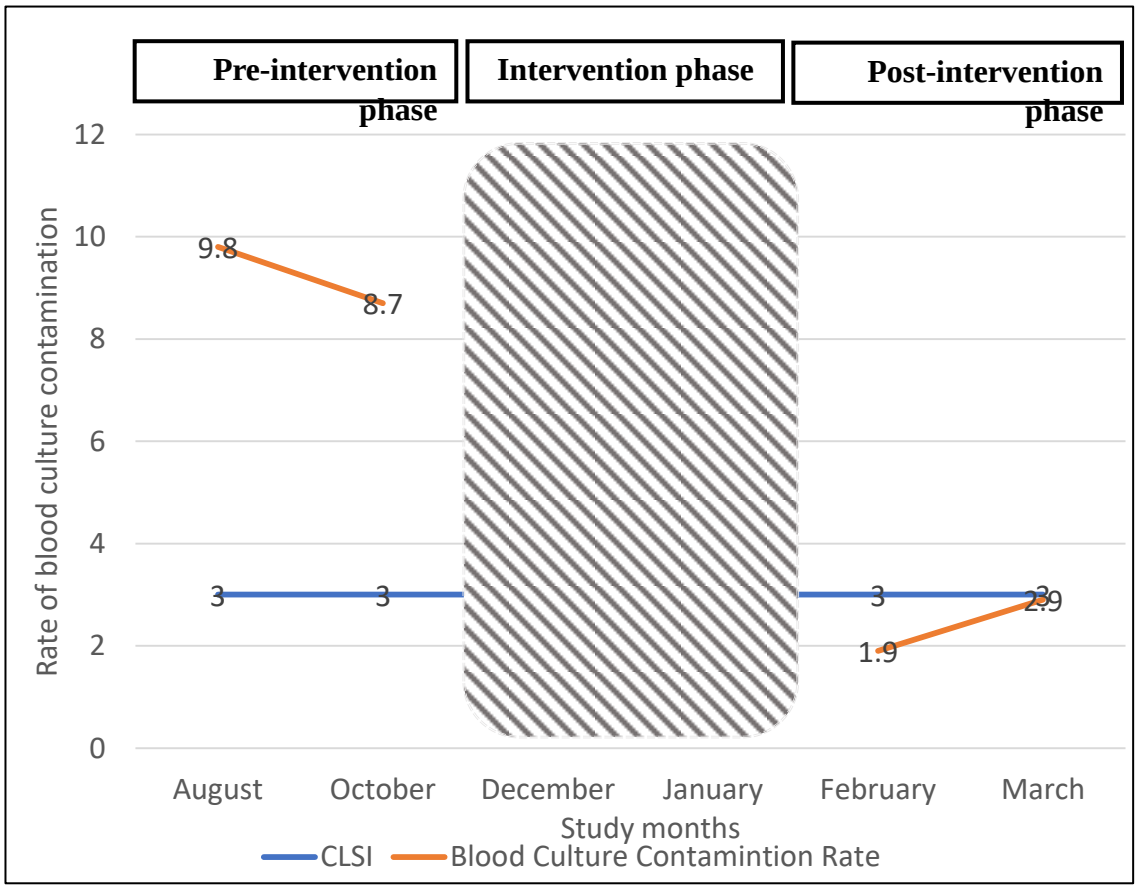
3.6 Blood Culture Contamination Rates

The primary outcome measure, the rate of BCC, was assessed over a four-month period, encompassing two months before the intervention and two months following its implementation. A total of 128 BC samples were collected and analysed during the pre-intervention phase, and 119 samples were analysed during the post-intervention phase**.**

The analysis revealed a statistically significant reduction in the BCC rate following the multimodal intervention. The pre-intervention BCC rate was calculated at 9.4% (12 contaminated cultures out of 128). In the post-intervention phase, the BCC rate decreased significantly to 2.4% (3 contaminated cultures out of 119). This reduction successfully met the study's objective of achieving a BCC rate below the 3% CLSI benchmark. The BCC rates are presented in Table 11 in Appendix K and Figure 5.

Figure 5

Comparison of blood culture contamination rates in the hospital during pre- and post-study phases



Chapter Four

Discussion

This study evaluated the effectiveness of a multimodal intervention aimed at reducing BCC rates and improving nurses' knowledge and compliance with standardized BC collection protocols. The discussion contextualizes the observed changes in nursing practice, knowledge, and contamination rates before and after the intervention, highlighting key factors influencing these outcomes.

Before the intervention, this study identified several factors contributing to BCC through questionnaires and compliance tools that assessed BC procedures from both peripheral veins and CVADs. These factors were categorized as unpreventable (patient, ward, and hospital-related) and preventable (nurses and collection-related), with the latter being the primary target of our intervention.

Preventable variables included deficiencies in nurses' knowledge and practices, such as inadequate training and instruction on collection procedures, a lack of feedback regarding contamination rates, and insufficient awareness of the consequences of BCC. Specific collection issues observed in peripheral venipuncture included nurses' incompetence in performing hand hygiene, ensuring adequate disinfectant contact time, proper skin preparation, disinfecting bottle tops, and wearing sterile gloves. For CVAD collection, observed incompetencies included failure to perform hand hygiene, failure to scrub the catheter hub before and after collection, failure to attach a new cap after collection, failure to disinfect bottle tops, and failure to wear face masks and sterile gloves. Furthermore, the pre-intervention phase revealed an absence of standardized checklists or posters, coupled with a lack of senior oversight, which could have supported nurses in adhering to BC collection protocols.

Unpreventable factors identified by the study researchers during BC withdrawal included patient characteristics such as challenging venipuncture sites, uncooperative behavior, dehydration, and critical illness. Hospital and ward-specific factors contributing to BCC included high workload, high patient volume, high traffic, crowded wards, absence of dedicated phlebotomists, time constraints for specimen collection, and a prevailing tolerance for high contamination rates.

These findings underscore that governmental hospitals are particularly susceptible to non-compliance with preanalytical BC test factors. Consequently, an ongoing system of monitoring and staff education is essential in such settings to reduce BCC rates and enhance BC collection techniques. This study was thus designed to develop and assess the efficacy of a multimodal intervention in reducing BCC rates to below 3% (as per CLSI guidelines) and improving nurses' knowledge and compliance with BC collection protocols.

4.1 Knowledge, practice, and competencies of the nurses regarding BC collection

This quasi-experimental study demonstrated that a multimodal intervention significantly improved nurses' knowledge and practices related to BC sampling ($p < 0.001$). These interventions led to a significant improvement in nurses' compliance with BC sampling from both peripheral veins and CVADs (p-value < 0.001 for both methods).

Several factors contributed to these positive outcomes. Firstly, the presence of an established infection control and prevention program in Palestine facilitated rapid response and implementation. Secondly, the study reinforced the importance of annual training and courses for medical personnel as integral components of infection prevention and control programs. thirdly, the implementation of checklists helped nurses recall each step of the procedure during BC sample collection. Fourthly, the use of competency assessment tools for each nurse encouraged self-correction and improvement in withdrawal techniques. Finally, documenting the name of the nurse performing the procedure fostered accountability, ensuring adherence to protocols.

The questionnaire survey revealed that all nurses consistently preferred peripheral BC collection in both study phases, which aligns with best practices, as blood for culture testing should ideally be drawn via peripheral venipuncture because it's generally associated with a lower contamination rate compared to indwelling intravenous catheters unless clinically necessary (5,22,68,69).

Blood samples for culture should be collected before antibiotic administration to be done correctly, as antibiotic therapy significantly reduces the detection of pathogens (99). In this study, nurses' compliance with collecting BCs before antibiotic administration significantly improved post-intervention (p-value = 0.031). Similar multimodal intervention trials have shown staff compliance increasing from 81.7% pre-

intervention to 90.5% and 94% in regular and phlebotomist groups, respectively (39). For instance, among sepsis patients not receiving antibiotics, the BC positive rate was 50.6% (78/154), whereas it was only 27.7% (112/405) among those receiving antibiotics (p-value < 0.001) (74).

Regarding BC collection before other laboratory tests, a significant improvement in nurses' compliance was observed in the post-intervention phase (p-value=0.004). This is crucial, as drawing additional Laboratory samples before BC can lead to contamination (100).

Furthermore, nurses' awareness of the negative effects of BCC significantly improved after the intervention(p-value <0.001). Educating nurses about the importance of BCC is vital, as contamination compromises the quality of care, prolongs hospitalization, and leads to excessive antibiotic exposure, which can have negative effects (e.g., allergic reactions, drug-drug interactions, antibiotic resistance, and Clostridium difficile infection) (3). Other potential outcomes include unnecessary removal of intravenous catheters or other devices (3).

The study highlights the importance of monitoring contamination rates, identifying collectors associated with contaminated cultures, and providing individual feedback to reduce BCC. The percentage of nurses who did not receive feedback decreased from 77.2% to 14% after the intervention. Several studies have shown a significant decrease in contamination rates of BC following feedback processes, often combined with retraining interventions(25,40,43,45,57,58,90,101).However, some studies suggest that educational interventions alone have limited effects on BCC rates, and direct feedback to phlebotomists is more effective (51).

4.1.1 Peripheral BC collection

Nurses' awareness regarding the use of antiseptic agents, specifically povidone-iodine and alcohol, significantly improved after the study intervention (p-value=0.004). Various disinfectants, including 70% isopropyl alcohol, tincture of iodine, povidone-iodine, iodophors, chlorine peroxide, and chlorhexidine gluconate, have been used in clinical settings (5,11,13,54,63–65,102). While some authors suggest alcohol-containing antiseptics might be more effective, no definitive data supports a preference for

alcoholic chlorhexidine over alcoholic iodine-containing preparations, alcohol followed by another disinfectant, or alcohol alone (3,7).

The present study showed a significant increase in nurses' knowledge regarding adherence to disinfectant contact time after the intervention compared to before the intervention (p-value < 0.001). This occurred as a result of the nurses' ignorance regarding the significance of the disinfectant contact time. During the pre-intervention phase, a significant percentage of nurses used sterile wipes to dry the venepuncture site right after disinfection, which might have led to higher contamination rates. Various barriers influence the effectiveness of skin antisepsis in preventing contamination. The time required for an antiseptic to achieve its maximal effect is crucial; for instance, tincture of iodine requires 30 seconds, 70% isopropyl or ethyl alcohol must air dry, and povidone-iodine formulations require 1.5 to 2 minutes of contact time for maximal antibacterial effect (5,64).

In this study, nurses' compliance with the venipuncture disinfection method, repeatedly disinfecting the skin from the centre to the periphery with iodine for 1.5 to 2 minutes, followed by 70% isopropyl alcohol and allowing it to dry for 30 seconds, dramatically increased in post-intervention (p-value < 0.001). The patient's skin at the collection site is widely considered the most common source of BC contamination(7). Therefore, venipuncture site disinfection is essential to reduce skin flora contamination. However, skin cannot be fully sterilized during antisepsis, as approximately 20% of bacteria reside in deep layers of the epidermis and dermis. Thus, maximizing bacterial kill, regardless of the antiseptic used, is crucial, while aqueous products are often applied in concentric circles to prevent the reintroduction of organisms, this method lacks scientific support (22).

Compared to pre-intervention, nurses' compliance with the correct technique for disinfecting bottle tops using a separate 70% isopropyl alcohol pad and allowing it to dry significantly improved after the intervention (p-value < 0.001). This was due to their failure to follow the guidelines during the pre-intervention period. They also believed that iodine should be used to disinfect the top of BC and that the bottle's rubber septa are sterile because they have a lid. Nevertheless, they made corrections and matched the guidelines' most recent advice during the post-intervention phase.

A CAP Q-Probes study across 640 hospitals found that applying an antiseptic to bottle tops was associated with a significantly lower contamination rate (2.3%) compared to institutions that did not use this technique (3.4%) (10).

Regarding the collection of correct blood volume for culture in both adult and pediatric patients, nurses' knowledge of BC collection from adult patients significantly improved in post-intervention (p-value = 0.002), but not for pediatric collection (p-value = 0.250). Another study found that staff compliance with collecting appropriate blood volume significantly increased from 35.9% pre-intervention to 39.1% and 71.2% in regular and phlebotomist groups, respectively (p-value < 0.001) (39). Inadequate volumes can impact contamination. Both overfilling and underfilling BC vials have been associated with increased contamination, false-negative or false-positive results, and delayed time to positivity (5,34,103).

Through the questionnaire, nurses' awareness of drawing multiple sets of BCs improved post-intervention compared to pre-intervention, though not significantly (p-value =0.063). This may be because the study's intervention did not target physicians who order BCs. However, many studies have demonstrated significant improvement in staff compliance with drawing paired BCs (39,46). Various studies also indicate that collecting paired or multiple BCs enhances pathogen isolation and facilitates the differentiation of contaminants from pathogens (5,34).

Also, it was observed in the study that the nurses' compliance with hand hygiene significantly increased in both methods (p-value<0.001). An ecological study examining the relationship between hand hygiene compliance and BCC in a tertiary care hospital found a significant correlation in the intensive care unit (p-value< 0.001)(77). Pre-intervention hand hygiene incompetence was attributed to a lack of time and forgetfulness, primarily due to high workloads and overcrowding in wards rather than the unavailability of alcohol-based hand rubs.

Regarding the use of sterile gloves, nurses' compliance significantly improved (p-value 0.031) for peripheral collection, but not significantly for CVAD collection (p-value = 0.317) because the majority of the nurses already used sterile gloves when collecting BC from CVAD. A study evaluating the effect of sterile gloves on BCC rates found no difference (p = 1.00) between clean (1%) and sterile (1%) groups. However, nonsterile

gloves can become contaminated and lead to BCC (11). Conversely, a single-center crossover trial found that the use of sterile gloves was associated with a significant decrease in BCC(62). Additionally, the use of sterile gloves for BC procedures has been a component of successful multi-interventional BCC reduction programs. These findings are consistent with a pre- and post-study that used a sterile collection bundle, including sterile gloves, which reduced false-positive BCs in a NICU (47).

4.1.2 Blood culture collection from CVAD

Nurses' compliance with wearing face masks during CVAD BC procedures significantly improved ($p < 0.001$). While current guidelines do not explicitly address mask use during BC collection, it is widely accepted that most contaminants originate during the preanalytical phase, specifically specimen collection (90). Theoretically, oral cavity organisms could be transferred from the clinician to a CVAD access port or the patient's skin surface during blood sample collection. A pre- and post-study using a sterile collection bundle, including a surgical mask, found a reduction in false-positive BCs in a NICU (18).

After the multimodal intervention, nurses' compliance with scrubbing the catheter hub before and after collection significantly increased (p-value=0.002). To our knowledge, no published studies have examined the direct effect of antiseptics on BCC rates when performing a scrub of the catheter hub (22). However, this issue is mentioned in the IDSA guidelines for the diagnosis and management of intravascular catheter-related bloodstream infection(98).

Moreover, Nurses' compliance with withdrawing the first blood sample significantly increased after a study intervention(p-value<0.001). If BCs are collected through an intravenous line, discarding the initial blood volume or flushing the line with saline is not necessary, as the antimicrobial activity of heparin is effectively neutralized in blood-derived antimicrobial compounds(104). Discarding the first volume is common to minimize dilution or contamination(85), but studies have found no significant difference in contamination rates between first and second drawn samples and discarding 5 to 10 mL of blood per culture can lead to significant blood loss and nosocomial anemia in severely ill, febrile patients.(82,84–86)

After the intervention, nurses' compliance with attaching a new end cap to the central line catheter hub was significantly higher than before (p-value = 0.008). In an observational study, nurses developed a kit containing all necessary supplies for collecting blood samples from catheters, including a new end cap, to reduce the risk of contamination for samples taken from central catheters (68).

4.2 Blood culture contamination rate

This study demonstrated a significant reduction in BCC in the post-intervention period (2.4%) compared to the pre-intervention phase (9.4%). These results align with CLSI and other standards, which recommend an acceptable BCC rate of less than 3% (5). Our findings are consistent with previous research, which demonstrates the effectiveness of multimodal interventions in reducing BCC (39,46,57,90). Literature reports BCC rates varying from 0.6 to 12.5%(7–10,14). This variability may be attributed to differences in the criteria used to define contaminants and the specific interventions employed across studies. While it was not possible to establish a direct relationship between the study intervention and BCC rates, or between nurses' knowledge/practice/competency and BCC rates in the pre- and post-intervention phases, but our study results indicate an inverse relationship: as nurses' compliance with peripheral and CVAD BC collection increased, BCC decreased. Similarly, an inverse association was observed between BCC rates and nursing knowledge; as nursing knowledge improved, BCC rates reduced.

Numerous strategies and recommendations exist to lower BCC, including employing specialized phlebotomists, using specialized BC collection sets, implementing bundled approaches, providing individual feedback on contamination rates and technique, changing skin antiseptics (e.g., chlorhexidine swabs), providing informational responses (e.g., regular emails on monthly contamination rates), and offering educational (9,18,21,22,24,33,36–40,47,48,50–52,57,60,67,90).

Our study employed a multifaceted approach to reduce BCC, incorporating standardized BC collection procedures, education, on-site observations, senior supervision, implementation of the BCC bundle, staff feedback, and active surveillance. This approach is supported by other studies employing multimodal interventions, which have shown significant reductions in pre-interventional BCC rates (e.g., from 6.16% to 3.03%, p = 0.023) (46). Another multimodal intervention, involving standard protocols, education, training, and enlisting trained phlebotomists, reduced contamination from

13.7% pre-intervention to 4.2% and 3.2% in regular and phlebotomist groups, respectively ($p < 0.001$) (39). Similarly, a multimodal intervention targeting nursing staff (training, guideline updates, data monitoring, feedback, and a BC pack) decreased BCC from 6.8% pre-intervention to 3.9% post-intervention (OR = 3.97, CI 2.86–5.49)(90). Therefore, our study's multifaceted approach, which included these elements, proved effective in reducing BCC.

4.3 Strengths and limitations of the study

This study possessed several key strengths. Firstly, its pre- and post-intervention design allowed for a robust assessment of changes in nursing practice over time, providing measurable evidence of the intervention's positive impact on clinical performance. Secondly, the study targeted a clearly defined and relevant population, nurses actively involved in BC collection in key hospital wards, ensuring that the intervention was precisely focused on those directly responsible for the procedures. Thirdly, the inclusion of all eligible nurses from the selected wards (total population sampling) minimized sampling bias and strengthened the internal validity of the findings. Fourthly, the use of clear inclusion and exclusion criteria ensured a consistent and appropriate study sample. Fifthly, conducting the study in a real-world clinical setting enhances the applicability of the results to similar healthcare environments. Lastly, to the best of the researcher’s knowledge, this study was the first in Palestine to employ a multimodal intervention on the BC collection process from both CVAD and peripheral sites.

Despite its strengths, the study had several limitations. As a non-controlled and non-randomized quasi-experimental design, the observed improvements may have been influenced by other confounding factors not accounted for. The multimodal nature of the intervention, while effective, prevented the analysis of individual component effects, making it difficult to ascertain which specific elements contributed most to the observed improvements. Observational assessment of BC procedures may have inadvertently caused behavioral changes among participants due to the Hawthorne effect. Additionally, because the BC procedures were only monitored during the morning shift, they could not effectively manage the evening and night shifts throughout the intervention phase. Furthermore, as a single-site study with a relatively small sample size, the generalizability of the findings to other healthcare settings or larger populations may be limited. Pre-intervention data lacked specific information on BC collection sites,

which restricted a detailed analysis of contamination rates between peripheral and CVADs. Fewer samples were collected from CVADs due to patient characteristics, which may have affected the statistical power for this subgroup. Due to the hospital facility, the nurses used a double-needle method to collect the BC, which had a higher contamination rate than the single-needle technique. Finally, since the intervention primarily targeted nurses and not physicians who order BC tests for patients, changes to test-ordering practices were beyond the scope of this study.

4.4 Conclusion

This study demonstrated that a multimodal intervention significantly reduced BCC rates and improved compliance with BC collection procedures from both peripheral veins and CVADs. Furthermore, the intervention enhanced nurses' knowledge and practice regarding proper BC collection techniques. These improvements collectively contributed to the overall efficacy and reliability of BC testing. The findings underscore the substantial value of structured, multifaceted interventions in promoting better clinical practices and ensuring higher quality in BC collection, ultimately leading to more accurate diagnostic outcomes.

4.5 Recommendations

Based on the compelling results of this study, the following recommendations are put forth, tailored for different stakeholders within the healthcare system:

1. To Healthcare Workers

- Consistently and precisely follow all steps outlined in the standardized bundle checklists for BC collection. This includes cleaning the bottle top, putting on sterile gloves, and washing your hands properly. However, use caution when disinfecting patient skin regarding the method of disinfection and the contact time of disinfectant during peripheral collection. HCW should wear a face mask, withdraw the first blood sample for culture, scrub the catheter hub both before and after BC collection, and attach a new cap aseptically after collection, particularly for CVAD collection.
- Actively participate in targeted health education and training programs to stay updated on best practices for BC collection and understand the critical impact of contamination.

- Utilize reminder systems and the BC collection competency tool for self-evaluation, identifying areas for improvement, and correcting procedural mistakes in real-time.
- Be receptive to performance-based feedback regarding individual contamination rates and technique, using it constructively to enhance practice.
- Pay particular attention to critical aspects such as ensuring adequate disinfectant contact time, collecting the correct blood volume, and understanding the importance of drawing multiple BC sets before antibiotic administration and laboratory tests.

2. To Policy Makers

- Facilitate the widespread implementation of similar multimodal interventions across all healthcare settings to reduce BCC rates systematically.
- Develop, disseminate, and mandate the use of standardized bundle checklists for BC collection procedures to ensure uniformity and adherence to best practices.
- Allocate sufficient resources for and ensure the continuous provision of targeted health education and training programs for all nursing staff involved in BC collection.
- Create and maintain effective reminder systems at the point of care and implement comprehensive systems for providing regular, performance-based feedback to staff on their contamination rates.
- Mandate and adequately resource real-time observations of BC collection procedures, coupled with mechanisms for immediate corrective actions and retraining when necessary.
- Consider the formal adoption and widespread use of the BC collection competency tool developed in this study, recognizing its value in staff evaluation and continuous quality improvement.
- Develop and implement policies to mitigate systemic factors contributing to BCC, such as high workload, overcrowding, and lack of dedicated phlebotomists, by ensuring adequate staffing and resources.
- Officially adopt and actively monitor adherence to acceptable contamination rate limits, such as the less than 3% target set by the CLSI, as a key performance indicator for quality improvement.
- Provide an initial specimen diversion device for nurses to collect blood for culture to avoid contamination and to decrease the risk of needle stick injury.

The broader adoption of these evidence-based strategies, through concerted efforts from both HCWs and policymakers, will lead to more accurate diagnoses of BSIs, consequently reducing associated morbidity and mortality, and minimizing unnecessary healthcare costs by preventing false-positive results and subsequent inappropriate antibiotic use.

List of Abbreviations

Abbreviations	Meaning
BC	Blood culture
BCC	Blood culture contamination
CLSI	Clinical and laboratory standard institute
CDC	Centers for Disease Control and Prevention
IRB	Institutional Review Board
IDSA	Infectious Diseases Society of America
CONS	Coagulase-negative Staphylococcus
HCW	Health care worker
CVAD	Central venous access devices
ICU	Intensive care unit
NICU	Neonatal intensive care unit
CHG	Chlorohexidine gluconate

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Appendices

Appendix A

Consent form to participate in a scientific research" 1"

موافقة للاشتراك في البحث العلمي "1"

أنا الباحثة مريم زيد طالبة ماجستير مكافحة وضبط العدوى من كلية الدراسات العليا من جامعة النجاح الوطنية اقوم ببحث علمي بعنوان **فعالية التدخلات متعددة الوسائط للحد من معدل تلوث زراعة الدم في المستشفيات الحكومية: دراسة ما قبل التدخل وبعده**، يستهدف طاقم التمريض في المستشفى بإشراف الدكتور زاهر نزال والدكتورة سعاد بلكبير.

يهدف البحث إلى تحسين عملية سحب عينات زراعة الدم التي من شأنها ان تعمل على تحسين الإجراءات الطبية ورعاية المرضى، فضلاً عن خفض التكاليف الإجمالية للرعاية الصحية من خلال تنفيذ تدخلات متعددة الوسائط، مثل تثقيف طاقم التمريض، وإدخال بروتوكول مرجعي موحد في الأجنحة، ووضع رسائل تذكريه، وتقديم ملاحظات على عملية السحب، وإجراء تصحيحات في الموقع استناداً إلى الملاحظات المباشرة وفقاً للبرتوكول المرجعي، فضلاً عن تقييم فعالية هذا التدخل من خلال تقييم الانخفاض في معدل تلوث زراعة الدم إلى اقل من ثلاثة في المائة وفقاً إلى معهد المعايير السريرية والمختبرية ، وتحسين التزام طاقم التمريض في بروتوكول سحب زراعة الدم بعد التدخل الخاص في الدراسة.

وتستند آلية الاختيار إلى معايير خاصة في البحث، تتطلب إجابة طاقم التمريض على الأسئلة الواردة في استبيان يقدم من قبل الباحث يتعلق ببعض المعلومات الشخصية عن الطاقم لغرض البحث، فضلاً عن المعرفة، والخبرة العلمية، والإجراءات المتبعة في سحب عينات زراعة الدم والعوامل التي تؤثر على ارتفاع معدل تلوث الدم. كما يتطلب التزام الطاقم في البروتوكول الموحد لسحب عينات زراعة الدم.

مشاركتك في هذا البحث اختيارية ويمكنك أخذ الوقت الكافي للتفكير في المشاركة. يمكنك الانسحاب متى ما شئت ولن يلحق ذلك بك باي ضرر. حيت سوف تكون مشاركتك على مدار 4 شهور وستقسم إلى ثلاث مراحل: مرحلة سابقة للتدخل مدتها شهر واحد، ومرحلة التدخل مدتها شهرين، ومرحلة لاحقة للتدخل مدتها شهر واحد.

حيث ستبقى معلوماتك سرية ولن يطلع عليها أحد تحت أي ظرف كان. سوف يتم تسجيل فقط اسمك والرقم التعريفي في نموذج الاستبيان وسيتم المحافظة على السرية التامة عن طريق وضع رموز رقمية لكل استمارة بحيث لا يظهر اسم المشترك، وستحافظ في مكان آمن لا يمكن الوصول إليه إلا من قبل الباحث والأفراد المرخص لهم. سيتم تزويدك بنتائج البحث في حال رغبت في ذلك.

الموافقة على المشاركة في الدراسة:

هل تؤكد أنك سوف توافق على المشاركة في البحث، بما في ذلك الإجابة على أسئلة الاستبيان والالتزام بتعليمات الدراسة؟

- نعم
- لا

Appendix B

Consent form to participate in a scientific research"2"

موافقة للاشتراك في البحث العلمي "2"

أنا الباحثة:" مريم أحمد خضر زيد" طالبة ماجستير: "مكافحة وضبط العدوى " في كلية الدراسات العليا – جامعة النجاح الوطنية. أقوم ببحث علمي بعنوان: "فعالية التدخلات متعددة الوسائط للحد من معدل تلوث زراعة الدم في المستشفيات الحكومية": دراسة ما قبل التدخل وبعده، بإشراف الدكتور: "زاهر نزال" والدكتورة: "سعاد بلكبير".

حيث يهدف البحث إلى تحسين عملية سحب عينات زراعة الدم التي من شأنها أن تعمل على تحسين الإجراءات الطبية، ورعاية المرضى، فضلاً عن خفض التكاليف الإجمالية للرعاية الصحية؛ من خلال تنفيذ تدخلات متعددة الوسائط، وتقييم فعالية هذا التدخلات من خلال تقييم الانخفاض في معدل تلوث زراعة الدم إلى أقل من ثلاثة في المائة، وفقاً إلى: معهد المعايير السريرية والمختبرية، وتحسين التزام طاقم التمريض في بروتوكول سحب زراعة الدم بعد التدخل الخاص في الدراسة.

وتستند آلية الاختيار إلى معايير خاصة في البحث، حيث تتطلب فقط تصوير المريض فيديو خلال عملية سحب عينة زراعة الدم، بالطريقة العلمية الصحيحة، وفقاً إلى معهد المعايير السريرية والمختبرية، والمراجع العلمية الموثوقة.

مشاركتك في هذا البحث اختيارية تماما، يمكنك أخذ الوقت الكافي للتفكير في المشاركة، ويمكنك الانسحاب متى شئت، ولن يلحق ذلك بك بأي ضرر.

لحماية خصوصيتك سوف يتم تصوير مكان عملية سحب عينة زراعة الدم فقط، ولن يتم اظهار أي تفاصيل من المريض خلال التصوير، وأيضا لن يتم أخذ أي معلومات خاصة عن المريض في الدراسة سواء: اسم المريض، أو أي معلومة أخرى.

حيث سيتم حفظ الفيديو في مكان آمن لا يمكن الوصول إليه إلا عن طريق الباحث، والأفراد المرخص لهم، وسيتم تزويدك بالفيديو المصور في حال رغبت في ذلك.

الموافقة على المشاركة في الدراسة:

هل تؤكد أنك سوف توافق على المشاركة في البحث، بما في ذلك تصوير المريض فيديو خلال عملية سحب عينة زراعة الدم؟

- نعم
- لا

Appendix C

IRB Approval Letter

An-Najah National
University
Faculty of Medicine &
Health Sciences
Institutional Review Board

جامعة النجاح الوطنية
كلية الطب وعلوم الصحة
لجنة اخلاقي البحث العلمي

Ref: Mas . July. 2024/14

IRB Approval Letter

Title of Research:

The Effectiveness of Multimodal Interventions on Reducing Blood Culture Contamination Rate in Governmental Hospitals: A Pre- and Post-Study.

Submitted by:
Mariam Ahmad Khader Zaid.

Supervisor:
Zaher Nazal ,Souad Belkebir

Approved:
11th July, 2024

Your Study Title" **The Effectiveness of Multimodal Interventions on Reducing Blood Culture Contamination Rate in Governmental Hospitals: A Pre- and Post-Study**.." *reviewed* by An-Najah National University IRB committee and was approved on 11th July. 2024

Hasan Fitian, MD

IRB Committee Chairman

IRB
Institutional Review Board

Nablus - P.O Box :7 or 707 | Tel (970) (09) 2342902/4/7/8/14 | Faximile (970) (09) 2342910| E-mail : IRB@najah.edu

Appendix D

Certificate of English

Certificate of English Proofreading and Editing

This certificate confirms that the thesis mentioned below was proofread by a copy editor and edited by a native speaker.

The following issues were corrected: grammar, punctuation, sentence structure, and phrasing.

Faculty of Graduate Studies at An-Najah National University may contact us for a copy of the edited document that the author submitted.

Title

The Effectiveness of Multimodal Interventions on Reducing Blood Culture Contamination Rates in Governmental Hospitals: A Pre- and Post-Study

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Appendix E

Competency Assessment Tool for the procedure of Blood Culture Collection from a Peripheral Veins

Competency Assessment Tool	Competency title: Procedure of Peripheral Blood Culture	
	Name:	ward:

Assessment code		Method of assessment	
1	No experience/ knowledge	O	Observation
2	Limited experience/knowledge, needs supervision and guidance	V	Verbal
3	Competent to perform independently/safely	T	Test
NA	Not available	D	Demonstration
Reference: Dougherty and Lister. (2015). The Royal Marsden manual of clinical nursing procedures (9th edition).			

Performance criteria: Skills required to achieve the competence		Method of Assessment	After Interventions	Before Interventions
1.	Take BC before the antibiotic dose	D/O		
2.	Hand Hygiene	O/V		
3.	Donning sterile gloves	O		
4.	Correct technique for cleaning the venipuncture area.	O		
5.	Correct technique for cleaning the top of bottles	O		
6.	Collect the BC first if blood is being taken for other tests.	O		
	Score: #of total points achieved /maximum score × 100 =			
Comment: Signature:				

Appendix F

Competency Assessment Tool for the Procedure of Blood Culture Collection from a Central Venous Access Device

Competency Assessment Tool	Competency title: Procedure of Blood Culture Collection from Central Venous Access Device	
	Name:	Ward:

Assessment code		Method of assessment	
1	No experience/knowledge	O	Observation
2	Limited experience/knowledge, needs supervision and guidance	V	Verbal
3	Competent to perform independently/safely	T	Test
NA	Not available	D	Demonstration

Reference:

1: Royal Hospital for women (2009). Clinical policies, procedures and guidelines.

2: Liverpool Hospital, 2015. Central Venous Catheters: Care and Management.

3: Dougherty and Lister. (2015). The Royal Marsden manual of clinical nursing procedures (9th edition).

4: Morton P., Fontaine D. (2013) Critical Care Nursing (10th edition), Lippincott Williams.

Performance criteria: Skill to achieve the competence		Method of Assessment	Before Intervention	After intervention
1.	Wearing mask	O/V		
2.	Put on sterile gloves	O/V		
3.	Perform hand hygiene	O/V		
4.	The proper method for cleaning bottle tops	O/V		
5.	The correct method of scrubbing the catheter hub before collection	O/V		
6.	The proper technique of	O/V		

	collecting a sample from a CVAD			
7.	The proper method of scrubbing the catheter hub after a collection	O/V		
8.	Attach a new cap aseptically	O/V		
	Score: #of total points achieved /maximum score × 100 =			
	Comments: Signature:			

Appendix G

A questionnaire for the Assessment of Nurses' Knowledge and Practice according to the Procedure of Blood Culture Collection

استبيان عن المعرفة والممارسات المتعلقة بسحب عينات زراعة الدم لطاقم التمريض

أنا الباحثة مريم زيد طالبة ماجستير مكافحة وضبط العدوى من كلية الدراسات العليا من جامعة النجاح الوطنية اقوم ببحث علمي بعنوان **فعالية التدخلات متعددة الوسائط للحد من معدل تلوث زراعة الدم في المستشفيات الحكومية: دراسة ما قبل التدخل وبعده**، حيث ان الدراسة تستهدف طاقم التمريض في المستشفى بإشراف الدكتور زاهر نزال والدكتورة سعاد بلكبير.

يهدف البحث إلى تحسين عملية سحب عينات زراعة الدم التي من شأنها ان تعمل على تحسين الإجراءات الطبية ورعاية المرضى، فضلاً عن خفض التكاليف الإجمالية للرعاية الصحية من خلال تنفيذ تدخلات متعددة الوسائط، مثل تثقيف طاقم التمريض، وإدخال بروتوكول مرجعي موحد في الأجنحة، ووضع رسائل تذكيريه، وتقديم ملاحظات على عملية السحب، وإجراء تصحيحات في الموقع استناداً إلى الملاحظات المباشرة وفقاً للبرتوكول المرجعي، فضلاً عن تقييم فعالية هذا التدخل من خلال تقييم الانخفاض في معدل تلوث زراعة الدم إلى اقل من ثلاثة في المائة وفقاً إلى معهد المعايير السريرية والمختبرية ، وتحسين التزام طاقم التمريض في بروتوكول سحب زراعة الدم بعد التدخل الخاص في الدراسة.

وتستند آلية الاختيار إلى معايير خاصة في البحث، تتطلب إجابة طاقم التمريض على الأسئلة الواردة في استبيان يقدم من قبل الباحث يتعلق ببعض المعلومات الشخصية عن الطاقم لغرض البحث، فضلاً عن المعرفة، والخبرة العلمية، والإجراءات المتبعة في سحب عينات زراعة الدم والعوامل التي تؤثر على ارتفاع معدل تلوث الدم. كما يتطلب التزام الطاقم في البروتوكول الموحد لسحب عينات زراعة الدم.

مشاركتك في هذا البحث اختيارية ويمكنك أخذ الوقت الكافي للتفكير في المشاركة. يمكنك الانسحاب متى ما شئت ولن يلحق ذلك بك باي ضرر. حيت سوف تكون مشاركتك على مدار 4شهور وستقسم إلى ثلاث مراحل: مرحلة سابقة للتدخل مدتها شهر واحد، ومرحلة تدخل مدتها شهرين، ومرحلة لاحقة للتدخل مدتها شهر واحد.

ستبقى معلوماتك سرية ولن يطلع عليها أحد تحت أي ظرف كان. سوف يتم تسجيل فقط اسمك والرقم التعريفي في نموذج الاستبيان وسيتم المحافظة على السرية التامة عن طريق وضع رموز رقمية لكل استمارة بحيث لا يظهر اسم المشترك، وستحافظ في مكان آمن لا يمكن الوصول إليه إلا من قبل الباحث والأفراد المرخص لهم. سيتم تزويدك بنتائج البحث في حال رغبت في ذلك.

الموافقة على المشاركة في الدراسة:

هل تؤكد أنك سوف توافق على المشاركة في البحث، بما في ذلك الإجابة على أسئلة الاستبيان والالتزام بتعليمات الدراسة؟

- نعم
- لا

Second Section: Personal Information.

Nurse name: ----------

Identification number: ----------

Please answer all the questions in this questionnaire, select one answer, and then draw a circle around the correct answer:

Ward:

- ICU
- Surgical& Medical
- Neonatal ICU
- Emergency
- Pediatric

Education level of the nurse:

- Diploma
- Bachelor
- Master

Number of years of work experience:

- 1-5 y
- 6-10 y
- more than 10 y

Do you receive training on blood culture collection?

- Yes
- No

The level of workload in the ward is appropriate to the staff number:

- Yes
- No

Is there high traffic and overcrowding in the ward?

- Yes
- No

<u>Third Section: The following questions related to knowledge of nurses in pre pre-analytical phase of the BC procedure, please select one answer and put a circle around the correct answer:</u>

The collection method for BC collection should usually be:

- Peripheral
- Central line
- Arterial line

The venipuncture site before BC collection should be cleaned with:

- Povidone iodine, then 70% alcohol from the center to the periphery
- Povidone iodine only
- 70% alcohol only
- Chlorohexidine

When the venipuncture site is cleaned, you should withdraw

- Directly after cleaning.
- After the use of a dry, sterile wipe to dry the cleansed area.
- After allowing the cleaned area to dry for 30 seconds.
- Time doesn’t matter.

What disinfectant should be used if you are disinfecting the top of the bottle?

- 70% Isopropyl alcohol
- Povidone iodine
- Chlorhexidine
- Not done

The volume of blood should be collected in adult cases:

- 1- 3 mL for each bottle
- 4- 7 mL for each bottle
- 8- 10ml for each bottle

The volume of blood should be collected in pediatric cases:

- 1-3 ml for each bottle
- 4- 7 mL for each bottle
- 8-10 for each bottle

If you draw several sets of BCs, you should withdraw from:

- Two separate venipuncture sites at the same time.
- Same site at the same time
- Two separate venipuncture sites approximately 15-30 minutes apart.

Do you know the consequences of BC contamination?

- Yes
- No

<u>Fourth Section: The following questions relate to the practices of nurses according to BC procedure; please select one answer and put a circle around the correct answer:</u>

Which of the following aspects helps you adhere to the correct method of blood sample collection? (You can select more than one choice)

- Visual reminders like posters
- Observing seniors
- Educational sessions

- Provision of a pre-formed checklist
- My knowledge
- None of the above

What makes you not perform hand hygiene when required?

- Inadequate availability of hand rub products
- Lack of motivation
- Allergy to hand rub product
- Forgetfulness
- lack the time
- All of the above
- None of the above

Have you ever received feedback about the BC contamination in your ward?

- Always
- Sometimes
- Never

I am grateful for your collaboration

Appendix H

Poster

Appendix I

Checklist for Procedure of Peripheral Blood Culture

Patient name: ---------- **Patient number: ----------** **Date of birth: ----------**			
Date of collection of BC *: ---------- **Time of collection of BC: ----------** **Number of sets collected-------** **Indication to BC collection: ----------**			
Department: ---------- **Doctor name: ----------** **Shift: ----------** **Name of nurse who collect BC: ----------**			
Max precaution barrier: *Hand hygiene *Gloves * Sterile gloves *Apron *Sterile apron	Anatomic site of the body for collection: *Antecubital (right, left) * Subclavian (right, left) * Dorsal hand (right, left) * Others ----------	The collection method: * Peripheral * Central line * Arterial line	**Volume of collected blood for each bottle:** *** 1-3ml** *** 4-7ml** *** 8-10ml**

Please, recognize the following:

- **Take BC with chills and fever.**
- **Take BC before antibiotic dose or before next dose of ongoing antibiotics.**
- **Anaerobic sample should only be sent in the following: immunodeficiency, malignancy, gastrointestinal disorder or per doctor order.**

Please: put ☑ if done and ✕ If not done.	Done	**Not done**
1-Completely assemble essential equipment's : Povidones iodine, 70% isopropyl alcohol, Gauze swabs, set of BC bottles according to the doctor order (anaerobic and aerobic), needles, syringe, non-sterile gloves /sterile gloves, appropriate document/form and clean tray or receiver.		
2- Explain and discuss the procedure with the patient.		
3-Perform hand hygiene.		
4-Apply a disposable tourniquet and palpate to identify vein.		
5- Clean skin using repeated motions from the center to the periphery with iodine and allow to dry for at least 30 seconds, then 70% isopropyl alcohol and allow to dry for 30 seconds. Don't palpate the site again after cleaning.		
6-Remove flip-off caps from bottles and clean them with 70% isopropyl alcohol pad and allow to dry. Use a separate pad for each vial.		
7-Perform hand hygiene and apply non-sterile gloves (sterile gloves are not essential except if you are not sure from re-palpation). `		
8- If blood is being taken for other tests, collect the BC first. Inoculate the aerobic culture first.		
9-Release tourniquet, remove the needle and apply pressure to the venipuncture site.		
10-Change the needle that is used to draw the specimen prior to inoculation the bottle.		
11-Fill aerobic bottle first, hold upright and use bottle graduation lines to accurately gauge sample volume then fill anaerobic Bottle, the volume MUST match.		

12-Remove gloves and wash/decontaminate hands.		
13-Label bottles with appropriate patient details while in the presence of the patient, ensuring the bar codes on the bottles are not covered or removed. (date, time,patient name, nurse name, ward, site of venipuncture, collection method).		
14-Tranport BC set to the laboratory within two hours by biohazard bags to incubate at 37°C.		`
15-Repeat steps (1–14) after the first set from different site spaced 30 minutes to one hour apart to collect the second BC set.		

*BC: Blood Culture

Appendix J

Checklist for Procedure of Blood Sampling from Central Venous Access Device for Culture

Patient name: ---------- **Patient number: ----------** **Date of birth: ----------**			
Date of collection of BC *: ---------- **Time of collection of BC: ----------** **Indication to BC collection: ----------** **Number of sets collected----------** **Department: ----------** **Doctor name: ----------** **Name of nurse who collect BC: ----------** **Shift: ----------**			
Max precaution barrier: *Hand hygiene *Gloves *Sterile apron *Mask * Sterile gloves *Apron	**Anatomic site of the body:** * Subclavian (right, left) *Jugular (right, left) *Femoral (right ,left) *Umbilical * Others ----------	**The type of intravascular device:** *Triple lumen *Arterial line *PICC *HD catheter *Other----------	**Volume of collected blood for each bottle:** ***1-3ml** ***4-7ml** ***8-10mL**

Please, recognize the followings:

- **For a patient with a central venous catheter, a peripheral venipuncture culture should be obtained first (as directed by the peripheral blood collection checklist), and then, 15 minutes later, a central line culture should be obtained using the same volume for both.**
- **Turn off all infusions for at least 1 minute before drawing blood.**
- **When drawing through multi lumens catheters, obtain BC from distal lumen if possible* If distal lumen is already in use, any unused lumen may be used.**

Please: put ✓ if done and ✗ If not done.	**Done**	**Not done**
1-Completely assemble essential equipment's: 20 ml syringe,70% isopropyl alcohol pad, clean gloves, mask, under pad, sterile gauze, needle, normal saline flush, heparin flush, sterile injection cap, culture bottles anaerobic and aerobic.		
2- Explain and discuss the procedure with the patient.		
3- Perform hand hygiene and apply clean gloves.		
4-Remove flip-off caps from bottles and clean them with 70% isopropyl alcohol pad and allow to dry. Use a separate pad for each vial.		
5-Perform hand hygiene and apply sterile gloves.		
6- Clean injection cap with 70%alcohol and allow drying completely. Remove end of IV tubing or injection cap from Catheter hub with non-touch technique.		
7- Disinfect catheter hub with 70% alcohol in twisting movement for 15 sec. Don't wipe		
8- Unclamp catheter (if necessary) to withdraw blood.		
9- Attach an empty 20 mL syringe to catheter hub, unclamp catheter then withdraw required blood for culture. (don't aspirate a discard volume).		
10- Re-clamp the catheter, remove a filled syringe and attach a sterile needle to it to inoculate the blood into bottles.		

11- Fill aerobic bottle first, hold upright and use bottle graduation lines to accurately gauge sample volume then fill anaerobic Bottle, the volume MUST match.		
12- Flush the catheter with 10 cc 0.9% N/S. Clamp the lumen. Disinfect the catheter hub with 70% alcohol in a twisting movement for 15 sec. Don't wipe, then attach a new sterile cap or IV tubing to the hub of the catheter. Resume infusion as ordered or clamp catheter (if necessary).		
13- Remove gloves and wash/decontaminate hands.		
14-Label bottles with appropriate patient details while in the presence of the patient, ensuring the bar codes on the bottles are not covered or removed. (date, time, nurse name, ward, site of collection).		
15-Transport BC set to the laboratory within two hours by biohazard bags to incubate at 37°C.		

*Blood Culture

Appendix K

Tables of Study

Table 11

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

Phase	Total number of cultures	Contaminated culture	BCC rate	P-value*
Pre-intervention	128	12	9.4%	<0.001
Post-intervention	119	3	2.4%	
*Wilcoxon rank test				

جـامعـــة النجاح الوطنية
كليـــة الدراســـات العليـــا

فعالية التدخلات متعددة الوسائط للحد من معدل تلوث زراعة الدم في المستشفيات الحكومية: دراسة ما قبل التدخل وبعد

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إشراف
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قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في مكافحة وضبط العدوى، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

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الملخص

خلفية: زراعة الدم تعتبر المعيار الذهبي التشخيصي للكشف عن التهابات مجرى الدم، والتي تساهم بشكل كبير في نسبة المرضى والوفيات في المستشفيات. ومع ذلك، حتى مع التكنولوجيا الطبية الحديثة، تظل معدلات التلوث تحديًا مستمرًا، مما قد يهدد دقة التشخيص واتخاذ القرارات السريرية.

الهدف: هدفت هذه الدراسة إلى تقييم فعالية التدخلات المتعدد الوسائط في تقليل معدل تلوث زراعة الدم إلى أقل من 3%، بما يتماشى مع إرشادات معهد المعايير السريرية والمخبرية، وكذلك لتعزيز معرفة طاقم التمريض والامتثال لممارسات جمع زراعة الدم الصحيحة سواء من الاوردة الطرفية وجهاز الوصول الوريدي المركزي.

الطريقة: أجرينا دراسة تدخل قبل وبعد لمدة ستة أشهر في مستشفى حكومي، لتقييم اربعة نتائج رئيسية: (1) معدلات تلوث زراعة الدم،(2)المعرفة النظرية للطاقم التمريض،(3) ممارسات طاقم التمريض و(4) الامتثال الإجرائي لسحب زراعة الدم من الاوردة الطرفية و جهاز الوصول الوريدي المركزي.

تضمنت حزمة التدخل خمس مكونات رئيسية: جلسات تعليمية منظمة، قائمة مرجعية موحدة، تذكارات بصرية، تغذية راجعة للأداء، وتصحيحات إجرائية فورية. تم إجراء التحليلات الإحصائية باستخدام SPSS اصدار 21، مع تحديد الدلالة عند $p<0.05$.

النتائج: أظهرت التدخلات متعددة الوسائط تحسنًا كبيرًا في جميع النتائج المقاسة. زادت درجات معرفة طاقم التمريض بشكل كبير من 55.48% قبل التدخل إلى 92.54% بعد التدخل($p<0.001$) وتحسنت ممارسات طاقم التمريض من 25.36% الى 40.19% ($p<0.001$) وايضا. وايضا الامتثال الإجرائي تحسنًا يشكل ملحوظ لكل من جمع عينات زراعة الدم من الوريد الطرفي (من 80.4% إلى 96.43%) وجمع عينات زراعة الدم من جهاز الوصول الوريدي المركزي من(68.25% إلى 94%)، حيث كانت كلا التحسينات ذات دلالة إحصائية ($p<0.001$). الأهم من ذلك، انخفض معدل تلوث زراعة الدم من 9.4% إلى 2.4%، محققًا هدف الدراسة بالانخفاض دون معيار 3% الخاص بإرشادات معهد المعايير السريرية والمخبرية.

الخاتمة: تظهر هذه الدراسة أن التدخلات المستهدفة متعددة الأوجه يمكن أن تقلل بشكل فعال من معدلات تلوث زراعة الدم لتلبية المعايير السريرية والمخبرية مع تحسين كل من المعرفة النظرية والامتثال العملي بين طاقم التمريض بشكل كبير. تؤكد هذه النتائج على قيمة الاستراتيجيات التعليمية والتشغيلية المدمجة في تحسين جودة علم الأحياء الدقيقة التشخيصي، مما يعزز في النهاية رعاية المرضى من خلال الكشف الأكثر موثوقية عن عدوى مجرى الدم.

الكلمات المفتاحية: التدخل المتعدد الأشكال، ت لوث زراعة الدم، امتثال طاقم التمريض، معرفة طاقم التمريض.