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Use of hair nets and face masks to decrease blood culture contamination rates

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ABSTRACT

Owing to a persistently high blood culture contamination rate of 3.2% exceeding the target rate of <3%, a midwestern United States hospital began a series of 3 additive interventions. After collecting phlebotomist data for approximately 3 months, reporting of individual contamination rates commenced. A specialized trainer reeducated staff with high rates, which resulted in a modest decrease in contamination rates (3.2% to 2.8%, $P = 0.23$). A second, additional intervention requiring phlebotomists to wear hair nets and face masks resulted in marked improvement from a mean of 2.8% to 1.1% ($P < .0001$). In a final, third addition, whenever possible, the replacement of nursing staff by phlebotomy staff for blood specimen collection did not result in a significant change in mean contamination ($P = 0.81$). Overall, the mean contamination rate progressively declined in a stepwise manner from 3.2% to 1.2% ($P = .0013$), with the greatest decline after adding hair nets and face masks.

1. Introduction

Blood cultures are often an important aspect in the evaluation of febrile patients. Unfortunately, blood culture contamination (BCC) accounts for up to 50% of all positive blood cultures (Gander et al., 2009; Roth et al., 2010). False-positive blood cultures as a result of microbial contamination can result in unnecessary expense, compromised patient care with inappropriate antibiotic therapy, increased workload for technologists, and adverse antibiotic effects, such as *Clostridium difficile* colitis (Gander et al., 2009; Moeller, 2017).

Many studies using a multitude of approaches to reduce BCC rates have been conducted. One such approach is an informational intervention to increase knowledge about proper blood culture practice (Roth et al., 2010); however, for a variety of reasons, education alone does not result in consistent adherence to guidelines for obtaining blood culture specimens. Another approach is to restrict blood culture specimen collection to a dedicated, trained, phlebotomy team (Moeller, 2017). Indeed, studies have found that phlebotomists have significantly lower BCC rates than nonphlebotomists have (Gander et al., 2009; Moeller, 2017).

Herein, we present the results of an unblinded, sequential prospective study of efforts to reduce BCC rates conducted in a midwestern United States teaching hospital. First, blood collection was standardized throughout the institution, and routine blood culture specimen collection was to be done mainly by phlebotomy staff (PS), except for Emergency Department; Critical Care; Renal Dialysis; Neonatal/Pediatric Intensive Care Units (NICU/PICU); and, on rare occasions, in other wards. At that point, BCC was monitored by department and reported monthly to area managers. PS, and shortly thereafter other hospital staff, were monitored individually and reported. As a further step, PS and nurses were required to wear hair nets and inexpensive surgical masks when collecting blood culture specimens. Whenever possible, the patient also wore a mask. Finally, owing to modestly high contamination rates found in non-PS blood cultures, the PS were expanded to obtain most blood culture specimens from the hospital departments, except for those from vascular catheter and in the NICU/PICU.

2. Materials and methods

2.1. Setting and microbiological culture methods

After a 3-year period of high BCC rates, the study was conducted from July 2011 through July 2017 in a 325-bed Level II Trauma Center, teaching hospital that cares for patients in 21 counties across 3 states. Baseline BCC rates were observed from January 1, 2008, until October

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1, 2011, when individual and department rate reporting back to phlebotomist was begun. Blood cultures were analyzed using the BacT/Alert system with plastic standard aerobic, plastic standard anaerobic, plastic aerobic, and anaerobic with charcoal bottles, and plastic pediatric bottle (bioMérieux, Inc., Durham, NC) until the change to the Bactec FX with plastic aerobic plus bottle, plastic anaerobic lytic bottle, and glass pediatric plus bottle (BD, Franklin Lakes, NJ) in December 2014.

During the entire study, an average of 7741 blood culture specimens was obtained annually (range 7346–8415). Throughout the study, a routine blood culture set included anaerobic and aerobic bottles with a standard blood volume of 10 mL per bottle. Bottles were transported to the laboratory and incubated in the continuous-monitoring analyzers for 5 days or until flagged as positive. Aliquots from positive bottles were Gram stained and subcultured using standard techniques.

2.2. Blood culture specimen collection

Before the start of interventions, venipuncture site disinfection was standardized with the use of ChloraPrep Single Swabstick (CareFusion, El Paso, TX) for 30 s and allowed to air dry. The tops of the bottles and venous access ports were cleansed with 70% isopropyl alcohol for 30 s. Blood was obtained using a syringe and transferred aseptically to the blood culture bottles. No attempts to discard the initial 2 to 5 cc of blood were made. As required by the blood culture standard operating procedures (SOPs), vinyl gloves were worn during all phlebotomies.

2.3. Definition of contamination

A bacterial blood culture was defined as a single blood specimen (from 1 venipuncture) inoculated into bottles, regardless the number of bottles. A bacterial blood culture was considered contaminated if 1 or more of the following organisms were identified in only 1 of a series of blood cultures: coagulase-negative *Staphylococcus* species, *Propionibacterium* species, *Micrococcus* species, *Corynebacterium* species, *Bacillus* species, and alpha- or gamma-hemolytic streptococci. Cultures with more than 1 contaminant species were counted as a single contaminated blood culture. If a pathogen was reported in a contaminated culture, it was excluded from the contaminated statistics.

Patients with endocarditis or line infections with these bacteria were subtracted after physician review of available clinical data. For the former, final diagnosis and treatment were used, and for the latter, exclusion of infected catheters by the Maki culture method was accepted, or a clinical diagnosis of septic phlebitis.

2.4. Monitoring and reporting contamination rates

In October 2011, BCC rates were reported to individual phlebotomists and, shortly thereafter, for Emergency and other hospital personnel who obtained blood culture specimens. Data were also provided to departments and PS supervisors. This allowed PS supervisors and clinical managers to address any contamination issues/trends for individuals with high BCC rates and to directly observe staff and correct improper collection techniques.

2.5. Addition of hair nets and masks

In July 2013, PS and registered nurses were mandated to wear hair nets and paper surgical face masks while collecting blood culture specimens. Patients were asked to turn their face away from the venipuncture site or, when possible, to wear a mask.

2.6. Blood culture specimen collection in high-volume departments

In response to higher contamination rates in a few remaining wards, primarily Emergency, (BCC 5.7% post first intervention and 2.3% total post intervention 2) with specimens not drawn by PS, in July 2015 trained PS began to collect those blood culture specimens obtained via venipunctures in all areas (except those drawn from vascular catheters) whenever possible.

2.7. Statistical methods

A repeated-measures analysis of variance was used to assess how the BCC rate changed over time. To assess differences among individual time periods, a Mann–Whitney *U* test was used. A P value of <0.05 was considered statistically significant.

3. Results

3.1. Effect of intervention on species of organism distribution

No difference in the species of BCC was seen with the change from the BacT/Alert system (bioMérieux, Inc., Durham, NC) to the Bactec FX (BD, Franklin Lakes, NJ) in the last year of the study (P=NS). In addition, no difference was noted in BCC species found in the periods before and after the addition of hair nets and masks (P=NS). Coagulase-negative staphylococci remained the dominant contaminants (Table 1).

3.2. Contamination rates

Despite SOPs on paper for 3 years prior to the interventions, intramural quality studies revealed that BCC rates consistently exceeded the recommended target of under 3% (CLSI, 2007). During the 4 months (starting July 2011) immediately prior to active interventions, average contamination rates remained above the 3% target rate (3.4%; range 2.5–4.0%; Fig. 1).

3.3. Effects of monitoring and reporting contamination rates

In October 2011, reporting of BCC rates back to PS and departments began. Overall, rates in Emergency, where the nursing staff did the majority

Table 1
Distribution of organisms classified as contaminants in blood culture sets.

Organism	Venipuncture without hair nets/face masks January 1, 2011–June 30, 2013		Venipuncture with hair nets/face masks July 1, 2013–November 30, 2018	
	Number	%	Number	%
Total organisms	467	–	143	–
Coagulase-negative staphylococci	300	64.2	87	60.8
Micrococcus spp.	40	8.6	11	7.7
Corynebacterium spp.	30	6.4	5	3.5
Propionibacterium spp.	39	8.4	20	14.0
Streptococcus spp.[a]	22	4.7	9	6.3
Bacillus spp.	9	1.9	4	2.8
Gram-positive rods[b]	27	5.8	7	4.9

[a] *Streptococcus* spp. include viridans streptococcus and anaerobic streptococcus.
[b] Gram-positive rods include *Corynebacterium* spp., *Propionibacterium* spp., *Bacillus* spp., and possible others that were not identified past the gram stain result.

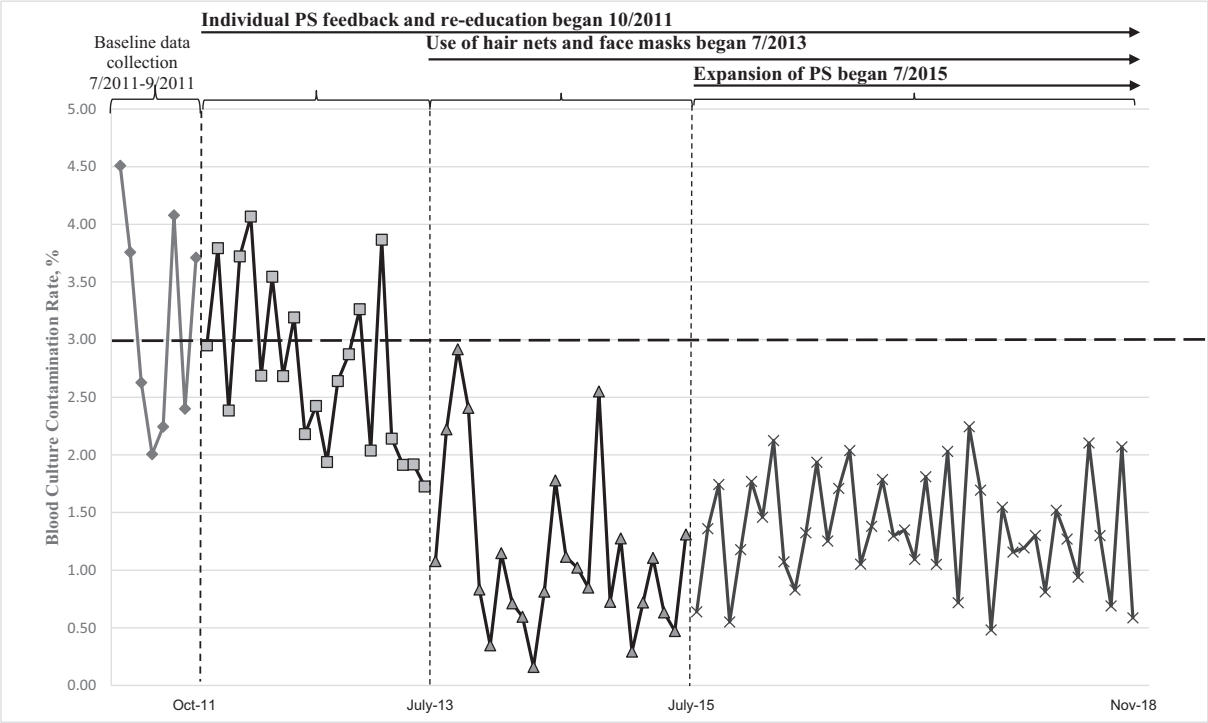

Fig. 1. Blood culture contamination rates during the 3 interventions. The horizontal dashed line represents the 3% target contamination rate, and the vertical lines represent the period of the implementation of hair nets and masks.

of the blood culture specimen collection, remained higher than those in which specimens were collected by laboratory staff (Table 2). With these individual reporting and reeducation on proper sterile blood culture specimen collection, a progressive decrease in BCC was seen through June 2013, falling from 3.2% to 2.8% ($P = 0.23$). This improvement occurred after reeducation of individual phlebotomists with high BCC rates was completed during the last 10.5 months of this intervention (mean 2.47%, $P = 0.06$).

3.4. Effects of hair nets and masks

After the addition of hair nets and masks was mandated for all blood culture specimen collection in July 2013, the overall average BCC rates significantly declined from 2.8% to 1.13%. ($P < 0.0001$; Fig. 1).

3.5. Expansion of phlebotomy services

In July 2015, staffing changes were implemented to have laboratory PS obtain blood culture specimens in all high-volume departments, including Emergency. Monthly reports continued to be sent to clinical managers for all the departments and were used for individualized training/retraining, as was the requirement of face masks and hair nets. Owing to the staffing changes implemented, the number of blood culture specimens obtained by non-PS in hospital departments was markedly reduced. Despite the PS expansion, the overall contamination rate did not significantly improve beyond the addition of hair nets and face masks (Fig. 1; mean = 1.21%; $P = 0.81$). Throughout the entire study, the Emergency Department remained the only area with inadequate improvement, with a decline from a maximum of 10.7% to 6.7% at the end of intervention 1, 2.3% at the end of intervention 2, and 2.8% at the end of intervention 3 (Table 2).

4. Discussion

A target BCC rate of <3% is standard. With implementation of a few interventions, we achieved a rate approximately 50% lower than this standard. The results of our study demonstrate that with a standardized

Table 2
Blood culture contamination rates by PS versus departments drawn by nursing staff.

Intervention	Date	PS	IV Therapy	Critical Care	Renal Dialysis	NICU/PICU	Other	Emergency[d]	Total
First	2011	170/5931 (2.9)	7/511 (1.4)	12/336 (3.6)	4/104 (3.8)	1/212 (0.5)	11/247 (4.5)	27/252 (10.7)	232/7593 (3.1)
Report/	2012	186/6187 (3.0)	12/636 (1.9)	2/81 (2.5)	1/84 (1.2)	1/187 (0.6)	6/139 (4.3)	14/270 (5.2)	221/7584 (2.9)
feedback	2013	71/3274 (2.2)	6/297 (2.0)	1/52 (1.9)	1/44 (2.3)	0/69 (0)	2/98 (2.0)	7/194 (3.6)	89/4025 (2.2)
Second	7/2013[a]	46/2909 (1.6)	4/283 (1.4)	2/57 (3.5)	0/50 (0)	0/66 (0)	1/124 (0.8)	7/173 (4.0)	60/3662 (1.6)
Addition of hair nets and face masks	2014	68/6223 (1.1)	5/322 (1.6)	0/68 (0)	1/80 (1.3)	0/191 (0)	4/434 (0.9)	1/180 (0.6)	79/7498 (1.1)
Third	3/2015[b]	62/6279 (1.0)	0/304 (0)	3/72 (4.2)	0/69 (0)	0/196 (0)	5/367 (1.4)	0/59 (0)	70/7346 (1.0)
Expanded phlebotomist services	2016	97/6437 (1.5)	5/292 (1.7)	0/62 (0)	0/44 (0)	0/218 (0)	7/410 (1.7)	2/34 (5.9)	111/7497 (1.5)
	2017[c]	65/4628 (1.4)	3/203 (1.5)	1/81 (1.2)	0/29 (0)	1/148 (0.7)	5/252 (2.0)	2/48 (4.2)	77/5389 (1.4)

Note: Data are presented as number of contaminated blood cultures/total blood cultures (percent contaminated).
Abbreviations: IV = intravenous; NICU/PICU = neonatal intensive care unit/pediatric intensive care unit.
[a] Hair net/face mask begun 7/1/2013.
[b] Expansion, using both education/feedback and hair nets/facemasks, of phlebotomy service to include, when feasible, Emergency and Critical Care (with the exception of vascular catheters).
[c] Data for January 2017 through August 2017.
[d] Emergency mean blood culture contamination: intervention 1 = 5.7%, intervention 2 = 2.3%, and intervention 3 = 2.8%.

blood culture specimen collection procedure, continuous reporting of BCC rates along with reeducation of any staff with high rates, and use of hair nets and face masks during specimen phlebotomy reduced BCC rates from 3.2% in 2008 to 1.1% in 2017 ($P = .0013$). However, the use of hair nets and face masks during all phlebotomies had the greatest impact on BCC rates ($P < .0001$). This parallels the use of hair nets and face masks to reduce bacterial contamination seen in industry—from food to pharmaceuticals.

One change that did not make a difference was the blood culture system used. Developments in automated blood culture systems using enriched culture media have been reported by others to increase contamination rates (Altindis et al., 2016; Cockerill et al., 2004). We found no difference in the genera of the contaminating bacteria or in the total percentage of BCC with the switch from the BacT/Alert system (bioMérieux, Inc., Durham, NC) to the Bactec FX (BD, Franklin Lakes, NJ).

Previous studies have found monitoring programs to be associated with lower BCC rates (Bekeris et al., 2005). During the baseline period in this study, all nursing and phlebotomy staff were trained on a standardized blood culture specimen collection procedure. Approximately 3 months later, we began reporting the BCC rates of individual phlebotomists and departments to identify areas in which improvement was possible. Owing to the large number of blood culture specimens collected by the PS, BCC rates could be reported by individual. Laboratory supervisors were charged with training/retraining. Others have also reported that BCC rates decline if staff members with high rates of BCC receive individualized training on proper technique and retraining (Eskira et al., 2006). During the early reporting period, we identified several factors that could contribute to BCC. For example, training of new staff was done by current staff, which served to perpetuate some incorrect techniques. Thereafter, a specialized trainer with the single collection procedure went to each department to train all staff in the correct procedures. New hires were all trained by the specialized trainer, and retraining was done individually as needed. With these interventions, a modest decrease in BCC rates followed in the next 21 months (mean of 2.8%; range 1.9–4.0%; $P = 0.23$), below the 3% target.

Use of surgical face masks and hair coverings to decrease shedding of pathogens is standard practice in operating rooms. An operating room study found high-level nasal carriage of *Staphylococcus aureus* by the patient to be the most important and only significant independent risk factor for surgical site infection with *S. aureus* (Kalmeijer et al., 2000). In July 2013, phlebotomists, like their surgical counterparts, began to wear hair nets and face masks during blood culture specimen collections. Patients who could not turn their head away from the phlebotomy site were asked to wear a face mask, as well. Possibly due to a reduction in bacterial contaminants shed onto phlebotomy equipment —unique to this study—the use of face masks and hair nets resulted in the greatest decrease in BCC rates ($P < .0001$).

Studies have shown dedicated phlebotomy teams to have lower BCC rates than nursing staff (Gander et al., 2009). Additionally, one study demonstrated that institutions in which nursing staff obtain most blood culture specimens have BCC rates more than 1% higher than those that use dedicated phlebotomy teams Bekeris et al., 2005). Therefore, in July 2015, routine blood culture specimen collection in emergency and critical hospital units began to be obtained, whenever possible, by the laboratory PS instead of non-PS staff (although nursing staff were still responsible for specimen collection from indwelling intravascular lines). However, even with this expansion of a dedicated phlebotomy team handling the majority of blood culture specimen collections (and with the continued use of feedback reports/reeducation and of hair nets and face masks), the overall BCC rate then remained at around 1.3% for the institution, and the overall BCC rate did not change. This failure to see further reductions was due to the relatively small number of cultures and relatively high BCC from the Emergency Department. This higher Emergency BCC rate possibly related to time constraints that curtailed adequate adherence to the full blood culture SOP.

A major limitation of this stepwise, noncontrolled, noncomparative study was that it is not possible to determine which step contributed to the greatest benefit because it took about 3 to 4 months to train approximately 92 full- and part-time PS, spread over 3 shifts. The first intervention improvement was mainly seen during the last 13 months of this rate reporting and reeducation intervention (mean rate = 2.47%; $P = 0.061$). This delay of improvement was possibly due to its corrective practices and/or to a change in behavior prompted by knowingly being monitored—a phenomenon known as the "Hawthorne effect" (Landsberger, 1958). Regardless, the downward trend might have also contributed to the additional improvement seen in intervention 2 and maintenance of low BCC rates seen in intervention 3. Another limitation of this study was that we did not discard an initial 2 cc to 5 cc of blood from the blood culture specimen obtained from venous lines, as has been proposed to reduce venous hub contaminants, and no standard sequence of blood collection for the blood culture and other blood specimens from a single phlebotomy was mandated (theNursePath, 2016).

A recent university center study investigated the use of a novel initial specimen diversion device (ISDD), commercially known as SteriPath (Steed, 2017). The false-positive culture rate dropped nearly 90%—from 1.78% to 0.22%. The ISDD was designed to mitigate the problem of skin fragment contamination by diverting the first 1 to 2 mL of the blood draw initially thought to include the problematic skin fragments and directing it to a separate chamber of the device. As contrary results have been reported (Dwivedi et al., 2009), whether combining use of an ISDD with the steps described here will decrease contamination further remains to be determined.

A previous study estimated the cost of a single BCC to be from $4500 to $10,078 in US dollars (Garcia et al., 2015). Using our baseline contamination rate of 3.7%, the estimated cost for false-positive blood cultures at our institution would have been from $12,492,000 to $27,976,528 for the 10 study years if no interventions had been implemented. Therefore, our institution saved between $4,185,000 and $10,696,540 in health care costs over the 10-year period.

In summary, the changes described in blood culture specimen collection procedure significantly lowered BCC rates. Hospitals that enforce new venipuncture standards of proper training of phlebotomists; monitor departmental and phlebotomist contamination rates; reeducate staff with high rates; and, most importantly, use hair nets and face masks can lower their false-positive BCC rates to less than 1.5%.

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Declaration of interest

The authors have no conflict of interest to declare.

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