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ELECTRONIC ARTICLE

Implementation of Evidence-Based Potentially Better Practices to Decrease Nosocomial Infections

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ABSTRACT

Objective. Six neonatal intensive care units (NICU's) that are members of the Vermont Oxford National Evidence-Based Quality Improvement Collaborative for Neonatology collaborated to reduce infection rates. There were 7 centers in the original focus group, but 1 center left the collaborative after 1 year. Nosocomial infection is a significant area for improvement in most NICU's.

Methods. Six NICU's participating in the Vermont Oxford Network made clinical changes to address 3 areas of consensus: hand washing, line management, and accuracy of diagnosis. The summary statements were widely communicated. Review of the literature, internal assessments, and benchmarking visits all contributed to ideas for change.

Results. The principle outcome was the incidence of coagulase-negative staphylococcus bacteremia. There was an observed reduction from 24.6% in 1997 to 16.4% in 2000.

Conclusions. The collaborative process for clinical quality improvement can result in effective practice changes.

Key Words: nosocomial infection • hand washing • line management • blood cultures • collaborative quality improvement • NIC/Q 2000

Abbreviations: NI, nosocomial infection • VON, Vermont Oxford Network • CONS, coagulase-negative staphylococcus • PBP's, potentially better practices • NICU, neonatal intensive care unit • PDSA, plan-do-study-act

KEY POINTS OF ARTICLE

- All participating sites began with hand hygiene improvements.
- Vascular line management was recognized as another key element in reducing infection.
- Improved accuracy of infection diagnosis is needed because of problems with contaminated blood culture.
- It was helpful to quantify the impact of infections including impact on length of stay and cost.

APPLYING LESSONS LEARNED TO PRACTICE

- Multiple issues may require resolution before program changes can be initiated.
- Ongoing evaluation is an important component of the change process.
- Public relations is an important aspect of the education process around new practices.

Nosocomial bacteremia is a significant contributor to neonatal morbidity and mortality.[1] The frequency of this complication varies among neonatal units and seems to be related, at least in part, to management decisions and practice style.[2] Investigations have suggested that selected interventions could lower the risk of nosocomial infections (NI's).[3,4]

As described in an earlier report, 6 institutions participating in the Vermont Oxford Network (VON) entered into a 2-year collaborative with the goal of reducing by 50% coagulase-negative staphylococcus (CONS) bacteremia for infants <1500 g birth weight.[5]

Bacteremic events caused by CONS were targeted because this organism is known to be the most frequent cause of neonatal NI.[1] To accomplish this objective, multidisciplinary teams representing each of the 6 institutions collaborated to develop lists of potentially better practices (PBP's) thought to be related to lowering infection rates. The PBP's were prioritized. As appropriate, PBP's were joined together into larger perspectives referred to as "summary statements." The summary statements addressed hand hygiene, line management, and accuracy of diagnosis.

The participating institutions implemented and documented their changed practices. This article describes the implementation at different institutions, obstacles that were encountered, and the effects on clinical processes and NI rates.

METHODS

Each participating institution made clinical changes to address the 3 areas of consensus:

- Hand hygiene
- Line management
- Accuracy of diagnosis.

As shown in Table 1, not all PBP's were undertaken by every institution.

Some practices had previously been incorporated as routine care at several hospitals. PBP's were given different priority at different hospitals. All recognized the importance of hand washing and either were already performing or changed to the PBP's in this area. "Hub care" practices were implemented eventually in all 6 participating units, although in 1, implementation was delayed until after this project was completed.

Line standardization was assessed and adopted in 5 of the 6 units. However, in most units, implementation of "closed system" access was deferred or was only partially implemented. At 3 hospitals, closed access was implemented for deep venous lines. Only 2 hospitals implemented closed access with their umbilical lines. One group described inadequate hardware as a barrier, forcing several product changes and delays in implementation.

The "accuracy of diagnosis" was variably addressed by the units and depended on the perception of need for changes in this area. Not all units seemed to have the same level of difficulty with contaminated blood cultures and overuse of antibiotics. The 2 units that implemented most of these changes had identified differences in the frequency of sepsis evaluations between themselves and the benchmark hospitals. Although a specialized phlebotomy team was developed as a PBP based on benchmarking, this was not implemented in any unit. This may be explained in part by the fact that the PBP would have required large changes in residency training and use of bedside nursing personnel that were not considered warranted.

See Table 1 for details.

TABLE 1. Summary of PDSA Cycles Performed to Address the Summary Statements (5 Centers Reporting)

	Specific PBP	PDSA or Other Implementation	Practice Already Implemented Before Focus Group	No Action
Hand hygiene				
When to wash	Promote hand hygiene before and after every patient contact	4	1	0
How long to wash	Duration of 10–15 s	4	1	0
Antisepsis and hygiene agents	Choose an effective agent	4	1	0
	Choose a compatible lotion	4	0	1
	Promote use of alcohol-based hand rubs	4	1	0
	Hand hygiene after glove removal	3	1	1
Initial wash	Promote first wash as means to mechanically remove soiled debris	4	1	0
Artificial nails	Ban artificial nails	3	0	2
Line setup and hub car				
Line setup	Minimize number of ports	5	0	0
	Closed access systems (deep lines)	3	0	2
	Closed access systems (umbilical lines)	2	0	3
Hardware changes	Lipid emulsion: every 24 h	1	4	0
	Total parenteral nutrition every 72 h except every 24 h when used with lipids	0	3	2
Hub care	Prepare hub with alcohol before entry	4	1	0
	Wash hands before entry; establish sterile field; prepare all surfaces	4	1	0
Compliance	Training program established	4	1	0
Accuracy of diagnosis				
Site and number of blood culture diagnosis with 2 blood cultures		4	0	1
Prepping for culture	Lines removed with many + cultures	1	3	1
	Blood culture 1-step prep: 10–30 s/30 s	2	2	1
	Blood culture prep: 2-step: 10 s/10 s/10 s/30 s	0	1	4
Personnel	Specialized team for drawing a blood culture	0	0	5
Blood culture volume	To draw at least 1 mL	4	0	1
	Document drawn volume	3	0	2
Treatment of suspected sepsis 48 h if blood culture is negative	Rx only 48 h	2	3	0
	Use ancillary tests C-reactive protein, absolute neutrophil count, immature to total neutrophil white blood cell ratio	1	3	1

Implementation of Specific Summary Statements

Hand Hygiene

Hand washing (mechanical removal of organisms from hands) is considered a key aspect of hand hygiene (elimination of organisms from hands). Because spread of organisms by hand contact is universally accepted as the leading means of dissemination of infectious agents, hand hygiene was adopted by the group as a first priority in lowering infection rates.[6] Both the Centers for Disease Control and Prevention and the American Hospital Association recommend routine hand washing before and after each patient contact, although compliance with this recommendation has always been problematic.[7] The PBP on hand hygiene emphasized the importance of vigorously washing hands 10 to 15 seconds before and after all patient contacts, after using gloves during patient care, and when in contact with patient equipment.

Improving compliance with hand hygiene presented unique challenges to participating institutions. When performed correctly before and after each patient contact, appropriate hand washing involves as many as 100 actions throughout the day. Even if everyone is supremely motivated, high workloads can generate a need for hand washings that, if conducted for the recommended duration, can exceed the time available for patient care.[8] The activity also involves participation of personnel from multiple disciplines, who work throughout the institution and have varying exposure to NICU goals and policy.

After review of the literature, the participating institutions recognized that improved compliance with current protocols was the first and most important goal. It was hypothesized that education, monitoring, and feedback to staff would modify behavior, resulting in improved compliance and effectiveness. At each institution, the first step was to conduct a baseline assessment of compliance with existing policy. All NICU's in the country have standing policies on hand washing with varying adherence to the policy. All units in the group to assess baseline compliance, which was universally reported as low by group members, used audit tools designed locally.

The second step was a campaign of education, using the documented incidence of poor compliance as a motivator to help staff adopt a higher level of commitment. The results of the baseline studies were disseminated through educational in-service sessions, e-mails, handouts, and demonstrations. At this stage, participating institutions not only reinforced the rationale for complying with existing policies but also capitalized on the discussions generated by negative results to introduce changes in policy. Most changes were directed at techniques to improve the frequency of hand washing while addressing concerns regarding skin breakdown and sensitivity to antisepsis agents.

The third phase involved repeated assessments of compliance after the initial campaign, usually in the form of small audits performed publicly to serve as reminders for staff, who became aware that they were being observed. In other cases, units devised methods using new personnel or rotating residents to obtain objective information without observational bias.

The fourth phase was feedback to staff on the data from these intermediate assessments. This was usually given as periodic updates on progress or lack of improvement. The feedback also involved exchange of information and processing of successful and unsuccessful strategies to introduce change.

The audits of hand washing compliance were the most common and perhaps the most important tools for changing behavior. Units initially developed their own audit tools. The rapid deployment of these tools enabled units to identify quickly the areas where improvement was necessary and provide feedback in a timely manner to staff. The downside to this decentralized approach was the inability to measure compliance for the group as a whole, because data were not obtained uniformly.

In an attempt to achieve uniformity, at the end of the 18-month collaboration, a single tool was adopted by the group[9] and used by all participating institutions (Fig 1). This audit tool was administered during the first quarter of 2001 at the 5 institutions that remained in the collaborative. In using the tool, observations were made anonymously by a single untrained observer in the NICU. Compliance was defined as appropriate use of antiseptic agent at hand washing opportunities, before and after each contact with a patient. Results of the audit showed 78% to 100% compliance (Fig 2). Preintervention baseline data were not available at all units for comparison.

Fig. 1A, Hand hygiene observation tool

Hand Hygiene Observation Tool

Date of Observation: Location (Pod): Time observed:

Person observed	Opportunity Assessed	Adequacy of Cleaning	Potential Break In compliance	
RN, RT, NNP, MD, Surgeon, PT/PT, etc.	A. Before patient care B. During patient care C. After patient care	A. Adequate (10-15 sec) B. inadequate (<10-15 sec) C. Noncompliant (not done)	1= Initial 2 min scrub 3= Using beeper 5= Chart use 7= Scale Use 9= Use of supplies 11= Touch face 13= other	2= Using phone 4= Diaper change 6= Computer use 8= One touch 10= Touch glasses 12= Touch hair

Persons Observed	**Opportunity Assessed**	**Adequacy of Hand Hygiene**	**Break in Compliance if observed**

Fig. 1B, Hand washing competency Observation Tool

B

NICU Handwashing

Name_____ Employee #_____

Department_____ Job Title_____

After successful completion of this evaluation, this provider is considered competent to verbalize and demonstrate appropriate handwashing policies and techniques in the Intensive Care Nursery.

Skill	Learning Resources/ Methods Used	Date Done	Initials
Information Pamphlet and Test			
1. Reads Handwashing Guidelines Pamphlet and completes test in pamphlet with score of 100% correct.	1,2,A		
Handwashing Observations			
2. Performs at least 10 observations of staff in regards to timeliness and adequacy of handwashing/ antisepsis in any of the following situations: • Initial hand wash • Handwashing before and after patient care • Handwashing after touching potentially contaminated objects	A		
Glo Germ™ Assessment			
3. Completes "Glo Germ™" assessment of handwashing adequacy.	A		

Evaluated by:_____ Initials _____

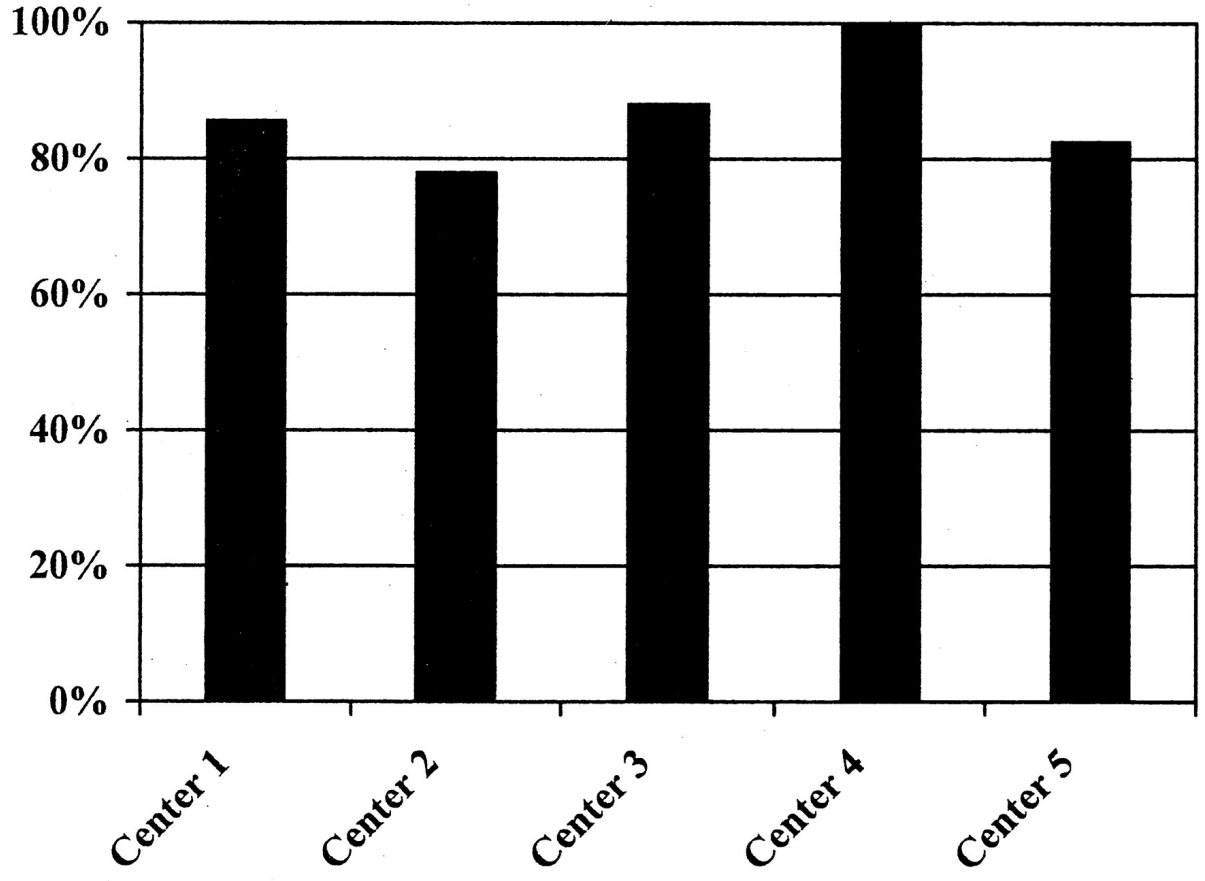
_____ Initials _____

_____ Initials _____

Learning Resources Legend	Number
Hospital Standard or Policy	1
Educational Pamphlet	2

Method Legend
A. Testing
B. Direct Observation

Fig. 2. Hand hygiene: program compliance after implementation.



The hand washing changes incorporated by group members were the result of a literature review and discussion among the groups. Most units adopted similar changes in the following areas: 1) initial wash, 2) interval wash, and 3) elimination of jewelry and artificial nails.

Initial wash

The traditional practice was to perform a 3- to 5-minute scrub using a brush on entry to the unit. When evidence that discouraged this practice was disseminated, this was an important step in improving compliance. It provided better credibility for hand washing "enthusiasts," because they were less likely to be seen as advocates of policies that were unpopular, unenforceable, or ineffective.

An initial wash of 15 to 60 seconds replaced the former practice. Brushes were recommended only for parents or staff who had heavily soiled hands.

Interval wash
This became the primary focus because it represented the area with the greatest noncompliance and potential for improvement. Barriers to compliance included skin breakdown from repeated friction and application of antisepsis agents, lack of time, involvement of multiple disciplines, and human nature.

Strategies to overcome these barriers included introduction of new antisepsis agents: 2% chlorhexidine instead of 4% chlorhexidine, the addition of 3% triclosan at the sinks for staff with chlorhexidine-sensitive skin, and use of lotions that were compatible with the antibacterial agents.

Some units added waterless alcohol gels at the bedside to enhance compliance when sinks were not readily accessible and time between patients was limited.[10] One unit performed 5 simultaneous PDSA cycles to evaluate different alcohol products before making a decision.

Once the new agents had been introduced, ongoing educational efforts were made using posters, e-mail messages, newsletters, instructional pamphlets, and videos. A novel product used by several units was Glo Germ, a substance that when applied to hands of staff demonstrates the efficacy of hand washing. This product clearly showed staff the effects of improper hand washing techniques. As mentioned above, serial audits with feedback to the staff were an important strategy for enhancing compliance.

The question of when hand washing was necessary came under scrutiny during this project.

It was clearly necessary to wash between patient contacts, but it was not clear why it was required when a provider touched the top of the incubator or side of the ventilator. Discussion of these issues led to the concept of a "clean touch" zone that surrounds an infant's incubator or crib. Providers were asked to practice hand hygiene when contacting or leaving the areas contiguous to the infant.

A PDSA cycle implementing the "clean touch" policy is provided for illustration in Fig 3.

Fig. 3. PDSA cycle regarding hand hygiene.

Objectives

1. To obtain data on improvement in handwashing practices of multidisciplinary staff members after implementation of **"Clean Touch"** policy and procedure.
2. To enhance handwashing practices in order to decrease nosocomial infection in the NICU by raising the awareness of multidisciplinary staff members.

Measurement: Random observations of handwashing practices of multidisciplinary staff members during different shifts, before and after implementation of "**Clean Touch**" policy, and procedure.

Plan

1. Develop Policy and Procedure (P&P) explaining "Clean Touch."
2. Complete random observations of handwashing practices of the multidisciplinary staff each shift for a minimum of 10 minutes (tallies to be transferred to handwashing thermometer in break room each shift) before and after implementation of "**Clean Touch**" P&P.
3. Disseminate information through in-services and memos to the multidisciplinary staff members and departments.
4. Improve communication and compliance by placing bulletins in staff bathrooms, visual cues at the sinks in the unit, and mock thermometer display for staff recognition in the break room.
5. Empower the staff to be "patient advocates" by monitoring everyone who touches the baby.
6. Seek staff input and feedback on the change process through staff meetings, counseling, discussions, etc.

Do

1. Revise **"Clean Touch"** P&P for handwashing.
2. Develop "**Clean Touch**" handouts for in-service and posttest.
3. Develop random observation tool for data collection.
4. Place mock thermometer in break room as a visual aid for staff awareness.
5. Present at next infection control meeting.
6. Make charge nurses responsible for staff education on the revised P&P.
7. Send memos to other departments about the revised P&P so they can educate non-NICU staff.
8. Supply appropriate handwashing agents in the unit. 1% Triclosan antisepsis handwashing solution was provided. Compatible hand lotion was provided to avoid noncompliance due to sore or dry hands. Waterless handwashing agent (70% alcohol gel) was also provided as an alternative handwashing agent.

Study

1. Baseline data were collected on handwashing practices by random observation, which showed considerable inconsistencies in handwashing practices among different categories of staff (RN, MD, RCP, Lab Tech, etc.). Compliance by category was as follows: - RN - 65 %; MD - 71%; RCP - 36%; Lab Tech - 0%; X-ray Tech - 50%.

2. All nursing staff were educated. Some of the respiratory care practitioners and medical staff still need to be educated.
3. Postimplementation random observations were done on 2/21/00, 2/22/00, and 2/29/00. The compliance rates were as follows: - RN – 84%; MD – 79%; RCP – 74%; Lab Tech – 67%; X-ray Tech – 64%.
4. Considerable improvement in handwashing practice was noticeable. Compliance with "clean touch" was especially commendable for the surgeons, RCPs, and Lab Techs.

Act

1. Still encountering some noncompliant ancillary staff like lab tech, x-ray tech, and medical staff like consultants, surgeons. Dealing with this problem on a one-on-one basis.
2. New memos have been sent to the radiology and laboratory department managers asking them to improve their staff compliance. The surgeons are responsive to the efforts and are improving their handwashing practices.
3. Have not completed the posting of the thermometer display for staff awareness, and have not been giving enough positive feedback to the staff. This lapse in communication needs to be rectified.
4. Need to continue doing random observations of handwashing practices to monitor compliance and obtain data on improvement.

Need to continue encouraging staff to be accountable for and committed to the "clean touch" change process so that it becomes a part of "unit culture."

Elimination of jewelry and artificial nails

Eliminating use of hand and arm jewelry and artificial nails met with opposition in all units. These practices represent personal lifestyles of NICU staff, and changes in them extend beyond the workplace (eg, elimination of stylish nails or switching to a simple wedding band). In some areas of the country, acrylic nails are an especially popular accessory worn by many members of NICU staff.

The infection control officers and nurse managers provided evidence linking NI with these practices. This was an important first step in achieving buy-in. In 1 unit, however, staff were willing to accept elimination of artificial nails only after several occurrences of pseudomonas NIs.[11] In some units, unequivocal unit policies created and enforced by the unit manager became the last resort in achieving compliance with elimination of jewelry and artificial nails. This is the least desirable strategy because authoritative enforcement of policies in 1 area often leads to a negative and subversive reaction in other areas and undermines staff's positive attitude toward responsible individual behavior in reducing infection.

Line Management

Epidemiologic studies indicate that neonatal NI's, particularly those as a result of CONS, are frequently associated with indwelling catheters.[12]

Organisms that colonize catheter hubs are often the same as those isolated from the catheter tips or blood of infants who have a diagnosis of catheter-related sepsis.[13] The frequency of line entry affects the incidence of catheter-related sepsis.[14]

Decontaminating hubs at the time of entry or connection with rubbing (friction) and alcohol will decrease colonization[15] and result in lower rates of bacteremia.[16]

Because the evidence strongly suggests that the design and management of vascular lines can play a significant role in lowering the risk of nosocomial bacteremia, the PBP included several PBP's directed at these issues.

The summary statement[5] recommended that line setups should provide access using the minimum number of ports. Breaks into the line should be reduced by adhering to recommendations that lipid infusions be changed only once every 24 hours. Parenteral fluids with amino acids should be changed once every 48 to 72 hours. Connectors and hubs need not be changed at other times unless there is breakdown or signs of residue. Finally, the most important PBP relates to antisepsis maneuvers surrounding hub entry or disconnection. At the time of entry, the operator, after first properly performing hand hygiene and establishing a sterile field, should rub the hub vigorously with alcohol. Implementation suggestions included provision of adequate supplies, a training program, and evaluation and monitoring tools.

The vascular line setup and care objectives required units to address several complex and ubiquitous components of medical and nursing practice.

These included standardization of line setups, ways to implement "closed" vascular systems (including umbilical lines), and line entry techniques (termed "hub care process"). The tasks related to implementing these PBP's were particularly daunting because current intravenous hardware and procedures for neonatal use are not standardized.

Each unit noted that it was time consuming and challenging to review, clarify, and then modify their many existing practices in light of the summary statement. These challenges were compounded when units sought to address the mechanics and processes necessary to implement "closed vascular access systems" for umbilical catheters. In addition, material management issues relating to hardware availability, product compatibility, stocking procedures, and communication required resolution. When access to a new provider was required, units had to overcome prohibitions against buying materials not provided by the hospital's buying consortia.

Significant efforts were required to develop (or revise) policies and procedures, staff education modules, skills teaching laboratories, competency tests (usually also requiring incorporation into the nurses' and respiratory therapists' annual performance evaluation processes, see Fig 4), and visual cues to reinforce the desired process (note the "hub care" logo in Fig 5). A PDSA cycle to address "closed access" is shown in Fig 6. Figure 7 shows the audit tool for line standardization and management.

Fig. 4. Hub care competency

{your medical center name}
Hub Care Competency Audit

Name:	Employee #:
Department: NICU	Job Title: Staff RN

After successful completion of this evaluation, this provider is considered competent to perform appropriate hub care in the NICU. Demonstrations may include one or all situations mentioned below.

Skill	Date Done	Initials
1. Verbalize rationale, importance, and applications of hub care in the ICN.		
2. Identify potential hubs correctly: • Stopcocks • Positive pressure heparin lock devices • Manifold device • Interlink lever lock or syringe cannula (each port access) • IV tubing connections, including spike into bag/bottle		
3. Demonstrate appropriate hub care procedures in **one of the following situations:**		
a. Drawing blood from a stopcock, especially demonstrating: • Appropriate aseptic handwashing procedures and use of clean gloves • Use of separate alcohol wipes for each "scrubbing" (FRICTION) • Scrubbing the hub X 10 seconds before disconnecting and before reconnecting syringes/flush • Use of sterile 4x4/2x2 barrier		
OR		
b. Administration of medication (bolus or syringe pump), especially demonstrating: • Appropriate aseptic handwashing procedures and use of clean gloves • Use of separate alcohol wipes for each "scrubbing" (FRICTION) • Scrubbing the hub X 10 seconds before disconnecting and before reconnecting syringes/flush • Use of sterile 4x4/2x2 barrier		
OR		
c. Hanging new IV fluids, especially demonstrating: • Appropriate handwashing procedures and use of sterile gloves • Use of sterile drape • Sterile technique in assembling IV tubing • Use of separate alcohol wipes for each "scrubbing" (FRICTION) • Scrubbing the hub X 10 seconds before disconnecting and before reconnecting syringes/flush/tubing • Use of sterile 4x4/2x2 barrier		

Evaluated by: _____

tool

Fig. 5. Needleless, closed system access to umbilical artery line; includes hub care logo.

A needleless access hub is attached to the specimen port of the umbilical artery catheter's 3-way stopcock. The hub is entered with a "manifold" that consists of a needleless access device attached to a 3-way stopcock with 2 attached syringes: the first for drawing back blood to clear infusate from the line (see syringe A) and the second for drawing off the specimen (see syringe B).

After obtaining the specimen (typically either a 1-mL syringe for blood gases or a 3-mL syringe for other laboratory tests) and returning the blood/infusate mixture from syringe A, the "manifold" is removed. The hub is then entered again with a 3-mL syringe (filled with flush solution) tipped with an access device. Flush solution is used as needed to clear blood from the line and the 3-way stopcock spaces. Each entry is preceded by "hub care." The "hub care" logo taped to the line serves as a "cue" for these antiseptic processes.

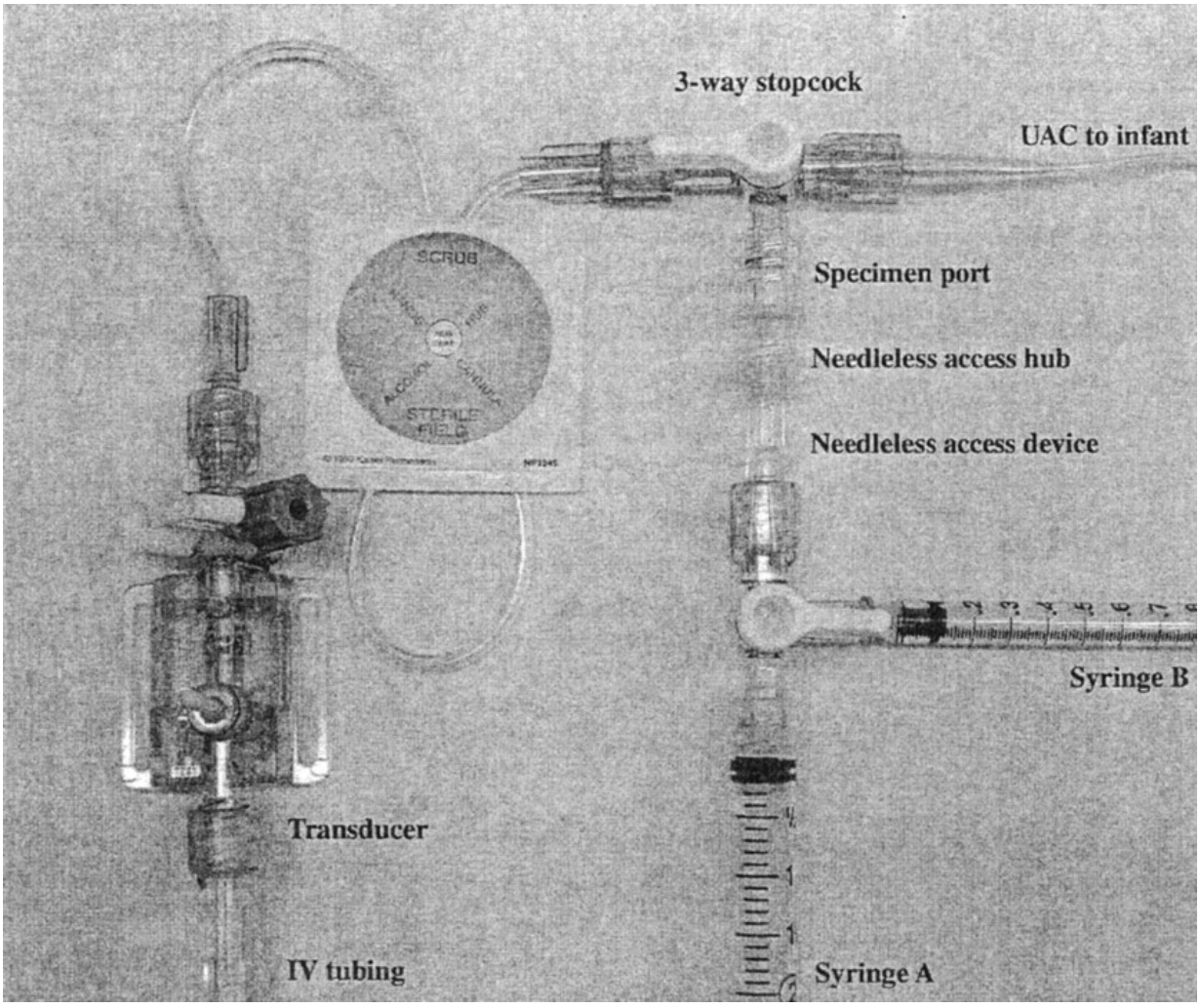


Fig. 6. Sample of PDSA cycle regarding vascular line setup

Objective: To develop and implement vascular access systems that use ports which do not require opening to access. This should include umbilical (arterial and venous) lines and central lines for infusing fluids, parenteral nutrition, and medications.

Measurement: Direct observation of vascular lines, assessing numbers and types of connections, before and after implementation.

Plan

1. Review available hardware within the hospital system.
2. Review requirements for "needleless" systems under California State Law.
3. Address requirements needed for "closed" systems for umbilical lines (the primarily clinical need was to remove blood specimens).
4. Develop competencies for anticipated new techniques.
5. Identify means to measure and monitor compliance.

Do

1. Review and critique vascular line setup.
2. Develop standardization of line setup as possible, using only new hardware available through the "needleless" system.
3. Identify a design for use with umbilical lines[27] and modify by combining functions of 3 stopcocks into one.
4. Develop policy for use of the new umbilical line setup (Fig 5).
5. Develop education curriculum and skills laboratory teach staff component processes with follow-up competency testing.
6. Develop process compliance tool to determine if lines meet the standards (Fig 7).

Study

1. Observational data identified insufficient flushing of blood residue from the 3-way stopcock, requiring readdressing umbilical line setup.
2. During development of the compliance tool, definition of the "needleless" system came under review.
3. Compliance with standardization of line setups was assessed by observation.

Act

1. Change in flushing protocol for the 3-way stopcock, including a circular motion to decrease blood residue.
2. Protocol change communicated to nursing personnel.*
3. Night charge nurse was asked to assess vascular setup for all extremely low-birth-weight infants on rounds, with feedback to staff regarding standardization of the setups.

*This protocol change was restudied. A trend toward increased umbilical artery thrombi suggested that the flushing was being accomplished too slowly. A follow-up "Act" cycle communicated to the staff the importance of completing the procedure expeditiously.

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Fig. 7. Vascular Access Monitor

VASCULAR ACCESS MONITOR
NICU

Days_____**Noc**____ **MR#**_____

Unit: _____ **Evaluator:** _____ **Date:** _____

Criteria	Yes	No	Comments
Peripheral IV Catheter: ☐Continuous ☐Hep Lock			**Site:**
1. Insertion date documented in MPOC or Flow Record			
2. T-connector extension set attached and ports closed with injection plug			
3. Site is clean and dry			
4. Site without evidence of infection/inflammation			
5. Dressing is occlusive, intact and clean			
6. Lipid tubing replaced every 24 hours			
7. IV tubing dated and changed every 72 hours			
8. Pharmacy expiration date on IV bag is current			
IV Piggyback:			
1. Maintained as a ***closed*** system (attached to main IV at ***all*** times)			
2. If ***no*** to #1, lever lock cannula replaced after each removal from port (left inside the wrapper)			
Central Cath/ Broviac, PICC, Hickman,			
Type:			
1. Insertion date documented in MPOC or Flow Record			
2. Extension tubing attached after catheter insertion to be changed every 72 hours			
3. Site is clean and dry			
4. Site without evidence of infection/inflammation			
5. Dressing is occlusive, intact and clean			
6. Bio-patch dressing is dated and changed every 7 days (except PICC)			
7. IV tubing dated and changed every 72 hours			
8. Lipid tubing changed every 24 hours			
9. Pharmacy expiration date on IV bag is current			
UAC/UVC			
1. Insertion date documented in MPOC or Flow Record			
2. Site is clean and dry			
3. Site without evidence of infection/inflammation			
4. Cord care documented every shift and PRN			
5. IV tubing/extension tubing dated and changed every 72 hours			
Stopcocks			
1. Is a stopcock used?			
2. Is it a UAC line?			
3. Are all ports on stopcock closed with an injection plug?			
4. Is stopcock /injection plug without evidence of blood residue?			

The first unit to adopt these changes distributed its materials electronically. As units made additional improvements and refinements, materials were recirculated back among the members.

The units rolled out new practices after announcements and other attention-getting events. Different communication styles were used by each of the units, reflecting local conditions and "unit cultures."

Finally, the means to monitor compliance and complications were addressed. Each unit included individual competency testing as part of their line and hub care program, both in the initial training phase and later as part of a collaborative-wide, post implementation assessment. Usually, an

aggregate score was calculated and displayed after post implementation testing. Later, using a common "hub care" indicator, 5 collaborating units tested a majority of their staff from 1 month to 1 year after implementation. Four units reported aggregate competency scores between 90% and 100% for their staffs. The remaining unit found only a 57% competency score.

Some units adopted a targeted approach to their reinforcement efforts, such as monitoring line setups daily for all infants with birth weights <1000 g (see Fig 6 "Act-Cycle" and Fig 7). This enabled reinforcement of compliance and education in real time ("one-on-one" process control) and also enabled the collection and distribution of aggregate trending data.

Accuracy of Diagnosis

The objective of this collaborative was to decrease the incidence of CONS bacteremia. CONS, as a component of normal skin flora, may contaminate blood cultures and lead to a false-positive identification of bacteremia.

The definition of CONS infection was that of the VON. It requires a positive culture from blood or cerebral spinal fluid, signs of generalized infection, and treatment with 5 days or more of antibiotics.[5] Because considerable variation occurs in blood-drawing practices and clinical interpretation of the significance of positive blood cultures, measured rates of CONS bacteremia may include both true CONS infections and false positives (contaminated blood cultures).

False-negative interpretation may occur when an inadequate specimen of blood is obtained.[17] Therefore, the participating units developed a PBP to assist in more accurately defining "true" infection. This PBP emphasized the site and number of blood cultures, preparing for blood culture, personnel performing blood cultures, volume of blood for culture, discontinuation of antibiotics, and ancillary tests.[1] It was recognized that a more accurate diagnosis of CONS bacteremia might not decrease the incidence of true bacteremia, but it would lower the reported rate by decreasing inclusion of false positives. This was considered desirable because the subsequent over treatment of these infants may lead to secondary morbidity.[18,19]

The first PBP implemented in this area related to obtaining 2 blood cultures with each nosocomial sepsis evaluation. Objections to implementation primarily related to excessive blood removal and skin punctures for extremely low birth weight infants. These concerns had to be addressed at the outset (Fig 8).

The approach had to be flexible to allow for limited blood drawing for the most fragile newborns. However, for most infants, obtaining dual cultures was an acceptable risk. Feedback to nurses and physicians led to routine implementation of the practice as nurse phlebotomists and physicians observed that the results of the double cultures were used to make better antibiotic treatment decisions. Five units implemented policies on obtaining double blood cultures. Some of the policies emphasized that the second blood culture should be obtained from a central line, to avoid the issue of multiple skin punctures. Two units designed decision trees that called for central line cultures and protocols for dealing with positive cultures, including line removal with repeated positive cultures.[20]

Fig. 8. PDSA for obtaining dual blood cultures.

Objective: To encourage practitioners to obtain two blood cultures for each nosocomial sepsis evaluation.

Measurement: Retrospective review of sepsis evaluations to determine the percentage with two or more blood cultures (either two peripheral or one peripheral and one from the line).

Plan: Evaluation of the practice of obtaining two blood cultures indicated that there was substantial opposition in the nursery to this practice because of concern about an excessive number of sticks. There was also a perception that the information obtained from the two blood cultures was not being used. The following plan was adopted:

1. A new policy was written to address the issue of excessive sticks. This policy limited the number of allowable sticks and contained a protocol to follow if blood was not obtained.
2. A system was set up to measure the number of blood cultures obtained with each sepsis evaluation, the results of those cultures, and the resulting antibiotic treatment decisions.
3. The results of the above measurements were to be reviewed and communicated to all the clinicians in the nursery on a monthly basis.

Do: All clinical staff received communication regarding the above plans in e-mails and bulletin boards. The plans were discussed in nursing and physician meetings.

Study: Dual blood cultures were obtained in 86% of sepsis evaluations in the first cycle. Attending physicians increasingly considered a single positive blood culture as possibly contaminated, and tended to discontinue antibiotics if only one of two cultures was positive. The conclusion was that the policy changes were working.

Act: Continue the measurements and provide feedback to staff about results. Monitor for negative effects (inadequately treated "true" infections).

Unit Conclusions: Double blood cultures have been successfully obtained in 65-80% of sepsis evaluations over a prolonged period and have been accepted as standard practice. Physicians have decreased antibiotic usage, because the percentage of positive blood cultures perceived as contaminated has increased from 27% to 60% with a single positive blood culture.

Improved skin preparation before drawing a blood culture was addressed by 2 units in new policies that changed the manner of skin preparation. The other units reviewed and reinvigorated existing phlebotomy procedures. The consensus reached was that the precise technique of preparing the skin was not as important as the rigor with which the chosen technique was used. Data suggest that 1 mL is the optimal sample volume for maximizing the yield when culturing blood.

The major objections to obtaining this volume were the actual volume of blood that had to be removed and the technical difficulties of obtaining 1 mL of blood with every peripheral phlebotomy. Four units initiated policies regarding drawing this volume of blood. Two units conducted PDSA's to facilitate implementation (Fig 9). After the PDSA cycles, 1 unit noted that 92% of cultures had a volume of 1 mL or greater.

Fig. 9. Example of PDSA's to improve consistency of obtaining adequate blood volume for blood cultures.

PDSA #1

Objective: Obtain at least 1 ml blood for blood culture, and document volume drawn.

Measurement: Number of blood cultures with documented blood volume

Plan: A plan was developed to communicate the requirement to phlebotomists, who were usually bedside nurses. Nurses were asked to manually document the volume of blood drawn in the nurses' notes. A clinical nurse specialist was assigned to perform a chart review to verify documentation. It was decided that 1 ml was a goal and not a minimum volume to be drawn.

Do: The plan was communicated to staff nurses by individual e-mail and discussed at required nursing update meetings. Charts were reviewed for documentation.

Study: At baseline, only 20% of blood cultures had documentation in nurses' notes of blood volume.

Act: An alternative manner of documentation was built into the order entry pathway on the computer. Whenever a blood culture was ordered via the computer, a field was present on the screen asking for volume of blood drawn.

PDSA # 2

Objective: To improve documentation of volume drawn for blood culture.

Measurement: Number of sepsis work ups with blood volume documented

Plan. Hospital information services personnel were asked to build the appropriate computer screen field in the order entry system. The information on the field would appear routinely on the final report of the blood culture from the microbiology laboratory. This information would be available to the physicians interpreting the blood culture results, and available for review for compliance with the volume policy.

Do: The appropriate computer field was created along with fields on report forms. The plan was communicated to nursing staff via individual e-mails and staff meetings.

Study: Information regarding volume of blood drawn was present in 75% of all blood culture results. Mean blood volume drawn was 0.7.

Act: The results of the review were reported to nursing staff, and gratitude expressed for volumes drawn and documentation. It was decided to continue to monitor and report results to nursing staff periodically.

The discontinuation of antibiotics at 48 hours when blood cultures were negative was considered important in limiting antibiotic exposure and decreasing the need for vascular access to deliver antibiotics. Most of the units reported that their previous practice was compatible with this PBP, but 3 reemphasized this practice with new policies and the development of the decision trees discussed above. Ancillary tests, such as C-reactive protein [21] and various white blood cell indices, were implemented in 1 unit to aid diagnosis and treatment decisions. Other units reported that these tests were already being used.

The practice of having a specialized team draw blood cultures was not implemented in any unit, despite evidence that such a team reduces the rate of contaminated blood cultures.[22] The major reasons for nonimplementation were cost and the requirement for substantial change in unit culture.

Multidisciplinary staff in all 6 units considered and discussed the PBP's.

The response of each unit depended on its existing practices and culture. Some of the PBP's had already been established and required no action or perhaps only reinforcement of existing policies. Most of the units, however, developed more comprehensive policies or decision trees that contained several of the PBP's (Fig 10).

Fig. 10. Example of 1 unit's policy for evaluating NI's.

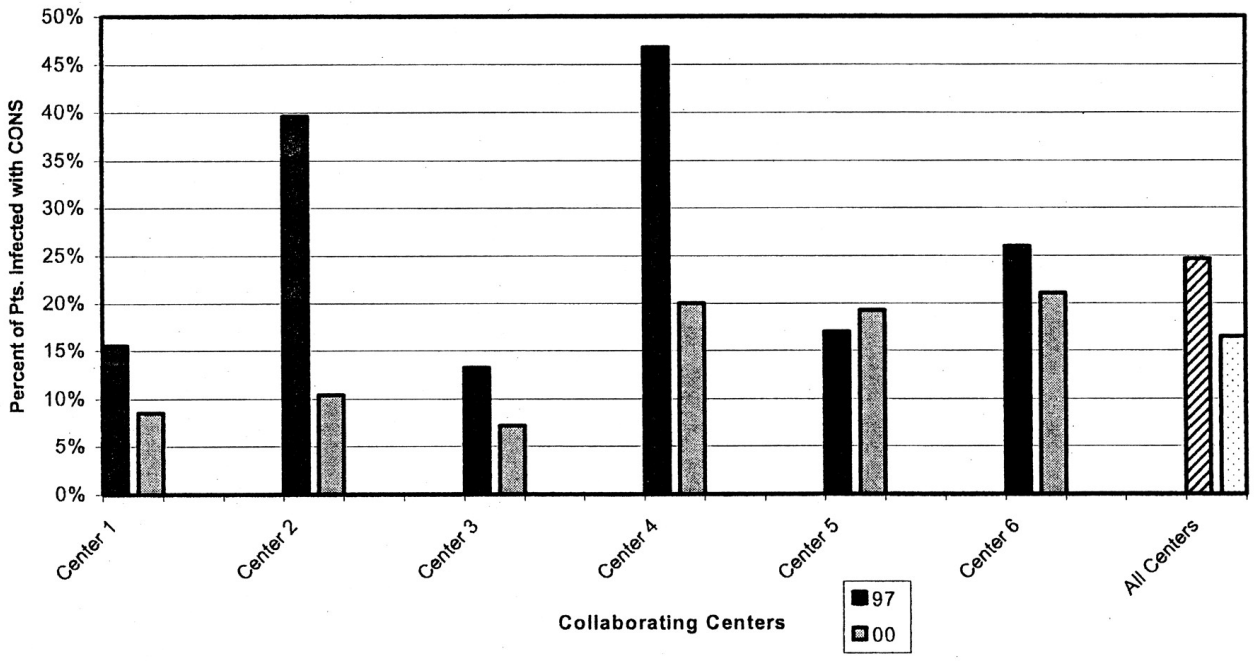
1. An attempt would be made to obtain two blood cultures in the course of a sepsis evaluation.
2. The sample site and volume of blood obtained would be recorded.
3. Emphasis was placed on the opinion that it may be appropriate not to start antibiotics in all situations. A list of clinical scenarios was presented in which antibiotics should be started.
4. Ampicillin and not Vancomycin, in conjunction with an aminoglycoside, could be used as the first antibiotic for suspected nosocomial sepsis in certain circumstances.
5. CRPs should be used to help differentiate true from contaminated blood cultures.
6. Antibiotics would be stopped at 48 hours unless both blood cultures were positive.
7. The decision to treat a baby with single positive blood culture or with one of two cultures positive for >5 days should be supported by overriding clinical and laboratory support with appropriate documentation.

RESULTS

The principal outcome measure was the incidence of CONS bacteremia. In 1997, the last year before the initiation of the cooperative, the mean incidence of CONS bacteremia for the collaborating institutions was 24.6%. For the 6-month period ending in December 2000, the mean incidence was 16.4% (relative risk: 0.67; 95% confidence interval: 0.51–0.87).

Figure 11 shows the changes in incidence of CONS bacteremia in the 6 participating institutions.

Fig. 11. CONS NI rates for the collaborative institutions before and after interventions.



DISCUSSION

This quality improvement collaborative resulted in the development of evidence-based summary statements directed at lowering rates of NI in NICU's. The statements were widely communicated and became the basis for multiple changes in clinical practices in the collaborating institutions. Review of the literature, internal assessments, and benchmarking all contributed ideas for change and identified practice options, with levels of evidence for each. Through small change cycles, involving monitored implementations, subsequent analysis, and shared experiences, collaborators quickly clarified priorities and began to understand the obstacles that needed to be addressed for success. Often, the data generated from trials at 1 institution became the strongest evidence available for making change decisions at the others.

Each unit began PDSA changes with hand hygiene practices. All addressed this issue, and approximately 80% of the hand hygiene PBP's were implemented throughout the focus group. Unit hand washing policies were recognized as the cornerstone for reducing nosocomial bacteremia. Because of the ubiquitous nature of hand washing, units with successful implementation of a hand washing policy were observed to have a philosophy of accountability, embodied in the statement that "nosocomial infection is not an entitlement in our unit." Thus, the occurrence of an infection represented a failure, not a natural event, in the hospital course of a preterm infant. The group observed this commitment in several of the benchmark hospitals where avoidance of NI and almost ritualistic hand washing were a part of the unit culture.

The collaborating institutions also recognized the importance of vascular line management in altering the rate of nosocomial bacteremia in the NICU. Each unit addressed hub care. The reduction of vascular line entry points was investigated by all, although not successfully accomplished by all. Interinstitutional collaboration was made difficult by lack of standardization of nomenclature and hardware for vascular access devices. Supply issues emerged with the hospitals' unique purchasing contracts, which limited the availability of some equipment.

At the same time, the situation in California was confounded by the requirement to implement "needleless" access systems, without provision of the means to do that in neonatal settings (eg, umbilical lines). In addition, this aspect of clinical care has not been widely investigated in randomized trials that provide clear evidence of which practices are efficacious in lowering infection rates, particularly in neonatal care. Thus, the experiences of this collaborative often represent the best available evidence.

The third PBP addressed improved accuracy of diagnosis. Members of the collaborative recognized that some CONS bacteremia may represent contaminated blood cultures. Improved techniques to obtain specimens were reviewed by all units, some of which adopted changes even without PDSA involvement. When collaborating units shared information regarding the frequency of contaminated cultures, those with the fewest identified false positives were noted to have the highest antibiotic usage. This suggested that at some units, clinicians were reluctant to label a positive blood as false, thus perhaps unnecessarily "treating" some infants with antibiotics. In these units, practices to improve clarification of CONS bacteremia were given high priority. In other units, PBP's about diagnosis accuracy were not targeted for initial changes.

Although many of the PBP's were unique, the implementation processes for all navigated a similar course. All had to overcome similar challenges, following the pattern described by Geertsma[23] in his assessment of practice behavior changes.

Before the PDSA cycles were initiated, it was necessary to educate unit staff about high NI rates. It quickly became evident that if staff did not see the importance of making change, then introduction of new procedures would not be possible. The impact of NI's on patient outcomes, including length of stay and costs, and the importance of staff behavior in lowering the risks of infection were emphasized early in the process. A large number of providers were involved in almost all of the targeted behavior changes. With hand hygiene practices and line management issues, all of the staff nurses, many physician providers, and personnel who frequented but were not directly assigned to the NICU needed to become aware of the altered practice.

Once the unit was primed for change, multiple issues often required resolution before a program could be initiated. For example, line setup needed to be understood, hub care needed to be defined, and alternatives needed to be described and evaluated before the simultaneous change of so many integrated practices was begun. The PDSA cycle model allowed for division of the task into many discrete components. In each unit, groups of 4 or more people addressed each of these components of the change agenda and worked simultaneously.

Involvement of so many staff facilitated participation in the change process and developed advocates of change among the staff. Change would not have been possible without the commitment of all disciplines working in the nursery. Everyone interfacing with the infants needed to participate actively in the new hand hygiene procedures. Observational tools to assess compliance had to apply to both the physician and the nursing staff. It was important that all staff felt a part of the team fighting to lower the risk of infection. Although hub and line care were primarily provided by nurses, medical leadership participated. Physicians emphasized the importance of these changes and provided positive feedback when procedures were done well.

Initial successes were reinforced so that other staff who were less open to change became more excited about the process. Public relations became an important aspect of the project, particularly in making change "fun." Posters emphasizing hand hygiene or "hub care" were colorful and usually in cartoon form. When Glo Germ was used to teach about hand washing, it was not used punitively. It allowed staff to laugh at their colorful hands, emphasizing the need to be more complete in rubbing with the next attempt.

Although these efforts worked well for limited issues, widespread staff involvement and buy-in were possible only with clear and frequent communications. Information was disseminated through e-mail, in-service sessions, regularly scheduled meetings, newsletters, open discussions, and posters. No 1 approach was successful for all institutions because cultures and structures differed. At 1 hospital with a personal computer available at each bedside, staff nurses routinely accessed e-mail notices. At another, e-mails were largely ignored and written memos and meeting announcements were much more widely used.

In addition to changing staff attitudes and knowledge base, interventions sometimes required structural change. For instance, 1 institution modified a computer order entry screen to facilitate the phlebotomist's entry on the site and quantity of the blood draw, data necessary for assessing the diagnostic accuracy of blood cultures. As noted above, when addressing line management, lack of standardization of equipment made interinstitutional collaboration difficult. In some cases, the changes could not occur until new products were purchased. However, change was aided by the free communication between institutions, usually involving administrative as well as medical personnel.

Evaluation was an important component of the change process. The PDSA cycle methodology reinforced the need to evaluate the impact of each intervention trial and readjust it as required. Intermediary process goals were used, and both individual and group feedback were provided to motivate continuous improvement. Unit-wide feedback was also a common feature of successfully implemented practice changes.

On the basis of the currently available data, this quality improvement collaborative seems to have been a success. Certainly, clinical processes were successfully changed in the 6 units. Hand hygiene compliance measures showed improvement.

Line setups were reevaluated and standardized, and nursing competency scores relating to line management improved. More rigorous criteria for the diagnosis of CONS infections were adopted in several units. Perhaps most important, preliminary data suggest an overall decline in nosocomial bacteremia in the participating units, from 26% to 16%. The differing improvement rates for CONS bacteremia between units might reflect unit differences in the commitment of personnel and the time available for implementing changes. However, the differences may also reflect that the cause of NI's is related to many processes and practices of care, which vary among units. This collaborative may have addressed predominant factors in some units but not in all.

The collaborative involved collectively thousands of hours of work. Initially, development and prioritization of the PBP's was done. Subsequently, implementation of the changes on the various services had to be completed. Associated with this investment has come an apparent decline in CONS NI's in the 6 collaborating NICU's. It has not been proved which, if any, of the interventions is responsible for the decreased rate of infection. In 1 institution, the decline in the infection rate may be related to more focused diagnosis, with less contamination and over treatment of false positives. However, for most of the NICU's, it seems that the actual risk of NI from CONS decreased during the project period. This experience supports the importance of multi-institutional, multidisciplinary collaboration for quality improvement in neonatal care.

FOOTNOTES

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