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SURVEY OF KNOWLEDGE, BELIEFS, AND PRACTICES OF NEONATAL INTENSIVE CARE UNIT HEALTHCARE WORKERS REGARDING NOSOCOMIAL INFECTIONS, CENTRAL VENOUS CATHETER CARE, AND HAND HYGIENE

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ABSTRACT

OBJECTIVE: To assess the knowledge, beliefs, and practices of neonatal intensive care unit (NICU) healthcare workers (HCWs).

DESIGN: Self-administered survey.

SETTING: A 55-bed NICU.

PARTICIPANTS: NICU HCWs (N = 215).

RESULTS: The response rate was 68%. Ninety-two percent knew central venous catheters (CVCs) should be capped, clamped, or connected to running fluids at all times. Ninety-five percent knew when to change gloves. Thirty-one percent knew the recommended duration for handwashing. Most HCWs believed sterile technique in CVC care (96%), gloves (91%), and handwashing (99%) prevent nosocomial infection (NI). Sixty-seven percent used sterile barriers to insert CVCs, 76% reported wearing gloves, 81% reported routine handwashing, 35% knew that bacterial hand counts are higher with rings, 30% knew that

long fingernails are associated with higher gram-negative bacterial hand contamination, and 35% knew that artificial fingernails are associated with higher gram-negative bacterial hand contamination. Most (93%) believed HCWs can affect outcomes of patients with NIs. Fewer believed rings (40%), artificial fingernails (61%), and long fingernails (48%) play a role in NIs, or that policies concerning number of rings (50%), cutting fingernails (35%), or prohibiting artificial fingernails (47%) would prevent NIs. Sixty-one percent of HCWs regularly wore at least one ring to work, 56% wore their fingernails shorter than the fingertip, and 8% wore artificial fingernails.

CONCLUSIONS: A disconnect existed between CVC knowledge and beliefs and practice. HCWs did not know the relationship between bacterial hand counts and rings and fingernails, and did not believe rings or long or artificial fingernails increased the risk of NIs (*Infect Control Hosp Epidemiol* 2004;25:747-752).

Nosocomial infections are a common occurrence in the neonatal intensive care unit. Central venous catheterization has been associated with nosocomial infection in this population,¹ and variations in central venous catheter care may account for the increase in catheter-related bloodstream infections in recent years.² Standardization of care and staff education can reduce central venous catheter-related nosocomial infection rates.³

It has also been suggested that the hands of healthcare workers play a significant role in the transmission of nosocomial pathogens.⁴ Artificial fingernails and rings of healthcare workers have both been associated with higher bacterial colony counts on the hands.⁵⁻¹⁰ In addition, bacterial colonization of the fingernails and hands of healthcare workers has been linked to the transmission of *Pseudomonas aeruginosa*, a common nosocomial pathogen among neonates.¹¹⁻¹⁴ Although evidence-based guidelines promoting handwashing and hand hygiene among healthcare workers are published and supported by several organizations,¹⁵⁻¹⁷ there is considerable evi-

dence that compliance with these measures is suboptimal.^{18,19}

We conducted a survey to assess the knowledge, beliefs, and practices of healthcare workers caring for high-risk patients in the neonatal intensive care unit of a midwestern children's hospital regarding nosocomial infections, central venous catheter care, and hand hygiene.

METHODS

We designed a self-administered survey to assess the knowledge, beliefs, and practices of neonatal intensive care unit nurses and patient care assistants regarding the preventability of nosocomial infections. The survey consisted of 71 questions in 7 content areas: demographic information (9 questions); central venous catheter care (15 questions); handwashing (6 questions); glove use (6 questions); artificial, natural, and polished fingernails (19 questions); hand jewelry (6 questions); and general infection control (8 questions). We also included 2 open-ended questions intended to gather qualitative data on barriers

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TABLE 1
DEMOGRAPHIC CHARACTERISTICS OF SURVEY PARTICIPANTS (N = 147)

Characteristic	No. (%)
Department	
NICU	130 (88)
Both NICU and PICU	2 (1)
Special care nursery	12 (8)
Assessment nursery	3 (2)
Type of healthcare worker	
Nurse	129 (88)
Respiratory therapist	2 (1)
Other*	16 (11)
Schedule	
Day shift	85 (58)
Full time	121 (82)
Female	146 (99)
Age > 40 y	63 (43)
In current job ≤ 5 y	72 (49)

NICU = neonatal intensive care unit; PICU = pediatric intensive care unit.

*Patient care assistant (n = 8); nurse practitioner (n = 2); nurse educator (n = 2); patient care technician (n = 1); advanced practice nurse (n = 1); neonatal nurse practitioner (n = 1); and other, with no elaboration (n = 1).

to infection control practice and study designs. We assessed knowledge and practice using a combination of multiple choice and true/false questions. The knowledge questions were taken from existing survey instruments whenever possible. We assessed the beliefs of participants through statements regarding infection control in these content areas. A 5-point Likert scale format (strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree) was used for the answers for these questions.

We pilot tested the survey with medical intensive care unit nurses as well as infection control nurses to determine its clarity, readability, and length. The Neonatal Intensive Care Unit Joint Practice Committee and the Washington University School of Medicine Institutional Review Board approved the project. A cover letter was attached to the survey to explain the purpose of the project, as well as any potential risks and benefits. Participation in the study implied consent. Survey participation was voluntary and anonymous, and individual results were kept confidential.

The investigators attended 5 neonatal intensive care unit nursing staff meetings in September 2001 to introduce the survey and answer any staff questions. The survey was then placed in the mailboxes of all neonatal intensive care unit nurses and patient care assistants in September 2001 (N = 215). Candy was distributed along with the surveys as an incentive to participate. Signs were posted throughout the unit to introduce the project, as well as to encourage participation, and reminder signs were posted halfway through data collection. A labeled

box was placed near the mailboxes for anonymous and voluntary survey return. Data were collected for 4 weeks. The response rate after 4 weeks was 43% (92 of 215). Surveys were redistributed with a new cover letter encouraging participation and asking those who had already completed the survey not to submit a second copy. After 4 additional weeks of data collection, the overall response rate was 68% (147 of 215). Responses were entered into a Microsoft Access (Microsoft Corp., Redmond, WA) database twice, and frequencies were analyzed using SPSS software (version 10.0; SPSS, Inc., Chicago, IL). Qualitative analysis was also performed for the two open-ended questions, including the frequency of each response.

RESULTS

A total of 147 completed surveys were returned, for an overall response rate of 68%. Demographic characteristics of survey participants are listed in Table 1. The survey respondents were 99% female, and 43% were older than 40 years. In addition, nearly half of the participants (49%) had been employed in their current position for 5 years or less.

Knowledge Questions

Frequencies for correct answers to knowledge questions are listed in Table 2. Of those who completed the survey, 134 (91%) of 147 reported having contact with arterial or central venous catheters. One hundred twenty-three (92%) of 134 knew central venous catheters should be either capped, clamped, or connected to running fluids at all times. One hundred forty (95%) of 147 knew that gloves should be changed after touching potential sources of microbial colonization, such as diapers, ventilator tubing, or Foley catheters. However, only 46 (31%) of 147 knew the recommended duration for handwashing, and only 51 (35%) of 147 knew that bacterial hand counts are higher when rings are worn. Similarly, 44 (30%) of 147 knew that long fingernails and 52 (35%) of 147 knew that artificial fingernails are associated with higher gram-negative contamination of healthcare workers' hands. Finally, 114 (78%) of 147 knew that length of stay, total parenteral nutrition, catheters, and severity of illness were all demonstrated to be risk factors for nosocomial infection among patients of neonatal and pediatric intensive care units.

Belief Questions

Frequencies of agreement (defined as those who answered "strongly agree" or "agree") with belief statements are summarized in Table 3. Most healthcare workers (129 of 134; 96%) believed use of sterile technique in central venous catheter care could prevent nosocomial infection. Nearly all of the participants (99%) believed handwashing by healthcare workers is a useful way to reduce infections among patients in the neonatal intensive care unit. Similarly, 134 (91%) of 147 believed use of gloves can prevent nosocomial infections. Fewer partici-

TABLE 2
FREQUENCIES FOR CORRECT ANSWERS TO KNOWLEDGE
QUESTIONS (N = 147)

Survey Question*	No. of Correct Answers (%)
True or False: The central line should be connected to running fluids, clamped, or capped off at all times.	123 (92) [†]
True or False: Total bacterial counts on the hands are higher when rings are worn.	51 (35)
True or False: Gloves should be changed immediately after touching a patient's sources of microbial colonization (such as diapers, ventilator tubing, or Foley catheters).	140 (95)
True or False: Long fingernails are associated with higher gram-negative colony counts on the hands than short fingernails.	44 (30)
True or False: Artificial fingernails are associated with higher colony counts of gram-negative bacteria on the hands compared with natural nails.	52 (35)
What is the recommended duration for hand-washing? 30 seconds, 20 seconds , 10 seconds, I don't know.	46 (31)
Which of the following have been demonstrated to be risk factors for nosocomial (hospital-acquired) infections in NICU and PICU patients? Length of stay, TPN, Lines/catheters, Severity of illness, All of the above , I don't know.	114 (78)

NICU = neonatal intensive care unit; PICU = pediatric intensive care unit; TPN = total parenteral nutrition.

*The correct answer is indicated by bold type.

[†]Taken from the subset of participants reporting contact with central venous catheters (n = 134).

pants believed that rings (58 of 147; 40%), artificial fingernails (90 of 147; 61%), or long fingernails (71 of 147; 48%) play a role in nosocomial infections, or that policies concerning the number of rings worn (74 of 147; 50%), requiring healthcare workers to cut fingernails short (51 of 147; 35%), or prohibiting artificial fingernails (69 of 147; 47%) would prevent nosocomial infection. However, 109 (74%) of 147 agreed that they would voluntarily remove artificial fingernails or cut long fingernails if it were recommended. Most participants (136 of 147; 93%) believed healthcare workers can affect the outcomes of patients with nosocomial infections.

Practice Questions

Responses to practice questions are summarized in Table 4. Of the subset of participants who reported contact with central venous catheters, only 90 (67%) of 134 reported using full sterile barrier precautions (gown, gloves, and mask) a majority of the time when inserting or assisting in the insertion of a central venous catheter. One

TABLE 3
FREQUENCIES OF AGREEMENT WITH BELIEF STATEMENTS (N = 147)

Survey Question	No. Who Strongly Agree or Agree (%)
Using sterile technique for catheter insertion and care reduces a patient's risk of developing a bloodstream infection.	129 (96)*
Hand jewelry worn by healthcare workers plays a role in transmitting infections to patients.	58 (40)
A policy limiting hand jewelry to wedding rings would be useful in reducing infection rates in the PICU and NICU.	74 (50)
Gloves are useful in preventing the spread of nosocomial (hospital-acquired) infections.	134 (91)
Long fingernails of healthcare workers play a role in transmitting infections to patients.	71 (48)
Cutting my fingernails even with the tip of the finger would reduce infections among my patients.	51 (35)
Removing artificial fingernails on healthcare workers would reduce infection risk among their patients.	90 (61)
A policy prohibiting the use of artificial fingernails by healthcare workers would be useful in reducing infections in the PICU and NICU.	69 (47)
Do you believe handwashing by healthcare workers is a useful way to reduce infections among NICU and PICU patients?	146 (99)
I would remove artificial fingernails or cut long fingernails voluntarily if recommended to do so.	109 (74)
A healthcare worker with my duties is able to affect the outcomes of nosocomial (hospital-acquired) infections in my patients.	136 (93)

PICU = pediatric intensive care unit; NICU = neonatal intensive care unit.

*Taken from the subset of participants reporting contact with central venous catheters (n = 134).

hundred nineteen (81%) of 147 of the survey respondents reported appropriate handwashing in routine practice (between patients, between procedures, after removing gloves, and before accessing catheters). One hundred eighteen (80%) of 147 reported using soap a majority of the time when washing hands, and 95 (65%) of 147 reported using alcohol foam to disinfect hands at least part of the time. Seventy-eight (53%) of 147 reported routinely changing gloves when they became soiled or ripped, between procedures, and between patients. One hundred eleven (76%) of 147 reported wearing gloves a majority of the time when they anticipated contact with a patient's blood or respiratory secretions.

In actual practice, 90 (61%) of the 147 surveyed healthcare workers regularly wore at least one ring to work, and 89 (61%) of the 147 reported wearing rings

TABLE 4
RESPONSES TO PRACTICE QUESTIONS (N = 147)

Survey Question*	No. Reporting Practice (%)
How often do you use full sterile barriers when assisting in or inserting a line/catheter? (76% to 100% of the time)	90 (67) [†]
How often do you wear rings to work? (26% to 100% of the time)	90 (61)
I change my gloves (circle all that apply): (When gloves are soiled, When gloves are ripped, Between caring for each patient, Between each procedure, All of the above)	78 (53)
Do you ever wear artificial fingernails? (Yes)	11 (8)
Do you usually wear your fingernails longer than the tip of your finger? (No)	82 (56)
I routinely wash my hands under the following circumstances (circle all that apply): (Between contact with different patients, Between procedures, After removing gloves, Before accessing lines/catheters, All of the above)	119 (81)
When washing your hands, what percentage of the time do you use soap? (76% to 100%)	118 (80)
How often do you wear gloves when you anticipate contact with a patient's body fluids (such as blood or respiratory secretions)? (76% to 100%)	111 (76)
Do you wear rings when in contact with patients? (Yes)	89 (61)
What percent of the time do you use alcohol foam to disinfect your hands? (26% to 100% of the time)	95 (65)

*The reported practice appears in parentheses.

[†]Taken from the subset of participants reporting contact with central venous catheters (n = 134).

when in contact with patients. Eighty-two (56%) of 147 wore their fingernails shorter than the fingertip, and 11 (8%) of 147 wore artificial fingernails.

Barriers to Infection Control

Table 5 lists the frequencies of self-reported barriers to infection control. Both multiple choice and open-ended responses were collected to the question, "Which of the following do you perceive as barriers to following hospital policies regarding infection control?"

DISCUSSION

A disconnect existed between central venous catheter care knowledge and belief and practice. Although participants demonstrated high knowledge of appropriate central venous catheter care and they believed such care was important in preventing infections, the reported actual practice of such procedures was low. Healthcare workers surveyed also demonstrated

TABLE 5
FREQUENCIES OF SELF-REPORTED BARRIERS TO INFECTION CONTROL (N = 147)

Barrier*	No. Reporting Barrier (%)
Logistics	80 (54)
Time	70 (48)
Lack of supplies	69 (47)
Lack of communication of infection control policies	58 (39)
Other staff members' duties	43 (29)
Pressure from families	14 (10)
Sick policy	13 (9)
Peer pressure	11 (7)
Lack of understanding, education, or interest	6 (4)
Other/miscellaneous	5 (3)
Emergencies	3 (2)

*Participants were allowed to report more than one barrier; therefore, percentages do not add up to 100.

high knowledge of and belief in the usefulness of gloves to prevent the spread of infection, yet the reported actual use of gloves was low. Although knowledge of the correct duration of handwashing was low, both belief in its utility and reported practice were high.

Knowledge was much lower concerning the relationship between artificial or long fingernails and rings and increased bacterial colony counts on the hands. Similarly, most healthcare workers did not believe that long or artificial fingernails or rings played a role in nosocomial infections. Most did not believe the introduction of policies banning artificial fingernails, restricting the number of rings worn, or restricting the length of fingernails would have an effect on nosocomial infection rates, but a majority did report that they would follow such policies or recommendations if they were put into place.

Almost all of the participants believed that healthcare workers can affect the outcomes of patients with nosocomial infections, and that their patients were susceptible to nosocomial infections. A majority of participants also agreed that bloodstream infections were common among their patients. Most were familiar with the risk factors for nosocomial infection in their patients, although few were familiar with the estimated rates of nosocomial infections or the number of nosocomial infections that are believed to be preventable.

Our survey attempted to determine the level of knowledge as well as the beliefs and actual practices of neonatal intensive care unit healthcare workers regarding nosocomial infections. We also attempted to determine the perceived barriers to adherence to infection control recommendations and policies. Our results support the notion that high levels of knowledge and belief do not necessarily lead to optimal infection control practices in this population. Several studies have attempted to gather infor-

mation on the knowledge, beliefs, and practices of health-care workers in different settings regarding hand hygiene and infection control.²⁰⁻²³ Previous data cite such issues as inadequate facilities,²⁴ lack of effective communication or knowledge,^{20,25} and time¹⁹ as perceived barriers to optimal hand hygiene practice. Our qualitative data suggest several additional barriers to adhering to infection control policies, including time, logistics (eg, room layout and placement of sinks), and lack of communication of infection control policies. These data are similar to the results of previous studies. Our data support previous suggestions that educational and behavioral interventions may improve knowledge and practice regarding infection control, especially in the area of hand hygiene.

This study has several limitations. First, responses were all self-reported. This could lead to the overreporting of socially desirable activities, or the downplaying of negative ones. However, because survey participation was anonymous, the social desirability response regarding belief should have been minimized. Observational studies are needed to verify the responses given regarding infection control practices, especially in the area of handwashing.

Second, because of a low initial response rate, data collection was conducted at two different times. However, the second round of data collection was much later (approximately 6 months) than the original data collection. This could have potentially affected the responses of participants, as those who responded during the second round of data collection could have participated in educational activities in the interim. To our knowledge, no significant hand hygiene education campaigns took place between the first and the second data collection in the neonatal intensive care unit. Furthermore, statistical analysis of the two groups showed no significant differences between the answers in the first and second periods of data collection, with the exception of the five variables listed in Table 6.

In addition, because participation was voluntary, it is likely that a selection bias occurred, with participants who were already interested in the subject of infection control being more likely to respond. Thus, the answers may not be representative of the level of knowledge, belief, and practice of the entire neonatal intensive care unit staff. In particular, we suspect that healthcare workers who routinely wear artificial fingernails may be underrepresented, lending potential bias to our study results. It is challenging to obtain information about healthcare workers' beliefs regarding the relationship between artificial fingernails and nosocomial infections in a systematic and accurate fashion. Anonymous self-administered surveys offer the advantage of an opportunity to honestly express beliefs and practices without negative consequences.

Overall, our study suggests that the knowledge, beliefs, and practices of neonatal intensive care unit nurses vary widely regarding risk factors for and prevention of nosocomial infections. Although knowledge is high in

TABLE 6
STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN THE FIRST AND SECOND PERIODS OF DATA COLLECTION (N = 147)

Survey Question	First Period	Second Period	P
Department			.009
NICU	75 (82)*	55 (100)	
NICU and PICU	2 (2)	0 (0)	
Special care nursery	12 (13)	0 (0)	
Assessment nursery	13 (14)	0 (0)	
Shift			.032
7 am to 7 pm	54 (59)	27 (49)	
7 pm to 7 am	29 (32)	20 (36)	
7 am to 3 pm	3 (3)	1 (2)	
3 pm to 11 pm	0 (0)	4 (7)	
11 pm to 7 am	0 (0)	2 (4)	
Other	5 (5)	1 (2)	
Do not wear fingernails longer than fingertip	45 (49)	37 (67)	.030
Artificial fingernails are associated with higher colony counts of gram-negative bacteria on the hands compared with natural nails. (answered true)	27 (29)	25 (45)	.048
Hospital policy currently recommends prohibiting artificial fingernails in the operating room. (answered true)	7 (8)	17 (31)	.0001

NICU = neonatal intensive care unit; PICU = pediatric intensive care unit.
*Numbers in parentheses are percentages.

some areas, as is belief in the utility of infection control practices in preventing the spread of infection, there is much room for improvement in the actual practices of central venous catheter care and hand hygiene. Multidisciplinary interventions are needed to improve knowledge and practice, as well as to reinforce beliefs in the importance of infection control. The results of this survey were presented to the Neonatal Intensive Care Unit Research Committee, which is composed of nurse managers, staff nurses, respiratory therapists, pharmacists, and neonatal intensive care unit attendings. Further studies are also needed to determine ways in which healthcare workers can overcome barriers to infection control, with the ultimate goal of reducing nosocomial infection rates and improving the health of patients.

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