ORIGINAL ARTICLE

Device-Associated Infections among Neonatal Intensive Care Unit Patients: Incidence and Associated Pathogens Reported to the National Healthcare Safety Network, 2006–2008

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OBJECTIVE. To describe rates and pathogen distribution of device-associated infections (DAIs) in neonatal intensive care unit (NICU) patients and compare differences in infection rates by hospital type (children's vs general hospitals).

PATIENTS AND SETTING. Neonates in NICUs participating in the National Healthcare Safety Network from 2006 through 2008.

METHODS. We analyzed central line–associated bloodstream infections (CLABSIs), umbilical catheter–associated bloodstream infections (UCABs), and ventilator-associated pneumonia (VAP) among 304 NICUs. Differences in pooled mean incidence rates were examined using Poisson regression; nonparametric tests for comparing medians and rate distributions were used.

RESULTS. Pooled mean incidence rates by birth weight category (750 g or less, 751–1,000 g, 1,001–1,500 g, 1,501–2,500 g, and more than 2,500 g, respectively) were 3.94, 3.09, 2.25, 1.90, and 1.60 for CLABSI; 4.52, 2.77, 1.70, 0.91, and 0.92 for UCAB; and 2.36, 2.08, 1.28, 0.86, and 0.72 for VAP. When rates of infection between hospital types were compared, only pooled mean VAP rates were significantly lower in children's hospitals than in general hospitals among neonates weighing 1,000 g or less; no significant differences in medians or rate distributions were noted. Pathogen frequencies were coagulase-negative staphylococci (28%), *Staphylococcus aureus* (19%), and *Candida* species (13%) for bloodstream infections and *Pseudomonas* species (16%), *S. aureus* (15%), and *Klebsiella* species (14%) for VAP. Of 673 *S. aureus* isolates with susceptibility results, 33% were methicillin resistant.

CONCLUSIONS. Neonates weighing 750 g or less had the highest DAI incidence. With the exception of VAP, pooled mean NICU incidence rates did not differ between children's and general hospitals. Pathogens associated with these infections can pose treatment challenges; continued efforts at prevention need to be applied to all NICU settings.

Infect Control Hosp Epidemiol 2012;33(12):1200-1206

Healthcare-associated infections (HAIs) are associated with increased morbidity, mortality, and healthcare costs.[1,2] It is estimated that each year 1 in every 20 patients contracts an HAI while receiving medical care.[3] The problem is of special significance among newborns. In 2002, an estimated 33,269 HAIs occurred in newborns in high-risk US nurseries.[1] Infants hospitalized in neonatal intensive care units (NICUs) are at particularly high risk for developing HAIs. This is likely secondary to their extensive exposure to central venous catheters, prolonged ventilatory support, and immature immune systems.[4] Furthermore, the number of infants cared for in NICUs is increasing; in 2009 in the United States, 503,941 infants were born prematurely, and almost 60,000 had a birth weight under 1,500 g.[5]

The high risk of infection in NICUs coupled with public reporting of device-associated infection (DAI) rates from intensive care units, mandated by some states, have led to changes in prevention practices (eg, implementation of central line bundles) over the last few years.[6,7] The last NICU update from the Centers for Disease Control and Prevention's (CDC's) National Nosocomial Infections Surveillance System was published in 1996,[8] and current national data are lacking. Updated national data are needed to better understand the current incidence, burden, and causative organisms of DAIs in this vulnerable population. These surveillance data are essential to develop appropriate prevention strategies and to measure progress for strategies already in place. In this report, we examined the most recent data reported to the CDC's National Healthcare Safety Network (NHSN) to evaluate variability in incidence and types of pathogens associated with all 3 DAIs reported to the NHSN in NICU patients: central line–associated bloodstream infections (CLABSIs), umbilical

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Received April 3, 2012; accepted November 11, 2012; electronically published October 23, 2012.

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https://doi.org/10.1086/668425 Published online by Cambridge University Press

catheter–associated bloodstream infections (UCABs), and ventilator-associated pneumonia (VAP). The pathogen distribution of each DAI type is described, and differences in rates for these DAIs between NICUs located in children's hospitals and those located in general hospitals are discussed.

METHODS

Surveillance System and Definitions

Data on CLABSI, UCAB, and VAP among NICU patients were obtained from the CDC's NHSN surveillance system from 2006 through 2008. NHSN surveillance methodology has been described elsewhere.[9] Facilities that choose to monitor DAIs in their neonatal care locations apply definitions based on the American Academy of Pediatrics' levels of newborn services to self-designate the level of care the neonatal unit provides.[10] Nurseries providing a combination of level 2/3 or level 3 care are considered NICUs in the NHSN.[11] Healthcare facilities select the types of DAIs and patient care locations in which they will perform surveillance for a minimum of 1 calendar month. Trained infection prevention professionals at these facilities collect and report data on a monthly basis using standardized methods and surveillance definitions.[9] Denominator data are reported stratified for each of the 5 NHSN birth weight categories (750 g or less, 751–1,000 g, 1,001–1,500 g, 1,501–2,500 g, and more than 2,500 g). For each DAI, date of birth, date of admission, date of infection, birth weight, death, discharge date, type of microorganisms isolated, and antibiograms were collected. Data on the presence of an umbilical catheter or nonumbilical central line were collected only for patients with primary bloodstream infections (BSIs; ie, BSIs that are not a result of an infection at another body site). If both a nonumbilical central line and an umbilical catheter were in place at the time of or within 48 hours prior to the development of the BSI, the infection was classified as UCAB. NICU-specific denominator data were collected by trained healthcare personnel as patient-days and specific device-days for each of the 5 birth weight categories.

CDC definitions of HAIs, including DAIs, have been published elsewhere and are based on a combination of clinical, laboratory, and sometimes radiologic findings.[9] Only primary BSIs that were laboratory confirmed were included in the analysis. The NHSN changed its BSI definition in January 2008 to require that, for common commensals such as coagulase-negative *Staphylococcus* (CoNS), 2 blood cultures within 48 hours of each other grow the same organism, along with certain signs and symptoms, to be considered a BSI; for this analysis, BSIs caused by common commensals from 2006 and 2007 were included only if 2 cultures were recorded.

Laboratory Data

Microbiological data for each DAI identified were collected from the facility's designated clinical microbiological laboratory. Up to 3 organisms per DAI may be reported. Laboratories were expected to use Clinical and Laboratory Standards Institute standards for antimicrobial susceptibility testing and reporting.[12] For each microorganism isolated, the susceptibility result was reported to the NHSN using the following categories: intermediate, resistant, susceptible, or not tested.

Data Analysis

Data were pooled across all participating NICUs, regardless of hospital type, during the 3-year period by birth weight category and type of DAI. Birth weight–specific pooled mean rates were calculated for CLABSI, UCAB, and VAP across all participating NICUs. Comparison of CLABSI, UCAB, and VAP rates between NICUs were restricted to NICUs located in children's hospitals and those located in general hospitals; other hospital types (eg, military and women's) were excluded from comparisons, given the small contribution of data by these facilities. Poisson regression was used to assess differences in pooled mean incidence rates, and nonparametric tests were used to assess differences in medians and rate distributions of CLABSI, UCAB, and VAP between children's and general hospitals. All rates are reported as cases per 1,000 device-days.

The length of hospital stay (LOS) was calculated as the difference between dates of admission and discharge. Date of discharge is not required to be reported; this variable was calculated only when discharge date was entered. Early-onset infection was defined as an infection occurring within the first 3 days of life. For each infection identified, the outcome of the patient (survived or died) was collected. Infections were considered contributory to death if reported by the infection preventionist to have either directly caused death or exacerbated an existing disease condition that then led to death. The date of device insertion is not required to be reported in the NHSN; therefore, the duration that the device stayed in place prior to the infection was calculated only for infections where these data were available.

The pathogen distribution by type of DAI and birth weight category was determined. Resistance for *Staphylococcus aureus* and *Enterococcus* species were analyzed only for those isolates that had susceptibility testing reported.

All analyses were performed using SAS, version 9.2 (SAS Institute). Results with a 2-tailed P value less than .05 were considered statistically significant.

RESULTS

A total of 304 NICUs in 286 hospitals reported DAI data to the NHSN during the period 2006–2008. The hospital types contributing NICU data included 255 general hospitals, 23 children's hospitals, 2 military hospitals, 3 women's hospital, and 3 women's/children's hospital. For BSI (CLABSI and UCAB), at least 78% of reporting NICUs contributed at least 6 months of data annually over the 3 years; similarly, for VAP at least 80% of NICUs reported at least 6 months of data

https://doi.org/10.1086/668425 Published online by Cambridge University Press

https://doi.org/10.1086/668425 Published online by Cambridge University Press

TABLE 1. Characteristics of Neonatal Intensive Care Unit (NICU) Patients by Birth Weight Category and Type of Device-Associated Infection, 2006–2008

	Birth weight category														
	≤750 g			751–1,000 g			1,001–1,500 g			1,501–2,500 g			>2,500 g		
Characteristic	VAP (n = 353)	UCAB (n = 232)	CLABSI (n = 738)	VAP (n = 197)	UCAB (n = 130)	CLABSI (n = 535)	VAP (n = 73)	UCAB (n = 98)	CLABSI (n = 390)	VAP (n = 37)	UCAB (n = 48)	CLABSI (n = 280)	VAP (n = 41)	UCAB (n = 61)	CLABSI (n = 193)
Age, days, median (IQR)	26 (17–47)	10 (6–15)	29 (17–60)	25 (15–44)	9 (7–13)	24 (15–48)	24 (15–45)	10 (8–13)	23 (15–44)	25 (15–74)	8 (6–11)	36 (19.5–76)	26 (16–69)	9 (5–14)	34 (20–65)
LOS, days, median (IQR)	80.5 (30–112.5)	22 (10–60)	75.5 (32–103)	73.5 (49–97)	67 (22–85)	70 (46–97)	87 (48–91)	41 (19–54)	58 (45–78)	55 (44–108)	25 (19–48)	55 (36–100)	67 (28–87)	21.5 (11–29)	50.5 (32–81)
Deaths, no. (%)	44 (12)	66 (28)	88 (12)	10 (5)	16 (12)	34 (6)	7 (10)	10 (10)	15 (4)	8 (22)	5 (10)	17 (6)	11 (27)	9 (15)	17 (8)
Contributed to death, proportion (%)	23/44 (52)	29/66 (44)	36/88 (41)	6/10 (60)	7/16 (44)	13/34 (38)	3/7 (43)	8/10 (80)	10/15 (67)	2/8 (25)	1/5 (20)	10/17 (59)	4/11 (36)	6/9 (67)	3/17 (18)

NOTE. CLABSI, central line–associated bloodstream infection; IQR, interquartile range; LOS, length of stay; UCAB, umbilical catheter–associated bloodstream infection; VAP, ventilator-associated pneumonia.

TABLE 2. Pathogen Distribution for Device-Associated Infections by Birth Weight Category

Type of infection, most common pathogens reported	Birth weight category, no. (%)					
	≤750 g	751–1,000 g	1,001–1,500 g	1,501–2,500 g	>2,500 g	Overall
CLABSI						
Coagulase-negative *Staphylococcus*	242 (29.7)	172 (29.2)	122 (28.2)	74 (23.2)	55 (24.8)	665 (28.0)
Staphylococcus aureus	145 (17.8)	121 (20.5)	95 (21.9)	47 (14.8)	24 (10.8)	432 (18.2)
Candida species	116 (14.2)	72 (12.2)	36 (8.3)	55 (17.3)	30 (13.5)	309 (13.0)
Enterococcus species	106 (13.0)	80 (13.6)	57 (13.2)	49 (15.4)	36 (16.2)	328 (13.8)
Klebsiella species	59 (7.2)	37 (6.3)	37 (8.5)	37 (11.6)	19 (8.6)	189 (7.9)
Other	147 (18.0)	108 (18.3)	86 (19.9)	56 (17.6)	58 (26.1)	455 (19.1)
Total CLABSI isolates	815	590	433	318	222	2,378
UCAB						
Coagulase-negative *Staphylococcus*	65 (26.0)	42 (31.1)	31 (32.9)	9 (20.5)	10 (17.8)	157 (27.1)
S. aureus	36 (14.4)	26 (19.3)	31 (32.9)	19 (43.2)	19 (33.9)	131 (22.6)
Candida species	45 (18.0)	21 (15.6)	6 (6.4)	3 (6.8)	7 (12.5)	82 (14.2)
Enterococcus species	20 (8.0)	7 (5.2)	5 (5.3)	1 (2.3)	7 (12.5)	40 (6.9)
Escherichia coli	25 (10.0)	8 (5.9)	4 (4.3)	5 (11.3)	4 (7.1)	46 (7.9)
Other	59 (23.6)	31 (22.9)	17 (18.1)	7 (15.9)	9 (16.1)	123 (21.2)
Total UCAB isolates	250	135	94	44	56	579
VAP						
Pseudomonas species	78 (19)	29 (12)	12 (12.1)	7 (17.9)	8 (17.0)	134 (16.1)
S. aureus	50 (12)	43 (18)	18 (18.2)	13 (33.3)	7 (14.9)	131 (15.8)
Enterobacter species	48 (12)	27 (11)	9 (9.1)	3 (7.7)	2 (4.3)	89 (10.7)
Klebsiella species	60 (15)	27 (11)	16 (16.2)	4 (10.3)	10 (21.3)	117 (14.1)
Other	169 (42)	114 (48)	44 (44.4)	12 (30.8)	20 (42.6)	359 (43.3)
Total VAP isolates	405	240	99	39	47	830

NOTE. CLABSI, central line–associated bloodstream infection; UCAB, umbilical catheter–associated bloodstream infection; VAP, ventilator-associated pneumonia.

annually. Pooled mean incidence rates were highest among NICU patients in the lowest birth weight category (750 g or less) across all 3 DAIs; rates by birth weight category, (750 g or less, 751–1,000 g, 1,001–1,500 g, 1,501–2,500 g, and more than 2,500 g, respectively) were 3.94, 3.09, 2.25, 1.90, and 1.60 for CLABSI; 4.52, 2.77, 1.70, 0.91, and 0.92 for UCAB; and 2.36, 2.08, 1.28, 0.86, and 0.72 for VAP.

Time of onset varied slightly between the types of DAIs; CLABSI and VAP tended to occur later in life (median age, more than 20 days), whereas UCAB occurred earlier in life (median age, less than or equal to 10 days) across all 5 birth weight categories. The age of infection onset (Table 1) seems to be reflective of the duration of the line, especially for UCAB. Among the 403 BSIs where date of device insertion was reported, the median time from insertion to onset of infection was 9 days (interquartile range [IQR], 6–12 days) for UCAB and 16 days (IQR, 8–28 days) for CLABSI. Date of discharge was available for 983 DAIs reported; neonates weighing 1,500 g or less at birth had a longer LOS compared with those weighing more than 1,500 g at birth (Table 1). Among the neonates who died, the percentage of infections considered to be contributory to death ranged from 18% to 80% and was greater among neonates with a birth weight of 1,500 g or less (Table 1).

Of the 2,705 BSIs (ie, CLABSI and UCAB), only 52 (1.9%) were early onset. A total of 55 pathogens among these 52 early-onset CLABSIs and UCABs were reported; the 3 most common pathogens were *Escherichia coli* (20%), *S. aureus* (16.3%), and group B *Streptococcus* (14.5%). Given the small number of early-onset BSIs reported, further analysis was not pursued.

Across all birth weight categories, there were 2,378 pathogens reported to be associated with the 2,136 CLABSIs. CoNS was the most frequently reported pathogen for CLABSI, followed by *S. aureus* (Table 2). The distribution seen for UCAB was similar except for the birth weight categories 1,501–2,500 g and more than 2,500 g, where *S. aureus* replaces CoNS as the most frequently reported pathogen. *Candida* species and *Enterococcus* species were the third or fourth most frequently reported across all birth weight categories for both CLABSI and UCAB (Table 2). The application of the requirement of 2 blood cultures for CoNS BSI resulted in an exclusion of 36% of all CoNS reported, which represents a 14% decrease in the overall number of pathogens reported. The distribution of the 830 pathogens associated with the 701 VAPs reported were similar between all birth weight categories: *Pseudomonas* species, *S. aureus*, *Enterobacter* species, and *Klebsiella* species were the most commonly reported VAP pathogens (Table 2).

Pooling data across all 3 DAI types, 673 *S. aureus* isolates had antimicrobial-susceptibility results available, and, of those, 222 (32.9%) were methicillin-resistant *S. aureus* (MRSA). Of

https://doi.org/10.1086/668425 Published online by Cambridge University Press

the 374 *Enterococcus* isolates with susceptibility results available, 22 (1.6%) were vancomycin resistant. Of the 347 *Enterococcus* isolates with susceptibility results for both ampicillin and vancomycin, 8 were resistant to ampicillin alone, and 2 were resistant to both ampicillin and vancomycin.

From the 266 NICUs located in general hospitals, there were 243,922 ventilator-days, 212,255 umbilical catheter–days, and 546,587 central line–days reported over the 3-year period; from the 30 NICUs located in children's hospitals, there were 92,605 ventilator-days, 38,101 umbilical catheter–days, and 192,403 central line–days reported. CLABSI and UCAB pooled mean rates, medians, and rate distributions were similar between NICUs located in children's hospitals and those located in general hospitals for all 5 birth weight categories. For VAP, pooled mean rates were lower in children's hospital NICUs than in general hospital NICUs among neonates weighing 750 g or less (1.68 vs 2.68; $P = .0002$) and neonates weighing 751–1,000 g (1.10 vs 2.31; $P = .02$); however, no differences were detected in the VAP medians and rate distributions (Table 3).

DISCUSSION

The pooled mean incidence rates of CLABSI among neonates, in particular among those weighing 750 g or less at birth, were almost 2-fold higher than CLABSI rates reported in medical and medical/surgical adult and pediatric ICUs.[13] These differences may be explained by the difficulty in obtaining venous access in this population, leading to placement of central lines in body site locations with a higher risk of infection (eg, groin) as well as long duration of central lines for purposes other than intravenous fluid administration (eg, blood draws and administration of total parenteral nutrition). The widespread adoption of evidence-based guidelines in adult settings has likely led to great decreases in CLABSI rates.[14-16] However, the differences between adult and NICU populations, coupled with a lack of research assessing prevention strategies in pediatric populations, have led to the adaptation and variable implementation of these guidelines in NICU settings.[17]

Among NICU patients, those weighing 1,000 g or less at birth had higher pooled mean rates for all DAIs than did those weighing more than 1,000 g at birth. The differences in rates between these groups of patients could be secondary to multiple factors: very immature immune systems, prolonged LOS with ongoing risk of infection, and frequent instrumentation with exposure to invasive procedures and devices. The median age of onset for DAIs in this analysis, with the exception of UCAB, was approximately 1 month for all birth weight categories. Umbilical catheters are generally inserted around the time of birth and are not left in place for an extended period of time; therefore, most infections associated with these lines were seen earlier in life. Among the NICUs where date of device insertion was available, the median duration of the device being in place prior to infection onset was 16 days for central lines and 9 days for umbilical catheters; this suggests that these BSIs are occurring during the maintenance phase of the central line. A recent study from the National Association of Children's Hospitals and Related Institutions (NACHRI) across 29 pediatric ICUs (PICUs) demonstrated that the main driver to reduce CLABSI rates in this pediatric population was related to daily maintenance and care of central lines and that maximizing compliance to central line insertion practices alone will be unlikely to significantly reduce CLABSIs in PICUs.[18] This is in contrast to adult ICUs, where adherence to central line insertion bundles has shown dramatic decreases in CLABSI rates.[15,16] Different components of central line maintenance bundles have been proposed and implemented in PICUs and NICUs with success;[7,18] however, further studies to determine which of these bundle components are most important for prevention are still needed.[18,19]

Early-onset device-associated BSIs were not commonly reported in the NHSN, and among those reported *S. aureus* was the second most frequent pathogen along with group B

TABLE 3. Pooled Mean Device-Associated Infection Rates among Neonates in Children's versus General Hospitals, 2006–2008

	CLABSI		UCAB		VAP	
Birth weight	Children's	General	Children's	General	Children's	General
≤750 g	3.06	4.06	4.65	4.67	1.68	2.68[a,b]
751–1,000 g	3.09	3.13	3.60	2.82	1.10	2.31[a,c]
1,001–1,500 g	2.22	2.27	1.43	1.74	0.81	1.39
1,501–2,500 g	2.32	1.84	0.87	1.02	0.68	0.96
>2,500 g	1.64	1.44	1.34	0.80	0.97	0.60

NOTE. Data are cases per 1,000 central line–days for central line–associated bloodstream infection (CLABSI) and umbilical line–associated bloodstream infection (UCAB) and are cases per 1,000 ventilator-days for ventilator-associated pneumonia (VAP).

[a] Rates were significantly different using Poisson regression (not based on median and rate distribution).

[b] $P = .0002$.

[c] $P = .02$.

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Streptococcus. The low numbers of early-onset infections reported across 304 NICUs, in addition to the high frequency of *S. aureus* (which has been reported as an infrequent pathogen of early-onset sepsis in other studies), needs to be interpreted with caution.[20] Although NHSN definitions include infections occurring in infants that result from passage through the birth canal as HAIs, they also exclude infections that are present or incubating at the time of admission.[9] Differentiating early-onset infections that are present or incubating at the time of admission (or birth) from those that are not can be challenging, as virtually all patients with maternally acquired infections will have a central line in place at the time cultures are collected. To decrease subjectivity in reporting, the NHSN Healthcare Infection Control Advisory Practice Committee (HICPAC) Surveillance Work Group is evaluating the implementation of a 3-day rule for HAIs (eg, only infections occurring on or after hospital day 3 will be considered HAIs).

On the basis of this analysis, the top 4 pathogens most frequently reported to the NHSN as associated with CLABSI and UCAB in NICUs, in rank order, are CoNS, *S. aureus*, *Candida* species, and *Enterococcus* species. In comparison to the Antimicrobial-Resistant Pathogens Annual Update,[21] which represents predominantly adult data, the most frequently reported pathogens for CLABSI were, in rank order, CoNS, *Enterococcus* species, *Candida* species, and *S. aureus*.[21] The high prevalence of CoNS and *S. aureus* BSI among neonates may be related to the neonates' fragile skin and relatively underdeveloped immune response. CoNS continues to be one of the leading pathogens of BSI among NICU patients despite the introduction of a stricter requirement requiring 2 positive blood cultures for common commensals in the NHSN. The 14% decrease we observed in the overall number of pathogens reported after the introduction of the 2-blood-culture requirement for common commensals is similar to what was reported in another study.[22] *Enterococcus* species were less common among neonates than among adult populations. One explanation for this finding may be that translocation of *Enterococcus* species across comprised colonic mucosa may result in necrotizing entercolitis (NEC), which can be classified as a secondary BSI in neonates; in adults, a similar scenario may be categorized as CLABSI given that the NEC definition is not applicable for patients more than 1 year of age.

For VAP, *S. aureus* and *Pseudomonas* species were the 2 most commonly reported pathogens. The pathogen distribution for VAP among neonates is similar to what was reported for pediatric and adult populations in the 2006–2007 NHSN Antimicrobial-Resistant Pathogens Annual Update[21] with the exception of *Acinetobacter* species, which represented only 1.3% of our neonatal isolates (data not shown), compared with 2.7% in that report.

In examining the resistance of selected organisms with reported sensitivities, we noted that 32.9% of *S. aureus* DAIs were MRSA. This proportion is less than what has been seen in adult settings (56.2%) but is higher than what was previously reported in NICU settings by Lessa et al,[23] where 23% of *S. aureus* isolated were MRSA, suggesting that MRSA may be an increasing problem in NICU settings.

There were considerably fewer children's hospital NICUs contributing data than general hospital NICUs. In our comparisons of DAIs between children's and general hospitals, pooled mean VAP rates were significantly lower in children's hospital neonates with a birth weight of less than 1,000 g. However, these differences in pooled mean VAP rates require further study and confirmation, given that no difference in VAP medians and rate distributions were found, the low number of children's hospital NICUs reporting data, and the difficulty in diagnosing VAP in neonates, especially among those infants with respiratory distress syndrome and other lung abnormalities. CDC efforts are under way to revise the current VAP definition and decrease variability in classification of VAP cases. Reassuringly, the similar rates of CLABSI and UCAB we observed between general and children's hospitals suggest that the risk of BSI among NICU patients does not differ by hospital setting.

This study is limited by several factors. First, the NHSN does not collect maternal or patient-specific risk factors, which limits our ability to analyze risk factors related to BSI or VAP among neonates. Second, NHSN hospitals self-designate their affiliation (eg, children's, general). Although misclassification may have occurred when children's hospitals designated themselves as general hospitals, data from the American Hospital Association Guide available in the NACHRI report show that approximately 5% of hospitals have a children's hospital designation in the United States.[24] This proportion is similar to what we have in the NHSN, where children's hospitals represented 7% of the hospitals reporting NICU data. Third, date of device insertion and date of discharge are not required data elements in the NHSN. This limited our ability to look at how long the device was in place prior to infection as well as LOS for all NICUs reporting DAI data. Fourth, the proportion of deaths associated with the infection may represent an underestimate, as infection prevention personnel are required to indicate whether the patient died at the time they enter the DAI event into the NHSN web-based system. It is possible that patients who died later during hospitalization were misclassified as alive since this was their status at the time the DAI event was reported. Finally, the reason for the difference in VAP rates between children's and general hospitals may be related to the difficulty of diagnosing and applying VAP definitions to the NICU patient. In addition, the relatively small number of children's hospitals reporting data for VAP compared with general hospitals limits the ability to generalize these findings. As children's hospitals continue to join the NHSN, reassessment of our findings should occur.

The unique characteristics of NICU patients, along with high rates of HAIs and increased prevalence of antimicrobial-resistant organisms in this vulnerable population, reinforce

https://doi.org/10.1086/668425 Published online by Cambridge University Press

the need for continued efforts to prevent DAIs in this setting and justify the current focus of HICPAC on the development of NICU-specific guidelines.

ACKNOWLEDGMENTS

We gratefully acknowledge the contribution of the staff at the hospitals that reported NICU data in the Patient Safety Component of the National Healthcare Safety Network. We also acknowledge Dr Scott Fridkin for critically reviewing the manuscript.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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https://doi.org/10.1086/668425 Published online by Cambridge University Press