Compliance with prevention practices and their association with central line–associated bloodstream infections in neonatal intensive care units

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Background: Bundles and checklists have been shown to decrease the rates of central line–associated bloodstream infections (CLABSIs), but implementation of these practices and association with CLABSI rates have not been described nationally. We describe implementation and levels of compliance with preventive practices in a sample of US neonatal intensive care units (NICUs) and assess their association with CLABSI rates.

Methods: An online survey assessing infection prevention practices was sent to hospitals participating in National Healthcare Safety Network CLABSI surveillance in October 2011. Participating hospitals permitted access to their NICU CLABSI rates. Multivariable regressions were used to test the association between compliance with NICU-specific CLABSI prevention practices and corresponding CLABSI rates.

Results: Overall, 190 level II/III and level III NICUs participated. The majority of NICUs had written policies (84%-93%) and monitored compliance with bundles and checklists (88%-91%). Reporting ≥95% compliance for any of the practices ranged from 50%-63%. Reporting ≥95% compliance with insertion checklist and assessment of daily line necessity were significantly associated with lower CLABSI rates ($P<.05$).

Conclusions: Most of the NICUs in this national sample have instituted CLABSI prevention policies and monitor compliance, although reporting ≥95% was suboptimal. Reporting ≥95% compliance with select CLABSI prevention practices was associated with lower CLABSI rates. Future studies should focus on identifying and improving compliance with effective CLABSI prevention practices in neonates.

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assess the association between compliance and CLABSI rates reported to the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN). The objectives of this study were to describe CLABSI prevention practices as defined by self-reported use of select insertion and maintenance bundle practices and insertion checklists in a sample of NICUs across the United States, and to determine the association of compliance with individual and combined practices with corresponding NICU CLABSI rates derived from existing NHSN surveillance data. We hypothesized that there would be variability in compliance with CLABSI prevention practices among NICUs, and that higher compliance with use of bundles and checklists would be significantly associated with lower CLABSI rates.

METHODS

Study design and eligible study hospitals

This analysis was part of a multicenter study, Prevention of Nosocomial Infections and Cost-Effectiveness Refined (P-NICER; National Institute of Nursing Research R01 NR010107) in which all nonveteran’s hospitals that were enrolled in the NHSN in 2011 were eligible to participate. The P-NICER study aimed to assess the impact of intensity of infection control processes and state-mandated reporting on device-associated and organism-specific health care–associated infection (HAI) rates in adult ICUs, pediatric ICUs, and NICUs across the United States. To be eligible for inclusion in this NICU-specific analysis, a hospital had to have an NICU, complete the survey described below, and agree to join the P-NICER NHSN Research Group. The latter agreement provided the study team access to the hospital’s device-associated infection rates from 2006 through mid-2012, as available.

The NHSN is the CDC’s national public health surveillance system for monitoring HAI. Participating hospitals use standardized definitions based on clinical and laboratory data, rather than on ICD-9 codes. A NICU was excluded from final analysis if there was a discrepancy between unit level as reported in the P-NICER survey compared with its classification within the NHSN. All procedures were reviewed and approved by Institutional Review Boards at Columbia University Medical Center, the CDC, and the RAND Corporation.

Survey of CLABSI-specific infection prevention practices

An online survey adapted from previous research assessing infection prevention and control (IP&C) practices was sent to eligible hospitals. A modified Dillman technique was used for recruitment and e-mail follow-up, which occurred between October and December 2011. To protect the confidentiality of hospitals participating in the NHSN, recruitment letters were sent by the CDC, and information about the study was posted on the NHSN Web site. The survey requested that every respondent be the director or manager of his or her hospital’s IP&C Department. To increase participation rates, respondents were entered into lotteries with $100 incentives.

For those hospitals with NICUs, the survey inquired about NICU-specific policies and practices related to CL insertion and maintenance. Respondents were asked whether the NICU had written policies for checklist use at CL insertion and used the following CL bundle practices (as defined by the study NICU): for insertion; monitoring of hand hygiene, use of maximal barrier precautions, and choice of optimal catheter insertion site and for maintenance; daily assessment of the need for the CL. The survey also asked about compliance with each practice during the last period monitored; compliance levels were defined based on a previous survey as all of the time (95%–100%), usually (75%–94%), sometimes (25%–74%), rarely or never (<25%), don’t know, or no monitoring performed. In addition to CLABSI prevention practices, the survey inquired about the level of each NICU (ie, neonatal critical care level II/III or level III as classified by the NHSN).

NICU CLABSI surveillance rates

All hospitals participating in this substudy reported NICU-specific CLABSI rates to the NHSN for all 4 quarters in 2011, and in accordance with NHSN methodology, stratified CLABSI rates by birth weight (BW) groups (<750, 751-1000, 1001-1500, 1501-2500, and >2500 g). In addition to hospital-level characteristics, such as teaching status and geographic location (ie, states categorized by census regions), NICU characteristics including the number of beds, and level (ie, neonatal critical care level II/III or III) also were obtained from the NHSN annual survey.

Statistical analysis

To determine the generalizability of the study sample, the CDC compared the NICU characteristics and CLABSI rates in the last quarter of 2011 of the study sites with the pooled NHSN data for nonparticipating NICUs (ie, those that did not respond to the survey and/or did not join the P-NICER NHSN Research Group) using the χ² test and ANOVA. The CDC did not provide the study team with direct access to NHSN data for non participants.

To determine whether the presence of a written policy for specific bundle practices, the use of an insertion checklist, and level of compliance with these practices were associated with lower CLABSI rates overall and among the different BW groups, we conducted bivariate analyses using Wilcoxon rank-sum and Kruskal-Wallis tests (for non-normally distributed right-skewed rate data). Pooled overall mean CLABSI rates per 1000 CL-days were calculated for each NICU by dividing the summed number of CLABSI events by the summed number of CL device-days, multiplied by 1000. The minimum level of compliance with using a checklist for CL insertion and using specific bundle components associated with lower overall CLABSI rates was determined in bivariate analyses. The following levels of implementation and compliance were tested based on previous studies in adult ICUs: presence of a written policy (yes/no); ≥95% compliance vs all other responses, including don’t know and no monitoring; and >95% vs 75%-94% vs all other responses. The minimum level of compliance associated with lower CLABSI rates determined in bivariate analysis was then used to conduct multivariable regression analyses, including a primary model, sensitivity analysis to assess robustness of the primary model, and secondary analysis.

The primary multivariable regression model was used to assess the association between level of compliance with each specific preventive practice, and overall CLABSI rates. The χ² goodness-of-fit test was used to guide model selection (negative binomial chosen over Poisson). The primary model was thus a negative binomial regression model adjusted for variables significant in bivariate analysis, with overall CLABSI rates as the outcome variable, level of compliance with each preventive practice as the exposure variable, and device-days as the offset variable. Incidence rate ratios (IRRs) were calculated for parameters of interest, and an α error of 0.05 was prespecified as the level for significance.

We followed the foregoing analysis with sensitivity analysis to assess robustness of the primary model. To account for possible non-independence of observations among NICUs from the same state, possibly owing to such factors as statewide CLABSI reduction collaboratives or state-mandated CLABSI reporting, we accounted for clustering by state, and calculated Huber-White robust standard errors. We also assessed for possible heterogeneity in duration and BW-specific use of CLs across compliance categories that could explain any observed association between overall CLABSI rates and the level of compliance in the primary model.
compliance was assumed to be low and classified as “rarely/never” in the primary model. To assess the robustness of this assumption, we repeated the analysis with missing responses reclassified under various levels of compliance (other than rarely/never), as a separate category, or excluded.

In secondary analysis, we used multivariable negative binomial regression to test the association between overall CLABSI rates and reported level of compliance with all practices or at least 1 prevention practice, regardless of the nature of that specific practice. In addition, we repeated the analysis specifically for each BW category using BW-specific CLABSI events and BW-specific CL-days for each NICU. All analyses were done with SAS version 9.3 (SAS Institute, Cary, NC).

RESULTS

Comparison of study sites with the NHSN surveillance sample

In the P-NICER study, 201 hospitals from 41 states with 204 NICUs responded to the survey and agreed to participate in the P-NICER NHSN Research Group, thereby providing the study team with access to their CLABSI rate data. The 204 study NICUs represented 23.4% (204 of 870) of the NICUs that reported CLABSI data to the NHSN in the last quarter of 2011. Of the study NICUs, 104 were level II/III and 100 were level III. CLABSI rates and NICU characteristics of the study sites and nonparticipating sites are compared in Table 1. The pooled mean CLABSI rates in the fourth quarter of 2011 were significantly higher for the level II/III NICUs that did not respond to the survey. Compared with nonparticipating sites, the study NICUs were more likely to be located in the northeastern United States and to be affiliated with a medical school.

CLABSI rates in participating NICUs

Fourteen of the 204 NICUs that submitted surveys and provided CLABSI rate data were excluded from analysis of the association of compliance with prevention practices and CLABSI rates. Reasons for exclusion included incomplete survey responses for prevention practices (n = 2) and inability to match survey results with NHSN data owing to discrepancies in the NICU level (n = 12). These excluded NICUs contributed 1037 CL-days (0.3%) of the total device-days in study NICUs.

Of the 190 NICUs included in this analysis, the overall 2011 annual pooled mean CLABSI rate was 1.6 infections/1000 CL-days. Rates by BW groups of ≤750, 751-1000, 1001-1500, 1501-2500, and >2500 g were 3.5, 2.0, 1.2, 1.0, and 0.9 infections/1000 CL-days, respectively.

Compliance with CLABSI bundles and checklists in study NICUs

The majority of the study NICUs (84.2%-93.2%) reported having written policies for insertion checklists and CLABSI bundle practices. The proportion that reported monitoring compliance with these practices ranged from 88.1%-90.8%. The rate of compliance of ≥95% for a specific practice ranged from 50% for daily assessment of CL need to 62.7% for use of maximal barrier precautions (Table 2). Overall, 124 NICUs (65.3%) reported ≥95% compliance with at least 1 practice, and 53 NICUs (27.9%) reported ≥95% compliance with all prevention practices.

Association of NICU characteristics and prevention practices with CLABSI rates

Bivariate analyses identified the number of NICU beds, NICU level, and medical school affiliation status as significantly associated with CLABSI rates (Table 3). Lower rates were seen in level II/III NICUs compared with level III NICUs, in NICUs with ≤15 beds compared with larger NICUs, and in NICUs unaffiliated with a medical school compared with NICUs affiliated with a medical school. Having a written policy for any of the surveyed practices was not significantly associated with a lower CLABSI rate (Table 3). Reporting ≥95% compliance with daily assessment of CL need was significantly associated with lower overall CLABSI rate. NICUs that reported ≥95% compliance with all of the preventive practices had a lower overall CLABSI rate than those that did not (1.1/1000 CL-days vs 1.5/1000 CL-days; P = .03).

On multivariable analysis, in the primary regression model, ≥95% compliance with use of an insertion checklist and daily assessment of CL need were significantly associated with lower overall CLABSI rates, with IRRs of 0.71 and 0.73, respectively (Table 4). In the primary model, NICU level was the only other significant predictor of CLABSI rate (IRR, 1.39; parameter estimate, 0.3; SE 0.1; P = .03) and level III NICUs had higher CLABSI rates.

In sensitivity analyses, after adjustment for intrastate clustering, only reporting of ≥95% compliance for an insertion checklist remained associated with lower CLABSI rates (IRR, 0.69; parameter estimate, 0.37; SE 0.19; P = .05). Assessment of BW-specific CL utilization across compliance categories found that total CL utilization was similar or higher in NICUs reporting ≥95% compliance with most preventive practices, except in those reporting ≥95% compliance with the daily assessment of CL need. NICUs reporting ≥95% compliance used CL lines more often in the smaller BW groups (Table 5). Redefining missing responses under other compliance categories or a separate category or excluding them did not alter the findings of the foregoing primary regression analyses (data not shown).

In secondary analysis, although reporting ≥95% compliance with at least 1 or all preventive practices, regardless of the specific

Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study sites</th>
<th>Nonparticipants in P-NICER NHSN research group</th>
<th>Nonparticipants in P-NICER NHSN research group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of hospitals</td>
<td>201</td>
<td>84</td>
<td>2398</td>
</tr>
<tr>
<td>Medical school affiliation, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>75 (37.3)</td>
<td>17 (20.2)</td>
<td>261 (10.9)</td>
</tr>
<tr>
<td>Graduate</td>
<td>27 (13.4)</td>
<td>6 (7.1)</td>
<td>202 (8.4)</td>
</tr>
<tr>
<td>Limited</td>
<td>26 (12.9)</td>
<td>11 (13.1)</td>
<td>257 (10.7)</td>
</tr>
<tr>
<td>Nonteaching</td>
<td>73 (36.3)</td>
<td>50 (59.5)</td>
<td>1678 (70)</td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For profit</td>
<td>30 (14.9)</td>
<td>17 (20.2)</td>
<td>497 (20.7)</td>
</tr>
<tr>
<td>Not for profit</td>
<td>159 (79.1)</td>
<td>59 (70.2)</td>
<td>1754 (73.1)</td>
</tr>
<tr>
<td>Other</td>
<td>12 (6.0)</td>
<td>8 (9.5)</td>
<td>147 (6.1)</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast (9 states)</td>
<td>49 (24.4)</td>
<td>9 (10.7)</td>
<td>406 (16.9)</td>
</tr>
<tr>
<td>Midwest (12 states)</td>
<td>58 (28.9)</td>
<td>14 (16.7)</td>
<td>515 (21.5)</td>
</tr>
<tr>
<td>South (17 states)</td>
<td>53 (26.4)</td>
<td>44 (52.4)</td>
<td>956 (39.9)</td>
</tr>
<tr>
<td>West (11 states)</td>
<td>39 (19.4)</td>
<td>17 (20.2)</td>
<td>487 (20.3)</td>
</tr>
<tr>
<td>Other (Hawaii, Alaska, Puerto Rico)</td>
<td>2 (1.0)</td>
<td>0</td>
<td>34 (1.4)</td>
</tr>
<tr>
<td>NICU characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of NICUs</td>
<td>204</td>
<td>66</td>
<td>600</td>
</tr>
<tr>
<td>Mean (median) CLABSI rate reported to NHSN, Q4 2011, per 1000 CL-days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level II/III NICU</td>
<td>1.5 (0)</td>
<td>1.4 (0)</td>
<td>1.8 (0)</td>
</tr>
<tr>
<td>Level III NICU</td>
<td>1.9 (0.2)</td>
<td>2.5 (1.5)</td>
<td>1.6 (0)</td>
</tr>
</tbody>
</table>

*P < .001, χ2 test.

**P < .01, ANOVA.
practice, tended toward an association with lower CLABSI rates, this was not significant in the multivariable analysis. On analysis of CLABSI rates by BW group in bivariate analysis, ≥95% compliance was associated with lower CLABSI rates in certain BW groups (Table 6); however, this association did not attain significance in the BW-specific multivariable regression analysis (data not shown).

**DISCUSSION**

To our knowledge, this study is the first to examine the practices of implementing and monitoring CLABSI-specific prevention practices and their association with CLABSI rates in NICUs across the United States. We found that although the majority of participating NICUs have instituted similar CLABSI prevention policies, there is considerable variability in compliance, and overall compliance tended to be less than optimal, with only 28% of the study NICUs reporting ≥95% compliance with all of the prevention practices assessed. This finding is important because in this analysis, instituting a policy, monitoring compliance, and reporting ≥95% compliance with specific prevention practices were all required to demonstrate an association with lower CLABSI rates. As our national focus broadens to include other patient safety goals, improving and sustaining excellent adherence to proven CLABSI prevention practices remains essential to achieve the target goal of zero CLABSI.

In this study, the use of a checklist at insertion and daily assessment of CL need were the only practices significantly associated with lower overall CLABSI rates in the primary analysis. After adjusting for state-level clustering, use of an insertion checklist was considered a strong predictor of lower CLABSI rates (Table 4). The findings support the Institute of Medicine’s recommendation to achieve high-performing care with high reliability. The findings also align with those of a previous study that found that NICUs with higher CLABSI rates had lower compliance with CLABSI prevention practices. Further research is needed to determine if implementation of these practices can reduce CLABSI rates. Our study did not address this question directly.

**Table 2**

Compliance with selected CLABSI prevention practices in 190 study NICUs

<table>
<thead>
<tr>
<th>Presence of written policy for prevention practices (n, %)</th>
<th>All the time (95%-100%)</th>
<th>Usually (75%-94%)</th>
<th>Sometimes (25%-74%)</th>
<th>Missing response</th>
<th>Don’t know</th>
<th>No monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checkpoint (163, 85.8)</td>
<td>85 (52.1)</td>
<td>28 (17.2)</td>
<td>4 (2.5)</td>
<td>10 (6.1)</td>
<td>21 (12.9)</td>
<td>15 (9.2)</td>
</tr>
<tr>
<td>Hand hygiene (176, 92.6)</td>
<td>110 (62.5)</td>
<td>20 (11.4)</td>
<td>2 (1.1)</td>
<td>8 (4.5)</td>
<td>19 (10.8)</td>
<td>17 (9.7)</td>
</tr>
<tr>
<td>Maximal barrier precautions (177, 93.2)</td>
<td>111 (62.7)</td>
<td>15 (8.5)</td>
<td>2 (1.1)</td>
<td>12 (6.8)</td>
<td>16 (9.0)</td>
<td>21 (11.9)</td>
</tr>
<tr>
<td>Optimal catheter site (165, 86.8)</td>
<td>97 (58.8)</td>
<td>22 (13.3)</td>
<td>1 (0.6)</td>
<td>10 (6.1)</td>
<td>17 (10.3)</td>
<td>18 (10.9)</td>
</tr>
<tr>
<td>Daily assessment of CL need (160, 84.2)</td>
<td>80 (50.0)</td>
<td>29 (18.1)</td>
<td>4 (2.5)</td>
<td>12 (7.5)</td>
<td>17 (10.6)</td>
<td>18 (11.3)</td>
</tr>
</tbody>
</table>

*One respondent observed compliance rates for maximal barrier precautions to be rarely/never (<25%).

**Table 3**

Factors associated with mean CLABSI rates in study NICUs in 2011, bivariate analysis

<table>
<thead>
<tr>
<th>Hospital/NICU characteristics</th>
<th>CLABSI rate/1000 CL-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td>Median</td>
</tr>
<tr>
<td>Hospital/NICU characteristics</td>
<td></td>
</tr>
<tr>
<td>Children’s hospital (yes/no)</td>
<td>1.5/0.7</td>
</tr>
<tr>
<td>Geographic location</td>
<td>0.9/0.7/1.2</td>
</tr>
<tr>
<td>Level (II/III/III)</td>
<td>0.3/1.2</td>
</tr>
<tr>
<td>Size (&lt;15, 16-30, 31-45, &gt;46 beds)</td>
<td>0.09/0.9/1.3</td>
</tr>
<tr>
<td>Medical school affiliation (yes/no)</td>
<td>1.3/0.0</td>
</tr>
<tr>
<td>Not-for-profit ownership (yes/no)</td>
<td>0.8/0.7</td>
</tr>
</tbody>
</table>

**Table 4**

Multivariable negative binomial regression model testing association of ≥95% compliance with prevention practices (independent variable) with CLABSI rates (dependent variable) in 190 study NICUs

<table>
<thead>
<tr>
<th>CLABSI prevention practices</th>
<th>Parameter</th>
<th>SE</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of checklist at insertion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand hygiene</td>
<td>-0.37</td>
<td>0.15</td>
<td>(-0.67 to -0.07)</td>
<td>.01</td>
</tr>
<tr>
<td>Use of maximum barrier precautions</td>
<td>-0.13</td>
<td>0.15</td>
<td>(-0.42 to 0.18)</td>
<td>.42</td>
</tr>
<tr>
<td>Choice of optimal catheter site</td>
<td>-0.17</td>
<td>0.15</td>
<td>(-0.46 to 0.13)</td>
<td>.27</td>
</tr>
</tbody>
</table>

*All models adjusted for NICU size, NICU level, and hospital teaching status. 
P = .05 after adjustment for state-level clustering. 
P = .07 after adjustment for state-level clustering.

**Table 5**

Distribution of CL-days across BW groups in compliance categories

<table>
<thead>
<tr>
<th>BW, g. % of CL-days</th>
<th>Compliance &lt;750</th>
<th>751-1000</th>
<th>1001-1500</th>
<th>1501-2500</th>
<th>&gt;2500</th>
<th>Total CL-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of checklist at insertion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>21.0</td>
<td>19.7</td>
<td>17.4</td>
<td>17.7</td>
<td>24.2</td>
<td>174,869</td>
</tr>
<tr>
<td>&lt;95%</td>
<td>20.2</td>
<td>16.0</td>
<td>21.8</td>
<td>20.2</td>
<td>21.8</td>
<td>181,436</td>
</tr>
<tr>
<td>Hand hygiene at insertion</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>20.6</td>
<td>17.5</td>
<td>19.1</td>
<td>19.2</td>
<td>23.6</td>
<td>195,103</td>
</tr>
<tr>
<td>&lt;95%</td>
<td>20.6</td>
<td>18.2</td>
<td>20.3</td>
<td>18.7</td>
<td>22.1</td>
<td>211,112</td>
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<tr>
<td>Use of maximum barrier precautions</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>21.1</td>
<td>17.3</td>
<td>18.5</td>
<td>19.4</td>
<td>23.7</td>
<td>201,178</td>
</tr>
<tr>
<td>&lt;95%</td>
<td>20.0</td>
<td>18.4</td>
<td>21.1</td>
<td>18.5</td>
<td>22.1</td>
<td>155,127</td>
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<tr>
<td>Choice of optimal catheter site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>20.9</td>
<td>17.8</td>
<td>18.5</td>
<td>19.1</td>
<td>23.8</td>
<td>182,817</td>
</tr>
<tr>
<td>&lt;95%</td>
<td>20.3</td>
<td>17.8</td>
<td>20.9</td>
<td>18.9</td>
<td>22.2</td>
<td>173,488</td>
</tr>
<tr>
<td>Daily assessment of CL need</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>24.7</td>
<td>18.6</td>
<td>18.7</td>
<td>18.3</td>
<td>19.8</td>
<td>148,636</td>
</tr>
<tr>
<td>&lt;95%</td>
<td>16.9</td>
<td>21.0</td>
<td>19.4</td>
<td>18.6</td>
<td>24.1</td>
<td>217,580</td>
</tr>
</tbody>
</table>
Use of checklist at insertion

<table>
<thead>
<tr>
<th>BW, g, mean (median) CLABSI rate/1000 CL-days</th>
<th>≤750</th>
<th>751-1000</th>
<th>1001-1500</th>
<th>1501-2500</th>
<th>&gt;2500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of checklist at insertion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>3.0 (0)</td>
<td>1.6 (0)*</td>
<td>0.8 (0)</td>
<td>0.8 (0)</td>
<td>0.2 (0)*</td>
</tr>
<tr>
<td>&lt;95% including all other responses</td>
<td>4.3 (0.2)</td>
<td>2.6 (0)</td>
<td>1.7 (0)</td>
<td>0.9 (0)</td>
<td>0.9 (0)</td>
</tr>
<tr>
<td>Hand hygiene at insertion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>3.3 (0.7)</td>
<td>1.7 (0)</td>
<td>1.2 (0)</td>
<td>0.8 (0)</td>
<td>0.3 (0)*</td>
</tr>
<tr>
<td>&lt;95% including all other responses</td>
<td>4.5 (0.7)</td>
<td>2.7 (0.4)</td>
<td>1.2 (0)</td>
<td>0.9 (0)</td>
<td>1.0 (0)</td>
</tr>
<tr>
<td>Use of maximum barrier precautions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>2.8 (0)</td>
<td>2.0 (0)</td>
<td>1.2 (0)</td>
<td>0.8 (0)</td>
<td>0.3 (0)*</td>
</tr>
<tr>
<td>&lt;95% including all other responses</td>
<td>5.2 (0.6)</td>
<td>2.4 (0)</td>
<td>1.3 (0)</td>
<td>0.9 (0)</td>
<td>1.0 (0)</td>
</tr>
<tr>
<td>Choice of optimal catheter site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>3.7 (0)</td>
<td>2.0 (0)</td>
<td>1.1 (0)</td>
<td>0.7 (0)</td>
<td>0.1 (0)*</td>
</tr>
<tr>
<td>&lt;95% including all other responses</td>
<td>4.0 (0)</td>
<td>2.3 (0)</td>
<td>1.4 (0)</td>
<td>1.0 (0)</td>
<td>1.1 (0)</td>
</tr>
<tr>
<td>Daily assessment of CL need</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥95%</td>
<td>2.9 (0)</td>
<td>1.8 (0)</td>
<td>0.6 (0)*</td>
<td>0.5 (0)</td>
<td>0.2 (0)*</td>
</tr>
<tr>
<td>&lt;95% including all other responses</td>
<td>4.5 (0.7)</td>
<td>2.3 (0)</td>
<td>1.8 (0)</td>
<td>1.2 (0)</td>
<td>0.9 (0)</td>
</tr>
</tbody>
</table>

*P < .05, Wilcoxon rank-sum test.

the only practice that remained significantly associated with lower CLABSI rates. Given that the checklist includes multiple components of an insertion bundle, this finding could suggest that additional unmeasured prevention practices may be important, including increased institutional investment in IP&C activities, generating a favorable climate for CLABSI prevention, and increased clinician attention during the insertion procedure, resulting in more meticulous technique.

The impact of maintenance bundles in reducing CLABSIs in neonates and children has been suggested previously. Ongoing initiatives, including the Agency for Healthcare Research and Quality—led Comprehensive Unit-Based Safety Program in NICUs, also emphasize maintenance practices, and our finding of the importance of daily assessment of CL need further supports this priority. We did not find ≥95% compliance with all components to be significantly associated with lower CLABSI rates in multivariable analysis. We speculate that this may be related in part to the small percentage of NICUs within our sample that reported excellent compliance with all prevention practices. In BW-specific analysis, a stronger association of ≥95% compliance with prevention practices and lower CLABSI rates was observed in the higher BW groups. This finding could be related to the differing pathophysiology of CLABSIs in extremely low BW infants (ie, mucosal or skin barrier injury) compared with that in larger and older infants (ie, contamination with skin flora during CL insertion/maintenance).

This study has several limitations. Our study NICUs constitute only 23% of the NICUs contributing to NHSN surveillance. Our sample is not representative of the larger NHSN population, given that the study NICUs tended to be academically affiliated NICUs and located in the northeastern United States. Compliance and rates were both self-reported by the hospitals’ IP&C directors/managers, and varying measurement approaches could have led to biases. Our survey assessed only 1 possible element of a maintenance bundle, and specific definitions and interpretations of each prevention practice could have varied between NICUs. A lack of temporal correlation between the measured time of self-reported compliance and CLABSI rates is possible. Finally, unique patient characteristics (eg, percentage of neonates with complex surgical issues, BW-specific case mix) were not fully captured by the NICU characteristics measured.

In conclusion, this study of CLABSI prevention practices in US NICUs found that the majority of NICUs have established policies for CLABSI checklists and bundles, and monitor compliance. However, compliance continues to vary widely among NICUs and is often below optimal levels. Reporting ≥95% compliance with a CL insertion checklist and daily assessment of CL need were significantly associated with lower CLABSI rates. Further efforts should focus on strategies to identify and improve compliance with effective CLABSI prevention practices in neonates.

References