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American Journal of Infection Control (AJIC) is the official scientific publication of the Association for Professionals in Infection Control and Epidemiology, Inc (APIC), a multidisciplinary international organization of health care professionals. The mission of AJIC is to improve health care by reducing risks of infection and related adverse outcomes by critical review, selection, and dissemination of new and relevant information in the fields of infection prevention and control and health care epidemiology in all health care settings and the community.
This issue of the American Journal of Infection Control features the much-anticipated National Healthcare Safety Network (NHSN) report. This report summarizes the 2006 data from the device-associated module in hospitals. Although the NHSN device-associated module directly builds upon the National Nosocomial Infection Surveillance (NNIS) system, and much of the data are familiar to infection control professionals who have been part of NNIS and/or benchmarking their institution’s data against NNIS, there are several important differences.

First, there is greater stratification, which includes increased categories of neonatal data by birth weight and type of neonatal intensive care unit (NICU). Device-associated infection and device utilization data are now provided for level II/III NICUs and level III NICUs separately. Furthermore, these data are further stratified for those most vulnerable neonates weighing 750 g and 751-1000 grams. Other new locations include pediatric medical/surgical intensive care units, medical wards, and medical/surgical wards. A new aspect of the report is the tables summarizing select attributes (e.g., criteria for confirming infection by location, distribution of infection types by location) of the infections. Last, for infection control professionals wishing to benchmark comparable institution-specific data against this report, guidance is given in how to calculate the infection rates and device utilization ratios. However, as noted by the authors, the data in some new categories are still limited. Additionally, for those who have benchmarked against NNIS in the past, care needs to be taken to ensure the location and patient populations are the same with the increased stratification.

In comparing the 2006 NHSN data to previous 2004 NNIS data, at first glance a trend of decreased infections almost across the board is noted. However, as the authors point out, caution is needed and the comparisons can be misleading. First of all, because of increased stratification, some patient populations are different. Furthermore, in non-NICU locations (i.e., pediatric and adult), the numerator of central line-associated primary bloodstream infections changed in 2006 such that only laboratory confirmed infections were included, which may account in part for the decrease. Future reports should help us discern whether the infection rates are actually decreasing due to the increased prevention strategies being implemented by the clinicians and/or if the decrease is due to changes in definitions.

The sample for this first-ever NHSN report is a subset of the NNIS hospitals, which, for the most part, are larger academic institutions. As the NHSN grows (which it is expected to do, with many states considering and/or using the system for mandatory reporting) and as enrollment is opened to all facilities, the volume of data in each category should increase and the profile of the hospitals may change to be more reflective of the nation. This will make the observation of future trends more powerful and generalizable.
This report is a summary of device-associated infections data collected and reported by hospitals participating in the National Healthcare Safety Network (NHSN) from January through December 2006. This report updates previously published data from the National Nosocomial Infections Surveillance (NNIS) system.1-3 The NHSN was established in 2005 to integrate and supersede 3 legacy surveillance systems at the Centers for Disease Control and Prevention (CDC): the NNIS system, the Dialysis Surveillance Network (DSN), and the National Surveillance of Healthcare Workers (NaSH). Similar to the NNIS system, NHSN facilities voluntarily report their healthcare-associated infection (HAI) surveillance data for aggregation into a single national database for the following purposes:

- Estimation of the magnitude of HAI;
- discovery of HAI trends;
- facilitation of inter- and intrahospital comparisons with risk-adjusted data that can be used for local quality improvement activities; and
- assistance for facilities in developing surveillance and analysis methods that permit timely recognition of patient safety problems and prompt intervention with appropriate measures.

Identity of all NHSN facilities is held confidential in accordance with Sections 304, 306, and 308(d) of the Public Health Service Act (42 USC 242b, 242K, and 242m(d)).

**METHODS**

The NHSN has both a Patient Safety and a Healthcare Personnel Safety surveillance component. Within the Patient Safety component, the data are collected using standardized methods and definitions and are grouped into specific module protocols4,5 as follows:

- **Device-associated module**: See section below.
- **Procedure-associated module**: Facilities choose to monitor in- or outpatients undergoing selected operative procedures for the presence of surgical site infection or postprocedure pneumonia.
- **Medication-associated module**: For certain locations, facilities choose to report susceptibility data for selected organisms and/or antimicrobial-use data for selected agents.

The modules may be used singly or simultaneously, but, once selected, they must be used for a minimum of 1 calendar month. All infections are categorized using standard CDC definitions that include laboratory and clinical criteria.5 Although the Device-associated module may also be used by facilities other than hospitals, including outpatient dialysis centers, this first report focuses only on Device-associated module data reported by hospitals. A report of data from this module for outpatient dialysis centers will be published separately. Data from the Procedure-associated module will be included in a subsequent NHSN Report when sufficient data are available. Data from the Medication-associated module will be published in a separate report.

**Device-associated (DA) module**: Infection control professionals (ICPs) may choose to collect data on central line-associated primary bloodstream infections,
ventilator-associated pneumonias, or urinary catheter-associated urinary tract infections (UTIs) that occur in patients staying in a patient care location such as an intensive care unit (ICU), specialty care area, or ward. In the NHSN, these locations are further characterized according to patient population: adults or children (in Tables, pediatric locations are so noted). In neonatal intensive care unit (NICU) locations (level III or level II/III), ICPs collect data on central line-associated and umbilical catheter-associated primary bloodstream infections or ventilator-associated pneumonia for each of 5 birth-weight categories (<750 g, 751-1000 g, 1001-1500 g, 1501-2500 g, and >2500 g). Corresponding location-specific denominator data consisting of patient-days and specific device-days are also collected by ICPs or other trained personnel.

RESULTS

Characteristics of the 211 NHSN hospitals from 40 states and the District of Columbia that contributed data for this report are shown in Table 1. For the Device-associated module in which data volume was sufficient for this first report, we tabulated device-associated infection rates and device utilization (DU) ratios for locations that did not report at least 50 device-days or patient-days. Because of this, the number of locations contributing data varies in the Tables.

Three new locations—pediatric medical/surgical ICU, medical ward, and medical/surgical ward—had sufficient data to be included in this report. The number of locations that were neurosurgical ICU or medical ward was not adequate to provide distributions of any infection rates and DU ratios. For burn ICU, there were insufficient data for ventilator-associated pneumonia and catheter-associated UTI rate and corresponding DU ratio distributions. For trauma ICU, insufficient data were available for ventilator-associated pneumonia rate distributions and for catheter-associated UTI rate and urinary catheter utilization ratio distributions.

The data for adult combined medical/surgical ICUs were split into 2 groups by type of hospital: “major teaching” and “all others.” Major teaching status was defined as a hospital that is an important part of the teaching program of a medical school and the majority of medical students rotates through multiple clinical services (see also footnote to Table 1).

For the Device-associated module, in non-NICU locations, the device-days consisted of the total number of central line-days, urinary catheter-days, and ventilator-days. The DU of a location is one measure of invasive practices in that location and constitutes an extrinsic risk factor for HAI. DU may also serve as a marker for severity of illness of patients, that is, patients’ intrinsic susceptibility to infection.

Tables 5 to 10 update and augment the previously published, device-associated rates and DU ratios from
the High Risk Nursery Component of the NNIS system. New for the NHSN Report are the 2 lowest birth-weight categories and separate tables for central line-associated bloodstream infections (BSI), umbilical catheter-associated BSI, and ventilator-associated pneumonia in level III and level II/III NICUs. For NICUs in the Device-associated module, device-days consist of the total number of central line-days, umbilical catheter-days, and ventilator-days. Each of the analyses of NICU data excluded rates or DU ratios for units that did not report at least 50 device-days or patient-days. Because of this, the number of units contributing data varies in the tables. Although the percentile distribution of the rates is provided, for most birth-weight categories the number of ventilator-associated pneumonias and ventilator-days is still small and the data should be considered provisional.

Tables 11 to 17 are new for this report and provide data on select attributes of the device-associated infections for each location. For example, Tables 11, 14, and 15 show the frequency and percentage distribution of the specific sites of BSI and the criterion used for identifying these infections. Note that for adult and pediatric ICUs and wards, only laboratory-confirmed BSI are allowed and shown, whereas clinical sepsis is included as a valid BSI specific site for neonates in NICU. For some of the patient care locations in these tables, the number of central line-associated BSI does not exactly match those shown in the rates tables because of an omission in the business logic in an early version of the NHSN Web interface. A total of 33 device-associated laboratory-confirmed BSIs for adult and pediatric ICU/wards did not have a criterion reported; the same was true for 5 BSIs in level III NICUs and 1 BSI in level II/III NICUs.
DISCUSSION

These data are the first reported from the new NHSN. Although NHSN facilities began collecting data on paper in 2005, the Web interface was not available for use until the end of October 2005. Thus, because many facilities were unable to enter data for 2005, we elected to consider that year as a pilot test of the system and, hence, included only data from January 2006 forward.

The hospitals reporting data included in this report are a subset of those that were members of the NNIS system, and the characteristics shown in Table 1 reflect this. However, as more states elect to use the NHSN as their system for meeting mandatory HAI reporting requirements and as enrollment is opened to all facilities, we expect to have a more diverse group of healthcare facilities reporting in the future.

Comparisons of these data with those of like locations from the last NNIS Report may be misleading. As noted in the results, it is not possible to compare the NICU data with the High Risk Nursery data of the NNIS system because of the multiple changes implemented in NHSN and because the volume of data is still limited for several of the birth-weight categories. Another difference in the NHSN is that data from pediatric ICUs are no longer combined with adult ICU data (eg, in the NNIS, pediatric surgical ICUs were combined with adult surgical ICUs). Data from pediatric ICU types are now reported as their own specialty types; for instance, pediatric medical/surgical ICU is separated and had sufficient data for inclusion in this report. Another example is that, in the NNIS Report, the central line-associated BSI rate for medical ICU was 5.0, and, in this report, it is 2.9. Two factors may account for this difference: (1) a change in the numerator in 2006...
Table 4. Pooled means and key percentiles of the distribution of ventilator-associated PNEU rates and ventilator utilization ratios, by type of location, DA module, 2006

<table>
<thead>
<tr>
<th>Type of location</th>
<th>No. of units</th>
<th>No. of VAP</th>
<th>Ventilator days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn ICU</td>
<td>12</td>
<td>124</td>
<td>10,098</td>
<td>12.3</td>
<td>0.0</td>
<td>0.0</td>
<td>1.3</td>
<td>4.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>48</td>
<td>100</td>
<td>35,727</td>
<td>2.8</td>
<td>0.0</td>
<td>0.0</td>
<td>1.4</td>
<td>4.0</td>
<td>8.1</td>
</tr>
<tr>
<td>Surgical cardiothoracic ICU</td>
<td>48</td>
<td>265</td>
<td>46,710</td>
<td>5.7</td>
<td>0.0</td>
<td>0.0</td>
<td>1.4</td>
<td>4.0</td>
<td>8.1</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>64</td>
<td>339</td>
<td>109,277</td>
<td>3.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.9</td>
<td>2.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Medical/surgical ICU</td>
<td>Major teaching</td>
<td>58</td>
<td>302</td>
<td>84,530</td>
<td>3.6</td>
<td>0.0</td>
<td>1.3</td>
<td>5.1</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>All others</td>
<td>99</td>
<td>372</td>
<td>135,546</td>
<td>2.7</td>
<td>0.0</td>
<td>0.0</td>
<td>1.6</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Pediatric medical/surgical ICU</td>
<td>32</td>
<td>81</td>
<td>32,936</td>
<td>2.5</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Neurosurgical ICU</td>
<td>15</td>
<td>97</td>
<td>13,799</td>
<td>7.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.6</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Surgical ICU</td>
<td>61</td>
<td>384</td>
<td>73,205</td>
<td>5.2</td>
<td>0.0</td>
<td>1.8</td>
<td>4.1</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Trauma ICU</td>
<td>19</td>
<td>329</td>
<td>32,297</td>
<td>10.2</td>
<td>0.0</td>
<td>1.8</td>
<td>4.1</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Percentile

<table>
<thead>
<tr>
<th>Type of location</th>
<th>No. of units</th>
<th>Ventilator days</th>
<th>Patient-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn ICU</td>
<td>13</td>
<td>10,098</td>
<td>24,067</td>
<td>0.42</td>
<td>0.08</td>
<td>0.16</td>
<td>0.26</td>
<td>0.33</td>
<td>0.43</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>50</td>
<td>35,727</td>
<td>126,002</td>
<td>0.28</td>
<td>0.18</td>
<td>0.27</td>
<td>0.35</td>
<td>0.47</td>
<td>0.56</td>
</tr>
<tr>
<td>Surgical cardiothoracic ICU</td>
<td>49</td>
<td>46,710</td>
<td>115,199</td>
<td>0.41</td>
<td>0.21</td>
<td>0.33</td>
<td>0.45</td>
<td>0.56</td>
<td>0.66</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>65</td>
<td>109,277</td>
<td>244,457</td>
<td>0.45</td>
<td>0.20</td>
<td>0.32</td>
<td>0.46</td>
<td>0.56</td>
<td>0.65</td>
</tr>
<tr>
<td>Medical/surgical ICU</td>
<td>Major teaching</td>
<td>58</td>
<td>84,530</td>
<td>195,551</td>
<td>0.43</td>
<td>0.20</td>
<td>0.32</td>
<td>0.46</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>All others</td>
<td>102</td>
<td>135,546</td>
<td>402,777</td>
<td>0.34</td>
<td>0.21</td>
<td>0.29</td>
<td>0.35</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Pediatric medical/surgical ICU</td>
<td>35</td>
<td>32,936</td>
<td>77,642</td>
<td>0.42</td>
<td>0.20</td>
<td>0.30</td>
<td>0.38</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Neurosurgical ICU</td>
<td>15</td>
<td>13,799</td>
<td>32,632</td>
<td>0.42</td>
<td>0.20</td>
<td>0.28</td>
<td>0.39</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Surgical ICU</td>
<td>62</td>
<td>73,205</td>
<td>176,695</td>
<td>0.41</td>
<td>0.21</td>
<td>0.28</td>
<td>0.39</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Trauma ICU</td>
<td>20</td>
<td>32,297</td>
<td>56,251</td>
<td>0.57</td>
<td>0.38</td>
<td>0.46</td>
<td>0.53</td>
<td>0.63</td>
</tr>
</tbody>
</table>

PNEU, pneumonia infection; VAP, ventilator-associated PNEU.

Table 5. Pooled means and key percentiles of the distribution of central line-associated BSI rates and central line utilization ratios for level III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>No. of units</th>
<th>No. of CLAB</th>
<th>Central line-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤750 g</td>
<td>42</td>
<td>118</td>
<td>18,458</td>
<td>6.4</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
<td>5.2</td>
<td>11.0</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>44</td>
<td>83</td>
<td>18,781</td>
<td>4.4</td>
<td>0.0</td>
<td>0.0</td>
<td>3.8</td>
<td>8.7</td>
<td>10.2</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>42</td>
<td>87</td>
<td>17,968</td>
<td>4.8</td>
<td>0.0</td>
<td>0.0</td>
<td>3.6</td>
<td>7.5</td>
<td>14.0</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>36</td>
<td>68</td>
<td>16,208</td>
<td>4.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4.1</td>
<td>8.5</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>32</td>
<td>50</td>
<td>16,131</td>
<td>3.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.9</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Percentile

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>No. of units</th>
<th>Central line-days</th>
<th>Patient-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤750 g</td>
<td>45</td>
<td>18,458</td>
<td>57,896</td>
<td>0.32</td>
<td>0.20</td>
<td>0.27</td>
<td>0.32</td>
<td>0.43</td>
<td>0.52</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>47</td>
<td>18,781</td>
<td>61,132</td>
<td>0.31</td>
<td>0.17</td>
<td>0.21</td>
<td>0.34</td>
<td>0.44</td>
<td>0.53</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>47</td>
<td>17,968</td>
<td>79,647</td>
<td>0.23</td>
<td>0.08</td>
<td>0.14</td>
<td>0.24</td>
<td>0.33</td>
<td>0.49</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>44</td>
<td>16,208</td>
<td>93,901</td>
<td>0.17</td>
<td>0.04</td>
<td>0.06</td>
<td>0.11</td>
<td>0.24</td>
<td>0.47</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>43</td>
<td>16,131</td>
<td>75,457</td>
<td>0.21</td>
<td>0.05</td>
<td>0.07</td>
<td>0.13</td>
<td>0.24</td>
<td>0.37</td>
</tr>
</tbody>
</table>

BSI, bloodstream infection; CLAB, central line-associated BSI.
such that only central line-associated laboratory-confirmed BSIs were included, whereas, previously, clinical sepsis infections were also included, and (2) an actual reduction in the number of BSI. This latter factor may be particularly likely because BSI prevention campaigns have been implemented by many hospitals since 2001.6-8

Tables 11 to 17 were included to aid the reader in interpreting the rates data. For example, most of the central line-associated and umbilical catheter-associated

### Table 6. Pooled means and key percentiles of the distribution of umbilical catheter-associated BSI rates and umbilical catheter utilization ratios for level III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Umbilical catheter-associated BSI rate(^a)</th>
<th>Birth-weight category</th>
<th>Percentile</th>
<th>No. of units</th>
<th>No. of UCAB</th>
<th>Umbilical catheter-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥750 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>751-1000 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1001-1500 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1501-2500 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;2500 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

\(^a\) Number of UCAB / Number of umbilical catheter-days × 1000.

### Table 7. Pooled means and key percentiles of the distribution of central line-associated BSI rates and central line utilization ratios for level II/III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Central line-associated BSI rate(^a)</th>
<th>Birth-weight category</th>
<th>Percentile</th>
<th>No. of units</th>
<th>No. of CLAB</th>
<th>Central line-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥750 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>751-1000 g</td>
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<tr>
<td></td>
<td>1001-1500 g</td>
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<tr>
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<td>1501-2500 g</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;2500 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Number of CLAB / Number of central line-days × 1000.
BSI were identified using the most objective criterion (1a)\(^5\); however, for adult and pediatric locations, there was considerable variation. Similarly, the specific site of ventilator-associated pneumonia most frequently reported used the clinical criteria of PNU1 for all locations.\(^5\) However, in adult and pediatric locations, nearly 40% of ventilator-associated pneumonias reported used the more rigorous criteria of PNU2 and PNU3.\(^5\) The specific site of catheter-associated UTI most frequently reported was symptomatic UTI. However, the distinction between this type of UTI and asymptomatic bacteriuria is often only the presence

**Table 8.** Pooled means and key percentiles of the distribution of umbilical catheter-associated BSI rates and umbilical catheter utilization ratios for level II/III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Umbilical catheter-associated BSI rate(^a)</th>
<th>No. of units</th>
<th>No. of UCAB</th>
<th>Umbilical catheter-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-weight category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 750) g</td>
<td>21</td>
<td>34</td>
<td>4314</td>
<td>7.9</td>
<td>0.0</td>
<td>0.0</td>
<td>7.4</td>
<td>22.6</td>
<td>35.7</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>20</td>
<td>18</td>
<td>4902</td>
<td>4.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.0</td>
<td>15.2</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>25</td>
<td>10</td>
<td>3789</td>
<td>2.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>10.3</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>22</td>
<td>4</td>
<td>3737</td>
<td>1.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>23</td>
<td>8</td>
<td>5542</td>
<td>1.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Umbilical catheter utilization ratio(^b)</th>
<th>No. of units</th>
<th>Umbilical catheter-days</th>
<th>Patient-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-weight category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 750) g</td>
<td>28</td>
<td>4314</td>
<td>24,853</td>
<td>0.17</td>
<td>0.08</td>
<td>0.10</td>
<td>0.20</td>
<td>0.31</td>
<td>0.44</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>34</td>
<td>4092</td>
<td>28,862</td>
<td>0.14</td>
<td>0.06</td>
<td>0.10</td>
<td>0.15</td>
<td>0.24</td>
<td>0.33</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>34</td>
<td>3789</td>
<td>39,771</td>
<td>0.10</td>
<td>0.04</td>
<td>0.08</td>
<td>0.11</td>
<td>0.14</td>
<td>0.19</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>35</td>
<td>3737</td>
<td>45,497</td>
<td>0.08</td>
<td>0.03</td>
<td>0.05</td>
<td>0.09</td>
<td>0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>35</td>
<td>5542</td>
<td>35,546</td>
<td>0.16</td>
<td>0.04</td>
<td>0.06</td>
<td>0.12</td>
<td>0.21</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**Table 9.** Pooled means and key percentiles of the distribution of ventilator-associated PNEU rates and ventilator utilization ratios for level III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Ventilator-associated PNEU rate(^a)</th>
<th>No. of units</th>
<th>No. of VAP</th>
<th>Ventilator-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-weight category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 750) g</td>
<td>36</td>
<td>56</td>
<td>22,002</td>
<td>2.5</td>
<td>0.0</td>
<td>0.0</td>
<td>1.7</td>
<td>4.1</td>
<td>9.5</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>37</td>
<td>33</td>
<td>15,251</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4.9</td>
<td>11.5</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>34</td>
<td>13</td>
<td>9308</td>
<td>1.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>26</td>
<td>8</td>
<td>7613</td>
<td>1.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>3.8</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>24</td>
<td>11</td>
<td>8901</td>
<td>1.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ventilator utilization ratio(^b)</th>
<th>No. of units</th>
<th>Ventilator-days</th>
<th>Patient-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-weight category</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 750) g</td>
<td>37</td>
<td>22,002</td>
<td>41,354</td>
<td>0.53</td>
<td>0.32</td>
<td>0.43</td>
<td>0.51</td>
<td>0.68</td>
<td>0.80</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>39</td>
<td>15,251</td>
<td>45,089</td>
<td>0.34</td>
<td>0.14</td>
<td>0.19</td>
<td>0.29</td>
<td>0.48</td>
<td>0.62</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>39</td>
<td>9308</td>
<td>60,905</td>
<td>0.15</td>
<td>0.06</td>
<td>0.10</td>
<td>0.14</td>
<td>0.28</td>
<td>0.40</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>39</td>
<td>7613</td>
<td>78,083</td>
<td>0.10</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.17</td>
<td>0.31</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>38</td>
<td>8901</td>
<td>60,171</td>
<td>0.15</td>
<td>0.03</td>
<td>0.05</td>
<td>0.10</td>
<td>0.25</td>
<td>0.36</td>
</tr>
</tbody>
</table>

PNEU, pneumonia infection; VAP, ventilator-associated PNEU.
\(^a\) Number of VAP ÷ number of ventilator-days × 1000.
\(^b\) Number of ventilator-days ÷ number of patient-days.

\(\text{BSI}\), bloodstream infection; \(\text{UCAB}\), umbilical catheter-associated BSI.
of fever, which can be difficult to attribute completely to infection versus other processes in critically ill patients.

If you would like to compare your hospital’s rates and ratios with those in this report, you must first collect information from your hospital in accordance with the methods described for the NHSN System. You should also refer to Appendices A and B for further instructions. Appendix A discusses the calculation of infection rates and DU ratios for the Device-associated module. Appendix B gives a step-by-step method for interpretation of percentiles of infection rates or DU ratios. A high rate or ratio (>90th percentile) does not necessarily define a problem; it only suggests an area for further investigation. Similarly, a low rate or ratio (<10th percentile) may be the result of inadequate infection detection. Hospitals should use these data to guide local prevention strategies and other quality improvement efforts aimed at reducing infection rates as much as possible.

Table 10. Pooled means and key percentiles of the distribution of ventilator-associated PNEU rates and ventilator utilization ratios for level II/III NICUs, DA module, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>No. of units</th>
<th>No. of VAP</th>
<th>Ventilator-days</th>
<th>Pooled mean</th>
<th>10%</th>
<th>25%</th>
<th>50% (median)</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3750 g</td>
<td>23</td>
<td>28</td>
<td>7399</td>
<td>3.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>5.4</td>
<td>15.7</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>23</td>
<td>24</td>
<td>4916</td>
<td>4.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>7.5</td>
<td>11.0</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>19</td>
<td>4</td>
<td>2762</td>
<td>1.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>12</td>
<td>0</td>
<td>1840</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>17</td>
<td>3</td>
<td>2595</td>
<td>1.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 11. Distribution of criteria for central line-associated laboratory confirmed BSI by location, 2006

<table>
<thead>
<tr>
<th>Type of location</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn ICU</td>
<td>104</td>
<td>81.9</td>
<td>11</td>
<td>8.7</td>
<td>12</td>
<td>9.4</td>
<td>127</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>120</td>
<td>67.0</td>
<td>36</td>
<td>20.1</td>
<td>23</td>
<td>12.8</td>
<td>179</td>
</tr>
<tr>
<td>Surgical cardiothoracic ICU</td>
<td>96</td>
<td>66.7</td>
<td>29</td>
<td>20.1</td>
<td>19</td>
<td>13.2</td>
<td>144</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>332</td>
<td>69.0</td>
<td>76</td>
<td>15.8</td>
<td>73</td>
<td>15.2</td>
<td>481</td>
</tr>
<tr>
<td>Medical/surgical ICU</td>
<td>167</td>
<td>56.0</td>
<td>63</td>
<td>21.1</td>
<td>68</td>
<td>22.8</td>
<td>298</td>
</tr>
<tr>
<td>Major teaching</td>
<td>214</td>
<td>49.9</td>
<td>115</td>
<td>26.8</td>
<td>100</td>
<td>23.3</td>
<td>429</td>
</tr>
<tr>
<td>All others</td>
<td>133</td>
<td>52.2</td>
<td>34</td>
<td>13.3</td>
<td>88</td>
<td>34.5</td>
<td>255</td>
</tr>
<tr>
<td>Pediatric medical/surgical ICU</td>
<td>39</td>
<td>52.7</td>
<td>13</td>
<td>17.6</td>
<td>22</td>
<td>29.7</td>
<td>74</td>
</tr>
<tr>
<td>Neurosurgical ICU</td>
<td>266</td>
<td>71.3</td>
<td>48</td>
<td>12.9</td>
<td>59</td>
<td>15.8</td>
<td>373</td>
</tr>
<tr>
<td>Trauma ICU</td>
<td>154</td>
<td>86.0</td>
<td>13</td>
<td>7.3</td>
<td>12</td>
<td>6.7</td>
<td>179</td>
</tr>
<tr>
<td>Inpatient medical ward</td>
<td>41</td>
<td>80.4</td>
<td>7</td>
<td>13.7</td>
<td>3</td>
<td>5.9</td>
<td>51</td>
</tr>
<tr>
<td>Inpatient medical/surgical</td>
<td>35</td>
<td>60.3</td>
<td>18</td>
<td>31.0</td>
<td>5</td>
<td>8.6</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>1701</td>
<td>64.2</td>
<td>463</td>
<td>17.5</td>
<td>484</td>
<td>18.3</td>
<td>2648</td>
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</table>

See Centers for Disease Control and Prevention for criteria.

BSI, bloodstream infection.
### Table 12. Distribution of specific sites of ventilator-associated pneumonia by location, 2006

<table>
<thead>
<tr>
<th>Type of location</th>
<th>PNU1</th>
<th></th>
<th>PNU2</th>
<th></th>
<th>PNU3</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn ICU</td>
<td>90</td>
<td>72.6</td>
<td>33</td>
<td>26.6</td>
<td>1</td>
<td>0.8</td>
<td>124</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>55</td>
<td>55.0</td>
<td>43</td>
<td>43.0</td>
<td>2</td>
<td>2.0</td>
<td>100</td>
</tr>
<tr>
<td>Surgical cardiothoracic ICU</td>
<td>144</td>
<td>54.3</td>
<td>119</td>
<td>44.9</td>
<td>2</td>
<td>0.8</td>
<td>265</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>274</td>
<td>80.8</td>
<td>61</td>
<td>18.0</td>
<td>4</td>
<td>1.2</td>
<td>339</td>
</tr>
<tr>
<td>Medical/surgical ICU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major teaching</td>
<td>191</td>
<td>63.3</td>
<td>111</td>
<td>36.8</td>
<td>0</td>
<td>0.0</td>
<td>302</td>
</tr>
<tr>
<td>All others</td>
<td>180</td>
<td>48.4</td>
<td>191</td>
<td>51.3</td>
<td>1</td>
<td>0.3</td>
<td>372</td>
</tr>
<tr>
<td>Pediatric medical/surgical ICU</td>
<td>67</td>
<td>82.7</td>
<td>13</td>
<td>16.1</td>
<td>1</td>
<td>1.2</td>
<td>81</td>
</tr>
<tr>
<td>Neurosurgical ICU</td>
<td>45</td>
<td>46.4</td>
<td>52</td>
<td>53.6</td>
<td>0</td>
<td>0.0</td>
<td>97</td>
</tr>
<tr>
<td>Surgical ICU</td>
<td>261</td>
<td>68.0</td>
<td>111</td>
<td>28.9</td>
<td>12</td>
<td>3.1</td>
<td>384</td>
</tr>
<tr>
<td>Trauma ICU</td>
<td>142</td>
<td>43.2</td>
<td>186</td>
<td>56.5</td>
<td>1</td>
<td>0.3</td>
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<td>Total</td>
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<td>920</td>
<td>38.3</td>
<td>24</td>
<td>1.0</td>
<td>2393</td>
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</table>

See Centers for Disease Control and Prevention for specific sites.

### Table 13. Distribution of specific sites of urinary catheter-associated UTI by location, 2006

<table>
<thead>
<tr>
<th>Type of location</th>
<th>ASB</th>
<th></th>
<th>SUTI</th>
<th></th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Burn ICU</td>
<td>24</td>
<td>25.0</td>
<td>72</td>
<td>75.0</td>
<td>96</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>141</td>
<td>46.8</td>
<td>160</td>
<td>53.2</td>
<td>301</td>
</tr>
<tr>
<td>Surgical cardiothoracic ICU</td>
<td>118</td>
<td>45.0</td>
<td>144</td>
<td>55.0</td>
<td>262</td>
</tr>
<tr>
<td>Medical ICU</td>
<td>254</td>
<td>37.4</td>
<td>426</td>
<td>62.7</td>
<td>680</td>
</tr>
<tr>
<td>Medical/surgical ICU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major teaching</td>
<td>151</td>
<td>33.6</td>
<td>299</td>
<td>66.4</td>
<td>450</td>
</tr>
<tr>
<td>All others</td>
<td>317</td>
<td>45.5</td>
<td>380</td>
<td>54.5</td>
<td>697</td>
</tr>
<tr>
<td>Pediatric medical/surgical ICU</td>
<td>24</td>
<td>21.2</td>
<td>89</td>
<td>78.8</td>
<td>113</td>
</tr>
<tr>
<td>Neurosurgical ICU</td>
<td>59</td>
<td>34.5</td>
<td>112</td>
<td>65.5</td>
<td>171</td>
</tr>
<tr>
<td>Surgical ICU</td>
<td>228</td>
<td>44.8</td>
<td>281</td>
<td>55.2</td>
<td>509</td>
</tr>
<tr>
<td>Trauma ICU</td>
<td>61</td>
<td>21.6</td>
<td>222</td>
<td>78.5</td>
<td>283</td>
</tr>
<tr>
<td>Inpatient medical ward</td>
<td>52</td>
<td>47.3</td>
<td>58</td>
<td>52.7</td>
<td>110</td>
</tr>
<tr>
<td>Inpatient medical/surgical ICU</td>
<td>50</td>
<td>57.5</td>
<td>37</td>
<td>42.5</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>1479</td>
<td>38.8</td>
<td>2280</td>
<td>61.2</td>
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</table>

See Centers for Disease Control and Prevention for specific sites.

### Table 14. Distribution of specific sites and criteria for device-associated BSI among level III NICUs by birth weight, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>LCBI</th>
<th></th>
<th></th>
<th>CSEP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central line-associated BSI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤750 g</td>
<td>47</td>
<td>40.9</td>
<td>18</td>
<td>15.7</td>
<td>10</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>45</td>
<td>54.2</td>
<td>8</td>
<td>9.6</td>
<td>27</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>43</td>
<td>49.4</td>
<td>8</td>
<td>9.2</td>
<td>30</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>33</td>
<td>48.5</td>
<td>13</td>
<td>19.1</td>
<td>19</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>24</td>
<td>49.0</td>
<td>4</td>
<td>8.2</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>192</td>
<td>47.8</td>
<td>51</td>
<td>12.7</td>
<td>128</td>
</tr>
<tr>
<td>Umbilical catheter-associated BSI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤750 g</td>
<td>17</td>
<td>41.5</td>
<td>3</td>
<td>7.3</td>
<td>14</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>10</td>
<td>41.7</td>
<td>2</td>
<td>8.3</td>
<td>10</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>7</td>
<td>35.0</td>
<td>2</td>
<td>10.0</td>
<td>9</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>4</td>
<td>40.0</td>
<td>0</td>
<td>0.0</td>
<td>4</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>2</td>
<td>28.6</td>
<td>1</td>
<td>14.3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>39.2</td>
<td>8</td>
<td>7.8</td>
<td>40</td>
</tr>
</tbody>
</table>

See Centers for Disease Control and Prevention for specific sites.

BSI, bloodstream infection; CSEP, clinical sepsis.
The authors thank the NHSN participants for their ongoing efforts to monitor infections and improve patient safety and our colleagues in the Division of Healthcare Quality Promotion, who tirelessly support this unique public health network.

References


Table 15. Distribution of specific sites and criteria for device-associated BSI among level II/III NICUs by birth weight, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>Criterion 1 N</th>
<th>%</th>
<th>Criterion 2a N</th>
<th>%</th>
<th>Criterion 2b N</th>
<th>%</th>
<th>CSEP N</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central line-associated BSI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤750 g</td>
<td>25</td>
<td>40.3</td>
<td>10</td>
<td>16.1</td>
<td>23</td>
<td>37.1</td>
<td>4</td>
<td>6.5</td>
<td>62</td>
</tr>
<tr>
<td>751-1000 g</td>
<td>19</td>
<td>39.6</td>
<td>12</td>
<td>25.0</td>
<td>17</td>
<td>35.4</td>
<td>0</td>
<td>0.0</td>
<td>48</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>15</td>
<td>44.1</td>
<td>4</td>
<td>11.8</td>
<td>13</td>
<td>38.2</td>
<td>2</td>
<td>5.9</td>
<td>34</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>6</td>
<td>35.3</td>
<td>3</td>
<td>17.7</td>
<td>8</td>
<td>47.1</td>
<td>0</td>
<td>0.0</td>
<td>17</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>9</td>
<td>27.3</td>
<td>2</td>
<td>6.1</td>
<td>20</td>
<td>60.6</td>
<td>2</td>
<td>6.1</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>38.1</td>
<td>31</td>
<td>16.0</td>
<td>81</td>
<td>41.8</td>
<td>8</td>
<td>4.1</td>
<td>194</td>
</tr>
</tbody>
</table>

| Umbilical catheter-associated BSI |               |    |                |    |                |    |        |    |       |
|≤750 g                | 16            | 47.1 | 10             | 29.4 | 6              | 17.7 | 2      | 5.9 | 34    |
| 751-1000 g           | 6             | 33.3 | 1              | 5.6  | 11             | 61.1 | 0      | 0.0 | 18    |
| 1001-1500 g          | 3             | 30.0 | 0              | 0.0  | 7              | 70.0 | 0      | 0.0 | 10    |
| 1501-2500 g          | 2             | 50.0 | 0              | 0.0  | 2              | 50.0 | 0      | 0.0 | 4     |
| >2500 g              | 1             | 12.5 | 4              | 50.0 | 2              | 25.0 | 1      | 12.5 | 8     |
| Total                | 28            | 48.3 | 15             | 16.9 | 28             | 31.5 | 3      | 100.0 | 74    |

See Centers for Disease Control and Prevention5 for specific sites and criteria.

BSI, bloodstream infection; CSEP, clinical sepsis.

Table 16. Distribution of specific sites of ventilator-associated pneumonia among level III NICUs by birth weight, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>PNU1 N</th>
<th>%</th>
<th>PNU2 N</th>
<th>%</th>
<th>PNU3 N</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤750 g</td>
<td>46</td>
<td>82.1</td>
<td>10</td>
<td>17.9</td>
<td>0</td>
<td>0.0</td>
<td>56</td>
</tr>
<tr>
<td>750-1000 g</td>
<td>30</td>
<td>90.9</td>
<td>3</td>
<td>9.1</td>
<td>0</td>
<td>0.0</td>
<td>33</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>13</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>13</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>7</td>
<td>87.5</td>
<td>1</td>
<td>12.5</td>
<td>0</td>
<td>0.0</td>
<td>8</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>9</td>
<td>81.8</td>
<td>2</td>
<td>18.2</td>
<td>0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>86.4</td>
<td>16</td>
<td>13.6</td>
<td>0</td>
<td>0.0</td>
<td>121</td>
</tr>
</tbody>
</table>

See Centers for Disease Control and Prevention5 for specific sites.

Table 17. Distribution of specific sites of ventilator-associated pneumonia among level II/III NICUs by birth weight, 2006

<table>
<thead>
<tr>
<th>Birth-weight category</th>
<th>PNU1 N</th>
<th>%</th>
<th>PNU2 N</th>
<th>%</th>
<th>PNU3 N</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤750 g</td>
<td>17</td>
<td>60.7</td>
<td>11</td>
<td>39.3</td>
<td>0</td>
<td>0.0</td>
<td>28</td>
</tr>
<tr>
<td>750-1000 g</td>
<td>20</td>
<td>83.3</td>
<td>4</td>
<td>16.7</td>
<td>0</td>
<td>0.0</td>
<td>24</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>1</td>
<td>25.0</td>
<td>3</td>
<td>75.0</td>
<td>0</td>
<td>0.0</td>
<td>4</td>
</tr>
<tr>
<td>1501-2500 g</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>2</td>
<td>66.7</td>
<td>1</td>
<td>33.3</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>67.8</td>
<td>19</td>
<td>32.2</td>
<td>0</td>
<td>0.0</td>
<td>59</td>
</tr>
</tbody>
</table>

See Centers for Disease Control and Prevention5 for specific sites.

The authors thank the NHSN participants for their ongoing efforts to monitor infections and improve patient safety and our colleagues in the Division of Healthcare Quality Promotion, who tirelessly support this unique public health network.

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The authors thank the NHSN participants for their ongoing efforts to monitor infections and improve patient safety and our colleagues in the Division of Healthcare Quality Promotion, who tirelessly support this unique public health network.
Appendix A. How to calculate a device-associated infection rate and device utilization ratio with Device-associated module data

Calculation of device-associated infection rate

Step 1. Decide on the time period for your analysis. It may be a month, a quarter, 6 months, a year, or some other period.

Step 2. Select the patient population for analysis, ie, the type of location or a birth-weight category in a NICU.

Step 3. Select the infections to be used in the numerator. They must be site specific and must have occurred in the selected patient population. Their date of onset must be during the selected time period.

Step 4. Determine the number of device-days, which is used as the denominator of the rate. Device-days are the total number of days of exposure to the device (central line, umbilical catheter, ventilator, or urinary catheter) by all of the patients in the selected population during the selected time period.

Example: Five patients on the first day of the month had 1 or more central lines in place; 5 on day 2; 2 on day 3; 5 on day 4; 5 on day 5; 4 on day 6; and 4 on day 7. Adding the number of patients with central lines on days 1 through 7, we would have 5 + 5 + 2 + 5 + 3 + 4 + 4 = 28 central line-days for the first week of the month. If we continued for the entire month, the number of central line-days for the month is simply the sum of the daily counts.

Step 5. Calculate the device-associated infection rate (per 1000 device-days) using the following formula:

\[
\text{Device-associated infection rate} = \frac{\text{Number of device-associated infections for an infection site}}{\text{Number device-days}} \times 1000
\]

Example:

Central line-associated BSI rate per 1000 central line-days

\[
= \frac{\text{Number of central line-associated BSI}}{\text{Number of central line-days}} \times 1000
\]

Calculation of DU ratio

Steps 1, 2, and 4. Same as device-associated infection rates plus determine the number of patient-days, which is used as the denominator of the DU ratio. Patient-days are the total number of days that patients are in the location during the selected time period.

Example: Ten patients were in the unit on the first day of the month; 12 on day 2; 11 on day 3; 13 on day 4; 10 on day 5; 6 on day 6; and 10 on day 7; and so on. If we counted the patients in the unit from days 1 through 7, we would add 10 + 12 + 11 + 13 + 10 + 6 + 10 for a total of 72 patient-days for the first week of the month. If we continued for the entire month, the number of patient-days for the month is simply the sum of the daily counts.

Step 5. Calculate the DU ratio with the following formula:

\[
\text{DU ratio} = \frac{\text{Number of device-days}}{\text{Number of patient-days}}
\]

With the number of device-days and patient-days from the examples above, DU = 28/72 = 0.39 or 39% of patient-days were also central line-days for the first week of the month.

Step 6. Examine the size of the denominator for your hospital’s rate or ratio. Rates or ratios may not be good estimates of the “true” rate or ratio for your hospital if the denominator is small, ie, <50 device-days or patient-days.

Step 7. Compare your hospital’s location-specific rates or ratios with those found in the Tables of this report. Refer to Appendix B for interpretation of the percentiles of the rates/ratios.

Appendix B. Interpretation of percentiles of infection rates or device utilization ratios

Step 1. Evaluate the rate (ratio) you have calculated for your hospital and confirm that the variables in the rate (both numerator and denominator) are identical to the rates (ratios) in the Table.

Step 2. Examine the percentiles in each of the Tables and look for the 50th percentile (or median). At the 50th percentile, 50% of the hospitals have lower rates (ratios) than the median and 50% have higher rates (ratios).

Step 3. Determine whether your hospital’s rate (ratio) is above or below this median.

Determining whether your hospital’s rate or ratio is a HIGH outlier

Step 4. If rate or ratio is above the median, determine whether the rate (ratio) is above the 75th percentile. At the 75th percentile, 75% of the hospitals had lower rates (ratios) and 25% of the hospital had higher rates (ratios).

Step 5. If the rate (ratio) is above the 75th percentile, determine whether it is above the 90th percentile. If
it is, then the rate (ratio) is a high outlier, which may indicate a problem.

**Determining whether your hospital's rate or ratio is a LOW outlier**

Step 6. If rate or ratio is below the median, determine whether the rate (ratio) is below the 25th percentile. At the 25th percentile, 25% of the hospitals had lower rates (ratios) and 75% of the hospitals had higher rates (ratios).

Step 7. If the rate (ratio) is below the 25th percentile, determine whether it is below the 10th percentile. If the rate is, then it is a low outlier, which may be due to underreporting of infections. If the ratio is below the 10th percentile, it is a low outlier and may be due to infrequent and/or short duration of device use.

Note: Device-associated infection rates and device utilization ratios should be examined together so that preventive measures may be appropriately targeted. For example, you find that the ventilator-associated pneumonia rate for a certain type of ICU is consistently above the 90th percentile and the ventilator utilization ratio is routinely between the 75th and 90th percentile. Because the ventilator is a significant risk factor for pneumonia, you may want to target your efforts on reducing the use of ventilators or limiting the duration with which they are used on patients to lower the ventilator-associated pneumonia rate in the unit.
Hospital work environments, nurse characteristics, and sharps injuries

Sean P. Clarke, PhD, RN
Philadelphia, Pennsylvania

Background: A growing body of research links working conditions, such as staffing levels and work environment characteristics, with safety for both patients and workers in health care settings, including sharps injuries in hospital staff nurses.

Methods: Surveys of 11,516 staff nurses from 188 Pennsylvania general acute care hospitals in 1999 were analyzed. Hospital work environments, measured using the Practice Environment Scales of the Nursing Work Index—Revised, and staffing were tested as predictors of experiencing at least one sharps injury in the preceding year, both before and after controlling for nurse risk factors, use of safety-engineered devices, and hospital structural characteristics.

Results: Nurses with less than 5 years of experience, perioperative nurses, and those performing routine venipuncture for blood draws were more likely to be injured. Nurses working in hospitals with the most favorable working environments were one-third less likely to be injured. Staffing levels were not associated with sharps injuries.

Conclusions: Across a large state, nurses working in acute care hospitals with better practice environments had fewer sharps injuries. Work environment conditions and specialty- and setting-specific risk factors deserve continued attention in sharps injury research. (Am J Infect Control 2007;35:302-9.)

Despite declines in needlesticks and other sharps injuries over the last decade that appear to be the result of worker education and the implementation of safer sharps,¹ sharps injuries to health care workers, particularly nurses, remain distressingly common. Sharps injuries are in part related to the number of procedures a health care worker performs that bring him or her into contact with sharps, which are affected by their specialty and hours spent on the job. Other personal characteristics (ie, age, gender, and experience) may also affect the types and amounts of sharps a nurse handles as well as the nurse’s skill in using and disposing of them. Nurses also may use different types of equipment, depending on their units within their institution, which may or may not be engineered to reduce their sharps risks.

Current thinking in health care safety emphasizes the importance of environmental context in the occurrence of errors and accidents.² In the case of needlestick injuries, a number of contextual variables frame the conditions under which nurses come into contact with sharps. These include hospital structural characteristics, such as size and teaching status that influence institutional clienteles and the need for procedures involving sharps, as well as the types and mix of personnel in a particular work setting (eg, high numbers of health care workers in training). There are also “modifiable factors” affecting practice that are subject to some control on the part of hospital leaders. Among these are staffing levels and work environment conditions believed to affect adherence to safe handling practices and have been tied to risk factors for percutaneous injuries with used sharps,³,⁴ as well as rates of actual sharps injuries.⁵,⁶ Many different aspects of working environments could influence safety issues yet understanding of mechanisms through which they affect practice is still limited. Therefore, a broad examination of work environment factors is warranted, from the status of nursing across the hospital as a whole, to relations between nurses with physicians, and the adequacy of staffing and resources. The overall experience level of staff in a hospital is affected by human resource practices and can also influence safety conditions. Because of the multitude of factors influencing sharps injuries and following previous work, it appears that extremes of organizational elements (the most favorable⁷ and least favorable⁸) tend to affect needlestick risks.

This article examines organizational factors as predictors of sharps injuries in nurses in general acute care hospitals in Pennsylvania. It is the first to use the Practice Environment Scales of the Nursing Work Index (NWI-PES),⁸ the measure of practice environments selected for the preliminary set of nursing-sensitive indicators put forward by the National Quality Forum, as a predictor of nurse occupational safety.⁹ It was hypothesized that nurses in hospitals with more favorable work environments, as well as higher staffing levels,
Methods

A random 50% of registered nurses (RNs) holding licenses in Pennsylvania were mailed questionnaires in 1999; the response rate for this survey was 52%. Some 13,152 nurses working in acute care general hospitals returned completed surveys. Respondents identified the hospitals where they worked and answered questions regarding their work history, perceptions of the work environments in their current jobs, job experiences, and occupational health issues. Attention in this study was confined to hospitals from which at least 10 self-identified staff nurses responded to the questionnaire to ensure the reliability of aggregate hospital-level measures. The final analytic sample consisted of 11,512 nurses in 188 hospitals. The Institutional Review Board of the University of Pennsylvania approved the original data collection and analyses here.

Measures

Nurse characteristics

Nurses’ personal characteristics examined included age, sex, and years of experience. After exploratory analyses and following a previous study, the latter variable was ultimately dichotomized into less than versus more than 5 years of experience. Nurses were asked the average number of hours they worked weekly over the preceding year. The clinical areas where nurses were permanently assigned were coded into 13 groups: medical-surgical nurses (the single largest category) was used as the reference category in these analyses.

Hospital characteristics

Three characteristics commonly used in health services research were analyzed. Hospitals were grouped by numbers of licensed and operating beds and teaching status in terms of whether or not any postgraduate medical training took place in the institution. Hospitals performing open-heart surgery and/or major organ transplants were considered to be high-technology facilities. Data were derived from the American Hospital Association Hospital Annual Survey for 1999, supplemented with 1999 data from the Pennsylvania State Department of Health and the Web sites for specific hospitals and hospital systems.

Work environment measures

The Nursing Work Index—Revised was developed from an in-depth study of hospitals with reputations for excellence in recruitment and retention of nurses. Nurses indicate on a 4-point scale (from strongly agree to strongly disagree) the extent to which they feel that 49 different work environment characteristics are present in their current jobs. The five Practice Environment Scales used here were derived from a factor analyses of several multihospital datasets. They include: nurse participation in hospital affairs (9 items), nursing foundations for quality of care (9 items; an item regarding nursing diagnoses was not used in this questionnaire), nurse manager ability, leadership and support of nurses (4 items; the survey omitted an item regarding supervisor use of mistakes as learning opportunities), staffing and resource adequacy (4 items), and collegial nurse-physician relations (3 items). Scores for each of these subscales were calculated for each nurse respondent; the mean score for all the nurses within each hospital was used as an analytic variable representing a characteristic of that hospital.

In this dataset, for the five PES subscales, eta-squared ranged from 0.05 to 0.15, intraclass correlation coefficients (ICC)(1) ranged from 0.04 to 0.13, and the estimated reliability of the hospital-level means (ICC)(2) ranged from 0.70 to 0.90. The strongest inter-rater agreements within hospitals were for the Nursing Participation in Hospital Affairs, and the lowest were for nurse manager and nurse-physician relations, both of which would be expected to show more variation across nurses and units.

Hospital-level mean workloads (staffing) and mean experience in nursing

Hospital-level staffing was calculated as the mean number of patients assigned to each staff nurse in a hospital carrying a load of at least 1 patient (excluding the responses of nurses reporting 20 or more patients) on the last shift she or he worked. A similar measure of the mean number of years in nursing across the staff nurse respondents was also computed as an indicator of experience levels in the hospitals.

Safety-engineered equipment

A series of questions was asked to determine the types of equipment nurses used for various types of potentially risky procedures. Specifically, they were asked if they regularly used needleless systems for accessing intravenous lines, as well as self-recapping needles and safety-lock syringes. Although decisions about equipment systems are often centralized at the hospital, department, or unit level, variations across units within hospitals have been noted by other researchers and it was decided to analyze these measures at the individual level because unit-level distinctions were not possible in this dataset.
Dependent variable: sharps injury

Using previously validated questions, nurses were asked whether or not they had ever been injured with a needle or sharp used on a patient. If they answered in the affirmative, they were asked how many injuries they had sustained in the previous year. Less than one percent of the nurses reported more than one injury and, therefore, the dependent variable analyzed was experiencing one or more sharps injuries in the prior year.

Analysis plan

After descriptive analyses of both the hospitals’ organizational characteristics and the nurses within them, models were fitted to examine the relationship between each nurse characteristic and the risk of a needlestick injury within one year, both before (unadjusted) and after control for all nurse personal characteristics. A separate set of models were fitted examining the relationships of hospital characteristics to injuries (size, high-technology equipment and services, teaching status) as well as nurses’ reports of regular use of the three safety-engineered device types, before and after control for nurse personal characteristics. Finally, the hospital organizational variables, including the organizational climate, staffing levels, and average nurse experience were examined individually as predictors of injury, before and after control for nurse personal characteristics, and hospital structural characteristics.

Exploration of the data failed to reveal a relationship between any of the organizational variables modeled as continuous variables and sharps injuries. Therefore, the impacts of hospital organizational characteristics were analyzed for nurses working in the top 25% of hospitals on each measure in comparison with all other nurses. Intercorrelations between the hospital-level measures of practice environment ranged from 0.37 to 0.79, suggesting that modeling associations between more than one PES scale simultaneously would be difficult. However, because evidence exists that hospitals that are superior on multiple organizational properties may have significantly better outcomes than those above average on only one, an additional variable was constructed to identify those hospitals that were the “best of the best,” or fell in the top 25% of hospitals on four or five (all or nearly all) of the practice environment measures.

Risks for nurses experiencing a sharps injury in the preceding year were calculated using logistic regression models controlling for the clustering of nurses within hospitals using Huber-White robust (sandwich) estimators. Although the dependent variable was reported by nurses as a count, very few (about 0.8%) reported two injuries and almost none reported three or more. No differences in model results were identified using Poisson regression, however, and for simplicity of presentation, logistic regression results (using the binary variable injury/no injury in previous year) appear here. Statistical significance level was set at \( P < .05 \). Stata Version 8.0 (College Station, TX) was used to conduct analyses.

RESULTS

The 188 hospitals in this study varied considerably in their structural characteristics. Across the hospitals between 10 (the lower limit for inclusion in this analysis) and 264 nurses responded to the questionnaire, with a mean of 61.3 nurses per hospital. A slim majority (55.3%) had between 101 and 250 beds, with a roughly equal proportion of hospitals with 100 and fewer beds (43 or 22.9%) and more than 250 (41 or 21.8%). A minority of hospitals (63 or 38.7%) had some type of postgraduate medical education (residencies or fellowships) on site, and slightly more than one quarter (54 or 28.7%) had high-technology facilities.

Table 1 shows the distribution of hospital-level working conditions computed by aggregating nurses’ responses within institutions. Nurses gave the highest
ratings to items measuring the presence of foundations for nursing care and positive nurse-physician relations (tending to somewhat or strongly agree that these elements were present), and were less likely to agree that staffing and resources, strong nurse managers, and nurses participated in hospital affairs. The spread here of scores for the NWI-PES was greater than that observed in a dataset representing past and current Magnet hospitals, as would be expected for a state-wide collection of facilities. Cut points for each of the scales (demarcating the “best” 25% or 47 hospitals on each subscale) are listed in Table 2. Of the 188 hospitals, 23 were in the top quartile on four or five out of five PES subscales (16% of the nurses worked in these top 12% of hospitals). The mean patient-per-nurse workloads across hospitals was approximately 6 and those hospitals where mean workloads were 5 and fewer patients were in the top 25% on this variable. Average nurse experience in the hospitals ranged from almost 8 to nearly 24 years. “Best in class” hospitals showed higher scores on each subscale of the NWI; nurses in these facilities had comparable patient loads and were slightly less experienced than those from the larger group of hospitals.

Among the nurses, medical-surgical nursing was the most common specialty (31.0%), followed by intensive/critical care, obstetrics, and perioperative care. The most common type of the three types of safety-engineered equipment reported was needleless connections for intravenous lines (77.2%). Less than half of the nurses indicated using self-recapping needles or safety-lock syringes. More nurses reported starting an intravenous line on their last shift (61.0%) than performing a routine phlebotomy (35.9%). Overall, 9.6% of the nurses reported a sharps injury in the preceding year, as compared with 7.2% of nurses in hospitals with the most favorable work environments.

Associations between individual nurse characteristics and injuries are presented in Table 3. Being male and being older were associated with higher needlestick risk before, but not after, controlling for other nurse characteristics. In fully adjusted models, perioperative nurses were twice as likely as medical-surgical nurses to be injured, and pediatric, neonatal, and psychiatric nurses were considerably less likely to experience one or more sharps injuries. Working more hours was associated with greater needlestick risk. Although performing an IV start on the last shift was not

### Table 2. Characteristics of the nurses

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All hospitals (N = 11,516)</th>
<th>Nurses in the 23 “best of the best” hospitals* (N = 1,854)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (%)</td>
<td>6.1</td>
<td>5.4</td>
</tr>
<tr>
<td>Age in years (SD)</td>
<td>39.6 (9.6)</td>
<td>38.6 (10.1)</td>
</tr>
<tr>
<td>Experience in nursing in years (SD)</td>
<td>13.8 (9.7)</td>
<td>13.1 (10.0)</td>
</tr>
<tr>
<td>Less than 5 years of experience (%)</td>
<td>18.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Experience at hospital in years (SD)</td>
<td>10.1 (7.6)</td>
<td>9.2 (7.5)</td>
</tr>
<tr>
<td>Mean weekly hours worked over past year (%)</td>
<td>35.1 (1.1)</td>
<td>34.2 (1.1)</td>
</tr>
<tr>
<td>Specialty (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicine/surgery</td>
<td>31.0</td>
<td>28.5</td>
</tr>
<tr>
<td>Intensive/critical care</td>
<td>19.6</td>
<td>19.7</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>9.9</td>
<td>12.1</td>
</tr>
<tr>
<td>Perioperative</td>
<td>9.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Emergency</td>
<td>7.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>3.9</td>
<td>3.6</td>
</tr>
<tr>
<td>Special procedures</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>2.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Clinics</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Rehab</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Neonatal</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Geriatrics</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Other specialties</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Safety-engineered equipment used regularly (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needleless IV systems</td>
<td>77.2</td>
<td>63.5</td>
</tr>
<tr>
<td>Self-recapping needles</td>
<td>39.4</td>
<td>39.9</td>
</tr>
<tr>
<td>Safety-lock syringes</td>
<td>37.4</td>
<td>38.4</td>
</tr>
<tr>
<td>Procedures on the last shift worked (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV start</td>
<td>61.0</td>
<td>52.0</td>
</tr>
<tr>
<td>Routine phlebotomy</td>
<td>35.9</td>
<td>36.0</td>
</tr>
<tr>
<td>Stuck with a used needle or sharp in past year (%)</td>
<td>9.6</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*Hospitals above the top quartile on 4 or 5 of the 5 NWI-PES subscales.
associated with sharps injuries, performing venipuncture on the last shift was associated with a 42% increased risk. In fully adjusted models, nurses’ personal reports of whether or not they used needleless IV tubing was the only equipment-related variable that was a significant predictor of risk. Use of self-recapping needles and safety-lock syringes was associated with decreased risk in the unadjusted models, but not after controls for nurse characteristics and the use of needleless IV tubing.

Nurses working in high-technology hospitals were at a significantly increased risk of injury, but employment in a large or teaching-intensive institution was not a risk factor before or after relevant controls (Table 4). Nurses in hospitals who ranked in the top 25% on the five NWI-PES scales were approximately 20% less likely to sustain needlestick injuries before and after controls for nurse hospital characteristics, hospital structural characteristics, and the use of protective equipment. The associations between best scores on the nurse manager and the staffing adequacy subscales and lowered sharps injury risk were on the margin of statistical significance, but the point estimates of the risk reductions associated with being in the best hospitals on the five subscales were in all the same general range. In fully adjusted models, nurses in the 25 hospitals that were in the top quartile on all or all but one of the five work environment scales were 34% less likely to experience an injury. Neither staffing levels nor mean experience levels across hospitals were predictors of needlestick injuries.

**DISCUSSION**

In a group of 188 hospitals across a large state, nurses’ work environments were an important predictor of needlestick injuries, consistent with findings in two earlier, smaller studies. The NWI-PES, used widely for institutional benchmarking internationally, predicted annual sharps injuries. When all five PES subscales were considered together, nurses in institutions that were “best in class” (ie, had mean scores in upper quartile on all or all but one of the subscales) showed a one-third reduction in risk of needlesticks after control for numerous nurse and hospital characteristics, including the regular use of safety-engineered sharps. While none of these best in class facilities were Magnet hospitals in 1999 (no Pennsylvania hospitals had yet applied for the designation), earlier work suggests

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**Table 3. Associations between individual nurse characteristics and 1-year needlestick risk**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unadjusted OR (95% CI)</th>
<th>P</th>
<th>Adjusting for all other nurse-level characteristics OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1.41 (1.12, 1.75)</td>
<td>.002</td>
<td>1.11 (0.89, 1.41)</td>
<td>.34</td>
</tr>
<tr>
<td>Age (10 year increment)</td>
<td>0.92 (0.86, 0.99)</td>
<td>.02</td>
<td>0.97 (0.90, 1.05)</td>
<td>.46</td>
</tr>
<tr>
<td>Specialty**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive/critical care</td>
<td>1.11 (0.92, 1.32)</td>
<td>.26</td>
<td>1.05 (0.87, 1.26)</td>
<td>.61</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>0.80 (0.63, 1.00)</td>
<td>.05</td>
<td>0.87 (0.69, 1.01)</td>
<td>.24</td>
</tr>
<tr>
<td>Perioperative</td>
<td>1.83 (1.49, 2.25)</td>
<td>&lt;.001</td>
<td>1.95 (1.56, 2.42)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emergency</td>
<td>1.31 (1.04, 1.64)</td>
<td>.02</td>
<td>1.22 (0.94, 1.58)</td>
<td>.14</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>0.47 (0.31, 0.72)</td>
<td>.001</td>
<td>0.51 (0.34, 0.77)</td>
<td>.002</td>
</tr>
<tr>
<td>Special procedures</td>
<td>0.76 (0.51, 1.14)</td>
<td>.19</td>
<td>0.81 (0.54, 1.07)</td>
<td>.12</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>0.51 (0.32, 0.82)</td>
<td>.005</td>
<td>0.54 (0.34, 0.85)</td>
<td>.002</td>
</tr>
<tr>
<td>Clinics</td>
<td>0.76 (0.45, 1.26)</td>
<td>.29</td>
<td>0.81 (0.48, 1.36)</td>
<td>.43</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>0.66 (0.37, 1.17)</td>
<td>.15</td>
<td>0.68 (0.39, 1.20)</td>
<td>.19</td>
</tr>
<tr>
<td>Neonatal</td>
<td>0.38 (0.19, 0.74)</td>
<td>.005</td>
<td>0.36 (0.19, 0.71)</td>
<td>.003</td>
</tr>
<tr>
<td>Geriatrics</td>
<td>0.82 (0.49, 1.36)</td>
<td>.44</td>
<td>0.91 (0.55, 1.51)</td>
<td>.73</td>
</tr>
<tr>
<td>Other/unspecified specialties</td>
<td>0.70 (0.50, 0.99)</td>
<td>.04</td>
<td>0.76 (0.54, 1.07)</td>
<td>.12</td>
</tr>
<tr>
<td>Less than 5 years experience</td>
<td>1.29 (1.10, 1.50)</td>
<td>.002</td>
<td>1.23 (1.02, 1.49)</td>
<td>.03</td>
</tr>
<tr>
<td>Average weekly hours worked in past year (10 hour increment)</td>
<td>1.21 (1.15, 1.28)</td>
<td>&lt;.001</td>
<td>1.16 (1.10, 1.23)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Procedures on last shift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV start</td>
<td>0.98 (0.86, 1.12)</td>
<td>.79</td>
<td>0.95 (0.82, 1.10)</td>
<td>.46</td>
</tr>
<tr>
<td>Routine venipuncture</td>
<td>1.31 (1.14, 1.48)</td>
<td>&lt;.001</td>
<td>1.36 (1.18, 1.58)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Safety-engineered equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needleless IV systems</td>
<td>0.73 (0.62, 0.86)</td>
<td>&lt;.001</td>
<td>0.75 (0.63, 0.89)</td>
<td>.001</td>
</tr>
<tr>
<td>Self-recapping needles</td>
<td>0.85 (0.74, 0.98)</td>
<td>.03</td>
<td>0.91 (0.78, 1.06)</td>
<td>.23</td>
</tr>
<tr>
<td>Safety-lock syringes</td>
<td>0.83 (0.72, 0.94)</td>
<td>.005</td>
<td>0.92 (0.79, 1.06)</td>
<td>.25</td>
</tr>
</tbody>
</table>

CI, Confidence Interval; IV, intravenous; OR, Odds Ratio.

*Modeled as a continuous variable.

**Reference category is medical-surgical nurses."
facilities that have received Magnet recognition have lower needlestick rates.\textsuperscript{7}

Although individual behaviors influence risks of sharps injuries and other occupational accidents, organizational factors appear to provide important context for safety by influencing the immediate working conditions under which potentially risky tasks are undertaken. Mechanisms are not altogether clear, but work environments and cultures appear to affect worker safety not only in health care, but in other industries as well.\textsuperscript{16-19} No evidence could be found in this dataset for greater use of safety-engineered equipment by nurses in hospitals with more favorable practice environments (perhaps because of the operational definitions used). Nonetheless, it is possible the practice environment factors here may be associated with the integration of safer work systems, thorough inservice training, and quality improvement efforts that encourage reporting, systematic study, and follow-up of injuries. Future studies may indicate that the measures here indirectly address the concepts of safety climate and culture, the collective tendency in some health care organizations to view accidents and errors as preventable through appropriate investments and collective action, which is hypothesized to lead to safer individual and group practices.\textsuperscript{20}

Somewhat surprising was the finding that staffing levels were not significantly related to sharps injury risk, especially in light of previous findings\textsuperscript{21,26} and the work of other researchers suggesting associations between staffing levels and other types of occupational injuries in health care facilities.\textsuperscript{21,22} However, prior work on needlesticks examined nurses from medical-surgical units in selected hospitals\textsuperscript{2,6} who may have experienced relatively similar practice conditions other than staffing and had more comparable work demands within units or hospitals. However, restricting analyses to nurses from medical-surgical units or to staffing levels did not reveal any associations between injuries and staffing levels. The measure of staffing used here (workload aggregated across units and shifts) provides a general indication of the distribution of patient load across nurses.\textsuperscript{10} Perhaps measures of investments in staffing across all units and specialties in a hospital are associated with outcomes in patients (who are often cared for in more than one area of a hospital),\textsuperscript{3,10,21} but occupational injuries may be more related to staffing in the specific areas where particular nurses work. Before drawing definitive conclusions about the impact of staffing on sharps injuries, further studies should be pursued using data where unit-level and nurse characteristics and other risk factors can be better measured and controlled.

As in a previous article,\textsuperscript{2} individual nurses with fewer than 5 years of professional experience had a higher risk of injury even after controlling for specialty and other characteristics, suggesting that nurses near the beginnings of their careers may still be developing skill or practice habits. Although staff nurse experience aggregated to the hospital level (ie, the collective experience level of nurses in a hospital) was associated with risks of near-miss incidents in an earlier article and was hypothesized to be related to handling and disposal of sharps,\textsuperscript{2} it was not predictive of surgical patient mortality risk.\textsuperscript{13} nor was it associated with actual injuries in an earlier study\textsuperscript{2} or in the present dataset. Future studies may or may not reveal that more refined or

<table>
<thead>
<tr>
<th>Table 4. Associations between hospital characteristics and hospital-level work environment characteristics and 1-year needlestick risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hospital structure</strong></td>
</tr>
<tr>
<td>Large versus small or medium</td>
</tr>
<tr>
<td>High technology</td>
</tr>
<tr>
<td>Teaching hospital</td>
</tr>
<tr>
<td><strong>Work environment (NWI-PES)</strong></td>
</tr>
<tr>
<td>Top quartile on nurse participation in hospital affairs</td>
</tr>
<tr>
<td>Top quartile on nursing foundations for quality of care</td>
</tr>
<tr>
<td>Top quartile on nurse manager ability, leadership and support of nurses</td>
</tr>
<tr>
<td>Top quartile on staffing and resource adequacy</td>
</tr>
<tr>
<td>Top quartile on collegial nurse-physician relations</td>
</tr>
<tr>
<td>Top quartile on 4 or 5 of 5 PES scales (ie, very best environments)</td>
</tr>
<tr>
<td>Bottom quartile on workload (most favorable staffing)</td>
</tr>
<tr>
<td>Most experienced staff (top quartile)</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
</tr>
<tr>
<td><strong>Adjusted for nurse-level characteristics and hospital structure</strong></td>
</tr>
<tr>
<td>Large versus small or medium</td>
</tr>
<tr>
<td>High technology</td>
</tr>
<tr>
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</tbody>
</table>

| CI, Confidence Interval; OR, Odds Ratio. |
setting-specific measures of expertise show associations with specific safety outcomes.

Routine phlebotomy appears to be a high-risk activity, probably because even safety-engineered devices cannot eliminate workers’ exposures to a bare sharp for at least a few moments when performing this procedure. While routine phlebotomy is certainly within nurses’ scope of practice, at various times and agencies, it has been delegated to specialized teams and sometimes to paraprofessionals. However, many health care facilities reassigned it to nurses in the course of work reengineering in the 1990s—and this shift may well have created additional sharps injury risks. It is not clear from the data on hand whether the elevated risk of injury associated with routine venipuncture is intrinsic to the task itself or relates to the circumstances under which nurses take on this task (ie, rushed or understaffed conditions, when dedicated phlebotomists are not available, or when nurses do not get sufficient practice to maintain dexterity or confidence).

Perhaps after further study, occupational health and infection control considerations might support assigning venipuncture to workers other than front-line staff nurses in at least some settings.

Although nurses in high-technology hospitals had higher risks of injury, perhaps because more sharps might be used in these facilities (although this cannot be determined from the data), neither larger hospitals nor those with medical residents and fellows showed increased injury rates. After controlling for a number of individual risk factors, nurses in critical care units did not appear to injure themselves more than medical-surgical nurses. However, nurses working in perioperative care were at a nearly doubled risk of injury. Because a rough proxy for venipuncture and IV use is included in these analyses, this high risk of injury among perioperative nurses is probably associated with sharps other than needles, specifically, surgical sharps (ie, scalpels and suture needles). This was not entirely surprising because other researchers have found that perioperative staff have higher injury risks than other staff associated with surgical tools. Sharps risk reduction for perioperative nurses clearly merits more attention from practitioners and researchers.

A few limitations bear mention. Although the response rate of 52% was favorable for a voluntary survey, the potential for nonresponse bias to have affected some of the associations cannot be ruled out. The study relied on nurses’ self-reports without external validation from other datasets, and thus recall bias affecting both reports of time at work and injuries is also a potential concern. However, because of well-documented problems with the underreporting of injuries to agency officials, survey data offer an essential complement to formal reports and institutional data in sharps injury epidemiology. Mailed surveys also present the only means to simultaneously collect data regarding working conditions across large representative groups of institutions, at least at the present time. Other biases, including limitations in understanding certain questions, may have affected other reports (eg, regarding the use of various types of safety-engineered sharps devices). Nonetheless, by examining reports from a representative cross-section of hospital nurses in virtually all general acute care hospitals in a large state, this study is the largest scale analysis of institutional working conditions in relation to sharps injuries to date, and as such provides important confirmation for previously identified trends. The study data were collected after widespread introduction of safety-engineered sharps devices but before passage of the Needlestick Safety and Prevention Act of 2000, which appears to have increased uptake of safer sharps and needleless technologies. Consequently, future studies may well show further reductions from the disturbing rate of nearly one nurse in ten experiencing at least one injury over a year observed here. Finally, staffing levels, working conditions, and equipment types affecting injuries may be better assessed at the unit level in future work, which was not possible with the dataset used in the present study.

In conclusion, nurses working in hospitals with better working environments were at lower risk of sharps injuries, even after controlling for specialty, hours at work, structural characteristics of hospitals, and self-reports of use of safety-engineered equipment. Examining contextual factors such as support for safe practices embedded in hospitals’ work environments, specialty-specific risks, and the use of specialized teams or workers for high-risk, high-frequency procedures are all critical to lowering occupational injury and infection rates as well as improving hospital safety.

Data collection was supported by the National Institute of Nursing Research, National Institutes of Health (ROI-NR04513, L. Aiken, University of Pennsylvania, PI); the Commonwealth Fund; the Agency for Healthcare Research and Quality; and the Baxter Foundation. Preparation of this article was assisted by a Mentored Career Award (K01-NR07895, S. Clarke, PI).

References


Designing a protocol that eliminates
Clostridium difficile: A collaborative venture

Jacqueline Whitaker, RN, MS, B. Susan Brown, BS, MT, Sue Vidal, RN, and Maria Calcaterra, BS, MT
Tampa, Florida

Background: Clostridium difficile is a health care–associated pathogen that is difficult to eradicate in the health care environment through the use of common hospital disinfectants. Many of these disinfectants fail to inactivate C difficile spores, which can result in patient-to-patient transmission. This study demonstrates that the use of 10% hypochlorite solution, along with interventions, reduced the incidence of health care–associated C difficile infection.

Methods: A case-only study was conducted over a 24-month period. Interventions used to reduce the incidence of health care–associated C difficile included 10% hypochlorite disinfection, soap and water hand hygiene, contact isolation for suspected and confirmed cases, educational tool for patients and visitors, daily isolation rounds, automated report functions, and standardized nursing unit isolation processes. The microbiology method that was used to isolate the C difficile organism for DNA typing included a minimum of 1 mL of stool placed in a conical screw top tube, and then an equal volume of 95% ethyl alcohol was added to the tube. Prereduced blood agar plates were inoculated with the treated and untreated specimen. Plates were incubated anaerobically for 48 hours at 37°C. Plates were examined for gray, flat colonies and gram stains performed; further testing was performed only on gram-positive rods.

Results: A 66% reduction in the number of health care–associated C difficile cases was achieved during the study. A total of 25 isolates was DNA typed per pulse-field gel electrophoresis. Two distinct genetic patterns were identified. Results yielded that the Florida isolates also had the epidemic strain of the organisms that was noted in Quebec, Canada and other parts of the United States.

Conclusion: A combination of automated daily isolation reports, use of a standardized methodology for isolation rounds, as well as development of a 10% hypochlorite disinfection protocol resulted in a dramatic decrease in health care–associated C difficile cases. Weekly nursing director reports and daily rounds by nursing leadership keep the direct line supervisors abreast of infection control issues on their respective nursing units. The addition of the dual-chamber bleach container ensured that the proper dilution was achieved when disinfecting reusable equipment. (Am J Infect Control 2007;35:310-4.)

Clostridium difficile is a spore-forming anaerobic bacillus that causes most cases of antibiotic-associated diarrhea.1 C difficile’s toxins damage the gut wall, causing problems ranging from mild diarrhea to severe pseudomembranous colitis, toxic megacolon, and bowel perforation.1 The organism that is known as C difficile inhabits the gut of up to 70% of newborns and 3% of healthy adults.2 Studies show that 50% of all hospitalized patients in the United States become colonized with C difficile.2

The target 469-bed tertiary care facility performs surveillance of health care–associated infections and community-acquired infections in the high-risk patient population, which includes multidrug-resistant organisms. In 2003, C difficile was not slated to be tracked and trended as part of the surveillance plan; however, in January 2003, the infection control department noted an increase in the number of positive C difficile cultures. Once this increase was noted, an investigation was initiated to prevent an outbreak in the facility. A review of the literature at that time revealed a number of studies regarding antimicrobial use and resultant C difficile–associated diarrhea (CDAD). The literature search yielded some references on the role of the environment in C difficile transmission, but little information on the use of hypochlorite solution to eradicate the spores in the environment.3–5 Furthermore, there was a dearth of literature on soap and water hand hygiene to remove spores from the hands.1,5

The purpose of the investigation was to determine the etiology of increased incidence of health care–associated C difficile cases to prevent the spread of this organism and development of active disease in our patient population. The specific objectives were to: (1) identify the etiology of the health care–associated C difficile cases, (2) develop an effective protocol to prevent the transmission of C difficile, and (3)
decrease the overall incidence of health care–associated *C. difficile* cases.

**METHODS**

A case-only study was conducted over a 24-month period. Every case—health care associated and community acquired—was entered into a spreadsheet software program. The following information was collected on each patient: date of admission, unit assignment, physician assignment, date of onset of signs and symptoms, type of antibiotic(s) prescribed prior to onset of infection, date first antibiotic administered, census history, and date treatment was initiated to address CDAD. Through analysis of this information, a nursing unit pattern was identified. Positive isolates from the qualitative enzyme-linked immunosorbent assay (Meridian Premier Toxin A&B, Cincinnati, OH) were cultured for DNA typing.

Microbiology used the following process to prepare the stool specimens for culturing. A minimum of 1 mL of stool was placed in a conical screw top tube. An equal volume of 95% ethyl alcohol was added to the tube. The tube was vortexed gently for 1 minute followed by vortexing at 15-minute increments for 1 hour. Prerduced blood agar plates were inoculated with the treated and untreated specimen. Plates were placed in an anaerobic box with an AnaeroPack (MCG, New York, NY) and a Dry Anaerobic Indicator Strip (BBL, Sparks, MD) and incubated for 48 hours at 37°C. Plates were examined for gray, flat colonies with irregular borders and a strong “horse manure” odor. Gram stains were performed on all suspicious organisms. Further testing was performed only on gram-positive rods.

An anaerobic challenge was performed on all gram-positive rods. Anaerobic isolates were tested with 15% catalase reagent (Hardy Diagnostics, Santa Maria, CA) and spot indole reagent (Remel, Lenexa, KS). Isolates that were negative for catalase and spot indole tests had final analysis with the Crystal Anaerobic Identification Kit (BBL) to determine if they were *C. difficile*.

Once the positive isolates were identified, DNA typing was performed by pulse-field gel electrophoresis (PFGE). The results revealed cross contamination of serial patients in the same room as well as room-to-room transmission of patients in rooms adjacent to *C. difficile*–positive patients. Six out of 8 submitted isolates exhibited an identical pattern (Fig 1).

This information was used to educate direct patient care staff regarding cross-contamination via the environment as a real possibility in this type of patient. The following also was shared with direct patient care staff to afford early detection of possible *C. difficile* patients:

Awareness regarding the types of antimicrobials that can prompt CDAD

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**Fig 1.** Pulsed-field profile of *Clostridium difficile* strains isolated from 8 patients showing molecular relatedness.
Knowledge that multiple loose stools with a foul odor should be a sign of possible CDAD
Physician awareness of the prescriptive patterns that can cause CDAD
Continuing education to keep a heightened level of awareness among direct patient care providers

As an adjunct to direct patient care provider education, one of the registered nurses volunteered to develop an educational tool for patients and visitors (Fig 2). The following interventions were implemented to reduce the incidence of health care–associated C difficile colonization and infection:

Placing patients in contact isolation until ruled out 10% hypochlorite disinfection
Soap and water hand hygiene
Automated report of multidrug-resistant organism history once patient is registered in hospital system
Development of an educational tool for patients and visitors
Nursing unit isolation rounds on a daily basis to ensure that patients are in the appropriate isolation
Automated Nursing unit rounds reports with isolation category type along with rationale for isolation of patient

Standardized Nursing unit process to organize isolation reports
Formulary restriction to prevent overuse of offending antibiotics

Throughout 2003, the infection control director and practitioners formulated and adjusted the disinfection protocol using a 10% hypochlorite solution in not only the patient rooms and nursing units, but expanded it to include all lateral environmental surfaces and reusable medical equipment. The disinfection protocol required the use of a 10% hypochlorite solution only in the first C difficile–positive patient’s room. Upon identification of the second C difficile–positive patient on that nursing unit, all patient rooms and the entire nursing unit were placed on the protocol; essentially, every lateral environmental surface and all reusable medical equipment located on that nursing unit was cleaned and disinfected in the same manner. This newly developed protocol also included placing a patient who was suspected of C difficile infection in contact isolation, cleaning the room with a 10% hypochlorite solution, and collecting stool specimens to determine if C difficile–antigen positive.

The room number and nursing unit designation of all C difficile– positive patients were entered on an

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**Fig 2.** Patient and visitor educational handout.
All electronic communication forms and disseminated to all nursing directors, nurse leaders, and the environmental services director as positive test results were received in the infection control department. The environmental services director checked the communication on a daily basis to ensure that each housekeeper was aware of unit(s) and patient rooms that needed the hypochlorite disinfection protocol. The positive antigen test information also was entered into the clinical software system to be exhibited on the next isolation report.

The isolation report and electronic communication form allowed for real-time identification and communication of positive *C difficile* patients during nursing and ancillary department change-of-shift report as well as isolation rounds. Isolation rounds are performed on a daily basis by the nurse leaders, in conjunction with the infection control practitioner rounds or independently as indicated. Isolation rounds consist of the nurse leader going to each patient room and ensuring that the isolation sign is on the door, the isolation card is on the chart, and the isolation information has been entered into the clinical software system. This daily isolation report is kept on a yellow clipboard in the nurses station for reference. The clipboard is stored in a standard location on every unit so that ancillary departments and physicians can access as needed. The contact isolation signs were updated to reflect the hypochlorite cleaning and disinfection protocol along with soap and water hand washing for *C difficile*-positive patients (Fig 3).

During 2004, soap and water hand hygiene was the recommended method to remove spores from the hands because alcohol was ineffective. The mechanical action of hand washing with soap and water removes the spores to prevent cross-contamination via the hands. Further refinement of the protocol in 2005 included the implementation of a dual-chamber hypochlorite solution container at our facility. The container dispenses a 10% hypochlorite solution that is mixed at the time of use.

The infection control department continued to track and trend health care–associated *C difficile*. During months when an increase in health care–associated cases was noted, investigations revealed that some portion of the *C difficile* protocol was eliminated or altered. When all of the key elements of the protocol were re instituted along with repeat education on the rationale for inclusion of that element, a reduction in the number of cases was noted.

**RESULTS**

Health care–associated *C difficile* infections peaked at a rate of 1.33 per patient day in February 2003. By December 2004, the rate had decreased to 0.45 per patient day, which equates to a 66% reduction in the number of health care–associated cases (Fig 4).

A total of 25 isolates was DNA typed per PFGE during this investigation. Of the 25 isolates that were submitted...
for DNA typing, two distinct genetic clusters were identified. Cluster 1 exhibited an average similarity of greater than 95%. Cluster 2 exhibited an indistinguishable pattern with a similarity coefficient of 98%. Cluster 1 consisted of 4 isolates (16%) that were similar out of the 25 isolates submitted. Cluster 2 consisted of 16 indistinguishable isolates (64%) out of the 25 isolates submitted.

Additionally, the DNA typing results from the target facility were sent to the Centers for Disease Control and Prevention (CDC) via the Florida Department of Health to determine if the positive isolates were related to the epidemic strain that was noted in Quebec, Canada. The positive C difficile isolates that were submitted to the CDC identified that our genetic pattern was the epidemic strain noted in Quebec and other parts of the United States. Three of 4 isolates (75%) that were submitted from our organization yielded the same DNA pattern found in Quebec and the other states.

DISCUSSION

Collaboration probably was the most important element in the development of this protocol to reduce the incidence of health care–associated C difficile cases significantly. The infection control director, infection control practitioners, nurse leaders, nurse directors, physicians, and environmental services director were committed to eradicating this problem. The automated print function of the daily isolation reports on the nursing units and in the infection control office, use of a standardized methodology for making isolation rounds, as well as development of a 10% hypochlorite disinfection protocol resulted in a dramatic decrease in the number of health care–associated C difficile cases. The weekly infection control director’s report and daily unit rounds by nursing leadership using the isolation report keeps the direct line supervisors abreast of key infection control indicators on their respective nursing units. The addition of the dual-chamber hypochlorite container ensured that the appropriate dilution ratio was achieved when direct patient caregivers disinfected reusable patient equipment. The combination of information technology, educational tools, standardized unit rounds, and development of a 10% hypochlorite disinfection protocol significantly reduced the incidence of health care–associated C difficile cases in the target facility.

RECOMMENDATIONS

It is recommended that the following actions continue as a result of this study: (1) track and trend this epidemiologically important organism to ensure protocol remains intact; (2) periodic education and reinforcement of the protocol as needed to reinforce the point that the environment played a key role in the transmission of this organism; and (3) coordination among nursing personnel, infection control personnel, and environmental services. All of these factors played an important part in reducing the incidence of C difficile infection in the target facility.

Fig 4. Health care–associated Clostridium difficile infections (rate per patient-day × 1000).

Glen Baker, environmental services director, Connie Eckstine, one-day surgery registered nurse, and Bruce Carter, materials management buyer, should be commended for their contributions to this study.

References

**Prevalence of Clostridium difficile environmental contamination and strain variability in multiple healthcare facilities**

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**Background:** Clostridium difficile spores can contaminate the hospital environment. Little is known about the prevalence and strain variability of C. difficile environmental contamination in health care facilities. The objective of this study was to assess C. difficile environmental contamination at various health care facilities in a metropolitan area and determine if the North American pulsed field gel electrophoresis type 1 (NAP1) strain was present.

**Methods:** A cross-sectional pilot survey was conducted. Forty-eight environmental samples were collected from six health care facilities. Samples were cultured for the presence of C. difficile, and positive samples underwent pulsed field gel electrophoresis, toxinotyping, and detection of binary toxin and/or tcdC deletion.

**Results:** C. difficile was cultured from 13 of 48 (27%) samples. Rooms housing a patient with C. difficile-associated disease (CDAD) were more likely to be culture positive than non-CDAD patient rooms (100% vs. 33%; P < 0.01); C. difficile was not isolated outside of patient rooms (0 of 12 samples). The NAP1 epidemic strain was found in 5 out of 6 facilities.

**Conclusion:** C. difficile spores frequently contaminated the hospital environment. Rooms with a CDAD patient were more likely to be contaminated than rooms without a CDAD patient. The NAP1 strain was prevalent throughout the metropolitan area.

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**BACKGROUND**

Clostridium difficile-associated disease (CDAD) is the most common cause of infectious health care–associated diarrhea.1 Previous studies have established that C. difficile can contaminate various surfaces in the hospital environment.2–5 However, little is known about the prevalence of C. difficile environmental contamination and variation in strain types among different healthcare facilities in a common geographic region. Recent outbreaks of CDAD have been attributed to a newly recognized strain of C. difficile, the North American pulsed field gel electrophoresis (PFGE) type 1 (NAP1) strain, which is toxinotype III, positive for binary toxin, and has an 18-base pair deletion in the tcdC gene.6 The prevalence of the NAP1 strain is unknown, particularly in hospitals without recent apparent CDAD outbreaks. The purposes of this investigation were to assess the prevalence and locations of C. difficile environmental contamination at various health care facilities and determine whether the NAP1 strain was present in these facilities.

**METHODS**

Six health care facilities in the St. Louis metropolitan area participated in this cross-sectional pilot study. Facilities from which samples were collected included one academic hospital, one Veterans’ Administration hospital, one community hospital, one skilled-nursing facility at a different community hospital, one long-term care facility, and one long-term acute care facility. Data were collected on the 2005 CDAD rates and room cleaning methods used at each of the health care facilities. Eight samples were collected at each health care facility: six from patient rooms and two from nurses’ stations (total = 48). At each health care facility, samples were taken from one room housing a patient with active CDAD and from two randomly selected rooms on...
the same ward without known CDAD patients or patients with symptoms consistent with CDAD. CDAD case patients were defined as having symptoms consistent with CDAD and a positive stool toxin assay within the week prior to sampling. Most rooms housing active CDAD patients were sampled within 72 hours of the patient’s diagnosis to ensure the patients were symptomatic at the time of sampling. All rooms had been cleaned within the 24 hours before the samples were obtained. Rooms were cleaned according to standard housekeeping practices at each facility and were not specially cleaned for this study. Each of the nurses’ stations sampled was located on the same floor as the CDAD and non-CDAD rooms.

In each room, one sample from “clean” environments (surfaces less likely to have fecal contamination) and one sample from “dirty” environments (surfaces more likely to have fecal contamination) was collected. Areas included in the “clean” sample were the patient’s bedside table, phone, nurse call button, and bedrails. Areas included in the “dirty” sample were the external surface of the toilet or commode and the floor surrounding the toilet or commode. Two samples were taken at each nurses’ station: one from areas with frequent hand contact (phones, keyboards, medication dispenser) and one from countertops. Samples were collected using cellulose sponges premoistened with DE neutralizing buffer (Solar Biologicals, Inc., Ogdensburg, NY). Samples were collected using aseptic technique. After sampling, sponges were sealed in individual plastic bags and shipped overnight to Centers of Disease Control and Prevention for culture and molecular characterization.

To process the samples, Butterfield’s phosphate buffer supplemented with Tween-80 was added to the bags containing the sponges. The sponges were homogenized in a Stomacher (Seward Ltd, West Sussex, UK) for approximately 5 minutes at 260 RPM. The effluent was split into two portions; one half was ethanol-treated (50% final concentration) for 1 hour at ambient temperature, and the other half was left untreated. The suspensions were concentrated by centrifugation at 3500 x g for 15 minutes, suspended in phosphate buffer, and subcultured on anaerobe blood agar and selective \textit{C. difficile}-agar, cycloserine-cefoxitin-fructose agar with 100,000 U/L lysozyme (formulation adapted from Wilcox, et al\cite{5}) in duplicate. The agar plates were incubated in an anaerobic chamber at 37°C for 5 days. The plates were examined for recovery of possible \textit{C. difficile} colonies after 2 days of incubation and held for an additional 3 days to definitively exclude \textit{C. difficile}. Identification of possible \textit{C. difficile} isolates was confirmed by conventional biochemical tests. PFGE, toxigenotyping, and detection of genes encoding binary toxin and deletions in \textit{tcdC} were performed as previously described.\cite{6,8-10} Comparisons were made in the proportion of positive samples by location using the Chi-square test.

**RESULTS**

Results of the environmental sampling are shown in Table 1. \textit{C. difficile} was recovered from 13 of 48 (27%) samples. \textit{C. difficile} was more likely to be recovered from rooms with a CDAD patient than rooms without a CDAD patient (6 of 6 vs. 4 of 12 [53%]; \( P < 0.01 \)). Rooms with a CDAD patient had significantly more culture-positive sites than rooms without a CDAD patient (9 of 12 [75%] vs. 4 of 24 [17%]; \( P < 0.01 \)). \textit{C. difficile} was more likely to be recovered from “dirty” sites than “clean” sites (9 of 18 [50%] vs. 4 of 18 [22%]; \( P = 0.08 \)). In rooms with a CDAD patient, \textit{C. difficile} was recovered from 5 of 6 (83%) “dirty” site samples vs. 4 of 12 (33%) samples from rooms without a CDAD patient (\( P = 0.13 \)). Four of six (67%) “clean” site samples from rooms with a CDAD patient were positive vs. 0 of 12

<table>
<thead>
<tr>
<th>Facility</th>
<th>CDAD Room</th>
<th>Non-CDAD Rooms</th>
<th>CDAD Rate (2005)</th>
<th>Environmental Cleaning Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Dirty: 1/1</td>
<td>Dirty: 1/2</td>
<td>0.9/1000 patient-days</td>
<td>CDAD rooms: 1:10 Bleach wipes daily</td>
</tr>
<tr>
<td></td>
<td>Clean: 0/1</td>
<td>Clean: 0/2</td>
<td></td>
<td>Non-CDAD rooms: Quaternary ammonia</td>
</tr>
<tr>
<td>B</td>
<td>Dirty: 1/1</td>
<td>Dirty: 0/2</td>
<td>2.6/1000 patient-days</td>
<td>Quaternary ammonia (all rooms)</td>
</tr>
<tr>
<td></td>
<td>Clean: 0/1</td>
<td>Clean: 0/2</td>
<td></td>
<td>Quaternary ammonia</td>
</tr>
<tr>
<td>C</td>
<td>Dirty: 1/1</td>
<td>Dirty: 2/2</td>
<td>Unknown</td>
<td>2-butoxyethanol-based solution (all rooms)</td>
</tr>
<tr>
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<td>Clean: 1/1</td>
<td>Clean: 0/2</td>
<td></td>
<td>2-butoxyethanol-based solution</td>
</tr>
<tr>
<td>D</td>
<td>Dirty: 0/1</td>
<td>Dirty: 1/2</td>
<td>4.7/1000 patient-days</td>
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<td>Non-CDAD rooms: Quaternary ammonia</td>
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<tr>
<td>E</td>
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<td>Dirty: 0/2</td>
<td>2.3/1000 patient-days</td>
<td>CDAD rooms: 1:10 Bleach daily</td>
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<td>Non-CDAD rooms: Quaternary ammonia</td>
</tr>
<tr>
<td>F</td>
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<td>Dirty: 0/2</td>
<td>3.9/1000 patient-days</td>
<td>CDAD rooms: 1:10 Bleach daily</td>
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<tr>
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<td>Clean: 1/1</td>
<td>Clean: 0/2</td>
<td></td>
<td>Non-CDAD rooms: Quaternary ammonia</td>
</tr>
</tbody>
</table>

*Results given as number of samples positive/number of samples collected.*
samples from rooms without a CDAD patient ($P < 0.01$). *C. difficile* was not recovered from any nurses’ station (n = 12 samples from 6 stations).

The various environmental cleaning procedures used and 2005 CDAD rates at each study facility are given in Table 1. CDAD rates ranged from 0.9/1000 patient-days to 4.7 per 1000 patient-days. One facility (C) did not track CDAD rates at the time of this study. Over half (4 of 6; 67%) of the facilities used a bleach-based product for cleaning rooms with CDAD patients and a quaternary ammonia compound for cleaning all other rooms.

PFGE and toxinotyping were performed on 12 of 13 isolates (Fig 1). Two predominant *C. difficile* toxino-types were recovered: 8 (67%) isolates were toxintype III, and 4 (33%) were toxintype O. All toxintype III isolates were NAP1, positive for binary toxin, and had an 18-base pair tcdC deletion. NAP1 was recovered from every health care facility except one (Facility A). Of rooms culture-positive for *C. difficile*, NAP1 was detected in 5 of 6 (83%) rooms with a CDAD patient and 2 of 4 (50%) rooms without a CDAD patient.

CONCLUSIONS

This study is the first to evaluate the prevalence of *C. difficile* environmental contamination in multiple health care facilities using the same sampling technique at each facility. Overall, 27% of environmental samples were positive, a proportion consistent with the findings of Verity et al and McFarland et al (23% and 29% of samples positive, respectively) but higher than the results of Kim et al and Clabots et al (11% and 15% of samples positive, respectively). Several of the findings of this investigation are consistent with the transmission patterns of *C. difficile*. *C. difficile* was more likely to be recovered from a room housing a current CDAD patient than from a room not housing a current CDAD patient ($P < 0.01$). Although the difference was not significant, *C. difficile* was more likely to be found in “dirty” sites (i.e., on or around a toilet or commode) than “clean” sites ($P = 0.08$). Importantly, *C. difficile* was not recovered from any of the samples taken from nurses’ stations, which suggests *C. difficile* environmental contamination is concentrated in patients’ rooms. This finding could have implications for housekeeping procedures in health care facilities, allowing environmental decontamination efforts to be focused on patient rooms.

In this investigation *C. difficile* spores were recovered from 33% of rooms where the patients had no signs or symptoms of CDAD. Patient cultures were not obtained as part of this study, so the source of this contamination is unclear. The spores may have originated from a CDAD patient previously housed in the room, which persisted in the environment. The contamination may have been spread from a room with a CDAD patient by the hands of a health care worker or by a member of the housekeeping staff. Finally, the patients in these rooms may have been asymptotically colonized with *C. difficile* and were contaminating their own environments.

**Fig 1.** PFGE results and dendrogram of *C. difficile* isolates recovered from surfaces in health care facilities. The dendrogram was created with BioNumerics V.4.01 software (Applied Maths, Austin, TX). NEG, negative; POS, positive; bp, base pair; NAP1, North American PFGE type 1.
Because of the small sample size of this study, no conclusive relationship can be drawn between the environmental cleaning procedures used by a facility and the facility's CDAD rates and/or environmental contamination burden. However, the data do reveal a few intriguing relationships that could direct future investigations into environmental decontamination of \textit{C. difficile} spores. Facility C had the highest percentage of positive environmental samples (50\% with recoverable \textit{C. difficile} spores), and facility C was the only facility to use an alcohol-based environmental cleaning product. Furthermore, facilities that used 1:10 bleach for environmental decontamination had CDAD rates that ranged from the lowest in the study (facility A) to CDAD rates that were the highest in the study (facility D). However, the possibility of confounding in a cross-sectional survey should be kept in mind; bleach decontamination of environmental surfaces may have been implemented in specific response to observed higher rates. At the time of the sampling, CDAD rate trends at the facilities using bleach varied, with some experiencing increasing rates, others with stable rates, and one experiencing decreasing rates.

Possibly the most important finding of this investigation is the widespread prevalence of the NAP1 \textit{C. difficile} strain throughout the St. Louis metropolitan area health care facilities. The NAP1 strain or a NAP1-related strain was found in every facility except one. This suggests the NAP1 strain does exist in endemic settings. Although increased fluoroquinolone use has been suggested as a risk factor for outbreaks with the NAP1 strain,\textsuperscript{11,12} protective effects that help prevent NAP1-strain outbreaks have not been determined. However, it should be noted that the CDAD rates in these health care facilities are on the higher end of the spectrum of recent rates reported from North American acute care facilities;\textsuperscript{13-15} thus high endemic rates could have masked the introduction of the NAP1 strain to this geographic region. These are issues that warrant further study.

This study, although small, is the first to use the same environmental sampling method at a variety of healthcare facilities and thus provides an indication of the overall burden of environmental contamination and strain variability of \textit{C. difficile} in healthcare facilities. \textit{C. difficile} spores were found frequently in rooms with a CDAD patient and less commonly in rooms with a non-CDAD patient, and were absent outside of patient rooms. This study was performed under “real-world” conditions—housekeeping practices were not influenced as part of the study—and thus the results of this study may be applicable to other health care facilities. The presence of the NAP1 strain, a strain implicated as the cause of recent CDAD outbreaks,\textsuperscript{6} in most of the facilities in this study suggests many facilities may be experiencing endemic rates that have already been impacted by this strain or they may be at future increased risk for similar CDAD outbreaks. Determining the role of environmental contamination in transmission will be important for developing effective prevention strategies that can limit further morbidity and mortality due to CDAD.

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\textbf{References}

Legionnaires’ disease among residents of a long-term care facility: The sentinel event in a community outbreak

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Background: A long-term care facility (LTCF) reported an outbreak of Legionnaires’ disease (LD) in September 2004.

Methods: We conducted case finding through enhanced surveillance, medical record review (n = 131), and community surveys (n = 258). We cultured water samples from the LTCF and assayed their outdoor air-intake filters for Legionella DNA. We also investigated a cooling tower, the only nearby outdoor aerosol source.

Results: Among 7 confirmed cases, 2 LTCF residents never exited, and 2 community residents never entered the LTCF during the incubation period. Among 63 water and biofilm samples collected from throughout the LTCF, we found no evidence of Legionella colonization, either in the potable water or air-handling systems. Conversely, we isolated a common outbreak-causing strain of Legionella pneumophila serogroup 1 from an industrial cooling tower located 0.4 km from the LTCF and recovered L pneumophila DNA from the LTCF’s outdoor air-intake filters, suggesting that aerosolized Legionella from the cooling tower most likely entered the LTCF through the air-intake system or, possibly, through open windows.

Conclusion: Residents of LTCFs can acquire LD from community sources. A cluster of LD cases among LTCF residents does not necessarily indicate transmission from within the LTCF. (Am J Infect Control 2007;35:319-23.)

Legionnaires’ disease (LD) accounts for an estimated 8000 to 18,000 cases of hospitalized community-acquired pneumonia in the United States annually.1 LD is also an important cause of health care-associated pneumonia. Approximately 35% of all LD cases reported to the Centers for Disease Control and Prevention (CDC) are acquired in health care facilities.2 Risk factors for LD include advanced age and chronic illness such as diabetes, cancer, and renal disease.3 Thus, residents in long-term care facilities (LTCF) are often at increased risk. Recommendations to prevent LD in health care facilities include staff education to promote appropriate diagnostic testing; maintenance of potable water systems at temperatures that inhibit Legionella growth; proper design, placement, and maintenance of facility cooling towers; and timely investigation of health care-associated cases to identify the source.4,5 We describe an investigation prompted by 2 cases among LTCF residents that led to the identification of a common-source community outbreak.

METHODS

Description of the outbreak

Between September 10 and October 16, 2004, 7 residents of Cherokee County, North Carolina, developed symptoms of LD, including 5 residents with exposure to indoor areas of a 134-bed LTCF or attached 50-bed hospital, 1 resident who visited nearby outpatient offices, and 1 resident who lived in the surrounding community. Because the first 4 cases that came to public health attention were all residents of the LTCF, the initial investigation focused on possible environmental sources within the LTCF. Later, when environmental sources within the LTCF proved to be free of Legionella, the investigation was expanded to encompass the neighboring community, including a suspect industrial cooling tower.

Epidemiologic investigation

Case definition. We defined confirmed LD as radiograph-confirmed pneumonia with symptom onset after September 1, 2004, and laboratory evidence of...
Legionella infection (positive for Legionella pneumophila serogroup 1 [Lp1] urinary antigen [UAg], isolation of Legionella from respiratory secretions or lung tissue, or a 4-fold rise in anti-Legionella antibody in paired sera). Possible LD included radiograph-confirmed or patient-reported physician-diagnosed pneumonia with symptom onset after September 1, 2004, without laboratory evidence of Legionella or another etiology.

**Case finding.** To identify incident cases of LD, we initiated laboratory-based active surveillance in Cherokee County and met with local physicians to promote awareness of the outbreak and reinforce the value of obtaining clinical cultures in addition to UAg testing. To identify possible recent cases of LD, we initially reviewed medical records of adults (>17 years) admitted to the hospital with respiratory symptoms. When the investigation was expanded to include the neighboring community, we additionally surveyed all workers of the factory served by the suspect cooling tower and all adult community residents who lived within a 0.8-km radius of the cooling tower.

The factory survey was administered by face-to-face interview at the factory over 2 days and all shifts. For the community survey, we used the Cherokee County computer-assisted dispatch database for emergency services to enumerate households within the target area and administered the survey by face-to-face interview in the home. Proxy interviews with adult household residents were conducted for otherwise eligible adults who were absent at the time of the survey. Both surveys relied on self-report; medical records were not reviewed.

**Environmental investigation**

We collected 45 water samples and biofilm swabs from the following LTCF sites using established procedures: all showers used by patients, hydrotherapy tubes, sinks in the on-site hair salon, sinks and bedpan washers in case-patient rooms, and coffee makers and ice machines; a sample of sinks and bedpan washers in noncase-patient rooms; and all 3 portable hot water heaters. We obtained 13 samples from distal sites in the attached hospital (which shared a potable water system with the LTCF) and collected 5 samples from condensate water in 5 large air-handling units on the roof of the LTCF and hospital complex.

When the investigation was expanded, all potential sources of aerosolized water within a 0.8-km radius of the LTCF were enumerated. Within the target area, we identified 2 industrial cooling towers, located approximately 0.4 km northeast of LTCF, and collected a total of 10 water and swab samples from these 2 towers and 1 sample from the municipal water supply feeding the towers.

Nine dry filter-paper samples were collected from 4 outdoor air-intake filters in 2 rooftop air handlers that served the LTCF. Paper was cut from filters, stored in sterile tubes, and tested for Legionella DNA using a polymerase chain reaction (PCR) assay.

**Laboratory methods**

**Culture and subtyping.** We cultured Legionella species from water and swab samples using standard methods. Legionella isolates were tested with specific antisera to determine the Legionella species and serogroup. A subset of isolates was tested using a panel of monoclonal antibodies to determine subtype. Because of a reagent shortage, only 1 isolate was tested for the presence of monoclonal epitope 6.

**Real-time PCR.** Filter-paper samples were suspended in sterile distilled water overnight. A 10-mL sample was removed and centrifuged at 3000 rpm for 30 minutes. The pellet was resuspended in Qiagen ATL lysis buffer, and a sample was extracted using a Qiagen Tissue kit (Qiagen, Inc., Valencia, CA). Extracted DNA samples were diluted 1:10 and tested using an in-house-developed real-time PCR assay with primers and probes specific for the mip gene of L pneumophila employing an ABI 9700 real-time PCR instrument (Applied Biosystems, Foster City, CA). Negative extraction controls were run to exclude contamination.

**RESULTS**

**Epidemiologic investigation**

**Case finding.** Four UAg-confirmed cases of LD were identified before the start of the investigation. Active surveillance identified 2 additional cases of UAg-confirmed LD. Chart review identified a possible seventh case that was subsequently confirmed by UAg testing. Despite efforts to encourage culture of respiratory specimens from all patients with community- or health care-associated pneumonia during the time of the investigation, no isolates of Legionella were available.

For the factory survey, we interviewed 200 (87%) of 230 employees, excluding delivery truck drivers; 1 met the possible case definition. For the community survey, we interviewed adult members of 39 (66%) of the 59 households located within a 0.8-km radius of the suspected cooling tower. Among the remaining 20 households, 4 refused to participate, 4 had no one at home, and 12 (mobile homes) had moved. Among 59 households, 59 interviews were completed, including 7 (12%) conducted by proxy. Among these 59 community residents, 1 resident met the definition of a possible case. In summary, the initial cluster consisted of 4 confirmed cases of LD; case-finding efforts detected
3 additional confirmed cases (for a total of 7 confirmed cases) and 2 possible cases.

**Descriptive epidemiology.** The 7 confirmed case patients ranged in age from 49 to 83 years, 1 was female, and all had significant underlying illnesses (for example, congestive heart failure, chronic obstructive pulmonary disease, renal failure, or lung cancer). All cases were hospitalized; 2 (29%) were fatal. All 7 confirmed cases were clustered in time. Date of symptom onset ranged from September 10 through October 16 (see Table 1). Three confirmed cases had substantial exposure to the LTCF during the incubation period of 2 to 10 days: 2 were nonambulatory residents, and 1 made daily visits, staying up to 6 hours per day. Two confirmed cases had no discoverable exposure to indoor areas of the LTCF but had substantial exposure to the attached hospital. The remaining 2 confirmed cases had no exposure to the indoor areas of the LTCF or hospital. One of these case patients lived approximately 0.4 km from the hospital. The other visited a medical office suite neighboring the hospital in the 3 days prior to symptom onset. Because case-finding efforts included active county-wide surveillance, retrospective chart review at the LTCF and hospital, and complete surveys of persons in geographic proximity to the suspected source, we believe these cases accurately define the scope of the outbreak.

**Environmental investigation**

No *Legionella* was isolated from any of 63 samples collected from the LTCF and the hospital water systems and air-handling systems, and no decontamination measures or other maintenance changes within the LTCF had been undertaken prior to the environmental investigation. Conversely, Lp1 monoclonal antibody subtype 1,2,5,6 (type strain Philadelphia 1) was isolated from 1 sump water sample and all 4 swabs taken from the larger of the 2 cooling towers serving the nearby factory. Lp1 subtype 1,2,5,6, was found in a second sump water sample, the only sample for which testing for epitope 6 was performed. No *Legionella* was recovered from a sample taken from the municipal tap that feeds the tower. Lp1 was also recovered from the smaller of the 2 cooling towers; however, this second tower was not in operation during the outbreak period.

The LTCF is provided with outdoor air through 2 roof-mounted intakes, which filter air through pleated prefilters followed by bag filters. The *mip* gene of *L pneumophila* was detected in 6 of 9 filter-paper samples snipped from these 4 filters. All 4 filters contributed at least 1 positive filter-paper sample, suggesting that the exterior of the LTCF was exposed to aerosols contaminated with *Legionella* and that the air intakes provided a route of entry for *Legionella* into the LTCF. In addition, unfiltered air could enter the LTCF through open windows because all patient rooms had operable windows.

**DISCUSSION**

The present LTCF outbreak of LD occurred as part of a wider community outbreak associated with an industrial cooling tower. Although health care-associated transmission via colonized potable water systems is more common, this outbreak indicates that acquisition of LD among residents of LTCFs does not necessarily signify an institutional source of transmission. Indeed, LD in such patients may provide early warning of a community source. For this reason, outbreaks of health care-associated LD should be investigated by a multidisciplinary team of infection control
practitioners, clinicians, microbiologists, and health care and public health epidemiologists.

Several observations support our conclusion that the industrial cooling tower was the source of this outbreak. All cases had some exposure to the vicinity of the cooling tower. Two case patients, as nonambulatory LTCF residents, had no possible exposure to any other environment. However, despite exhaustive testing, no Legionella was cultured from the water systems or condensate from air-handling systems serving the LTCF or hospital. Two other case patients lacked exposure to the water and air inside the LTCF or hospital. Lp1 subtype 1,2,5,6—a subtype commonly associated with outbreaks (the CDC, unpublished data)—was detected in a nearby industrial cooling tower, and this tower was the only identified source of aerosolized water within a 0.8-km radius of the LTCF. An L pneumophila gene sequence was detected in multiple outdoor air-intake filters of air handlers serving the LTCF, suggesting that L pneumophila was introduced into the LTCF via an aerosol from the outdoors, either through open windows in resident rooms or the LTCF air-intake system.

Our investigation was limited by the lack of a clinical isolate, despite our best efforts to obtain one; thus, we were unable to determine whether Legionella isolated from the cooling tower matched the infecting strain. This limitation highlights the importance of obtaining respiratory specimens for culture from all patients with health care-associated pneumonia. Because each case of health care-associated LD represents an environmental transmission event, physicians should maintain a higher index of suspicion for LD for all patients with community-acquired pneumonia, regardless of whether they appear to be sporadic cases. Six days after the investigation began—when environmental samples collected within the LTCF proved to be negative—we expanded the investigation to include possible community cases and sources. Early identification of aerosol-generating devices in proximity to health care institutions may facilitate the identification of the source of the outbreak. In some circumstances, it may be appropriate to disable presumptively such devices until the investigation is completed and the actual source identified. In the United Kingdom, regulations require all premises with cooling towers and evaporative condensers to maintain those systems in a way that minimizes the risk of transmission of Legionella; there are no comparable statutes in the United States.

Finally, our study also demonstrates that community-acquired cases of LD that are temporally or geographically related to a health care-associated outbreak should not be discounted and may help direct the search for a source. Physicians should maintain a higher index of suspicion for LD for all patients with pneumonia, regardless of whether they appear to have acquired their illness from a community or health care setting.

References


A performance assessment of airborne infection isolation rooms

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Background: Airborne infection isolation rooms (AIIRs) help prevent the spread of infectious agents in hospitals. The performance of 678 AIIRs was evaluated and compared with construction design guidelines.

Methods: The pressure differentials ($\Delta P$) between the isolation rooms and adjacent areas were measured, and ventilation and construction details were recorded for each room. Ultrafine particle concentrations were evaluated in the rooms, surrounding areas, and ventilation systems serving the rooms. Measurements were analyzed as a function of room parameters.

Results: Only 32% of the isolation rooms achieved the recommended $\Delta P$ of $-2.5$ Pascals (Pa) relative to surrounding areas. AIIRs with solid ceilings had an average $\Delta P$ of $-4.4$ Pa, which was significantly higher than the average $\Delta P$ of $-2.0$ Pa for rooms with dropped ceilings ($P = .0002$). Isolation room ultrafine particle concentrations were more highly correlated with particle levels in surrounding areas ($R^2 = 0.817$) than in the ventilation systems serving the rooms ($R^2 = 0.441$). Almost all ventilation filters serving AIIRs collected fewer particles than anticipated.

Conclusion: The results indicate that hospitals are not all maintaining AIIRs to correspond with current guidelines. The findings also support the contention that having tightly sealed rooms helps maintain appropriate pressure differentials. (Am J Infect Control 2007;35:324-31.)

To limit airborne transmission of infectious agents in health care facilities, heating, ventilating, and air-conditioning (HVAC) systems are used to establish airborne infection isolation rooms (AIIRs). Properly functioning AIIRs require consistent negative-pressure differentials relative to the surrounding areas and sufficient air changes per hour.

HVAC systems provide fresh, conditioned, and filtered air to a building through supply ducts. Air-handling units move air through the system. Filters in an air-handling unit are a main line of defense against the spread of infectious disease in hospitals. Filter manufacturers rate their products according to the type of test conducted to determine the efficiency of the filters. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) dust spot efficiency rating measures a filter’s ability to capture atmospheric dust particles. The rating is given as the percentage of particles collected. Generally, standard prefilters are rated between 20% and 40%, whereas final filters may be rated above 80%. High-efficiency particulate air (HEPA) filters capture at least 99.97% of 0.3-μm diameter particles.

In addition to the supply ductwork, a system of return or exhaust ductwork is also found within a building. At many facilities, air exhausted from AIIRs is expelled directly outdoors. In others, exhausted air is passed through HEPA filters before it is returned to the supply system to limit the spread of infectious agents within the facility. AIIRs operate by having the return ducts remove air from the rooms at higher rates than the supply ducts add air. To balance the flows, air enters from outside an AIIR through cracks under doors or other points of entry. This creates a slight negative pressure within the AIIR relative to the surrounding areas.

Streifel and Marshall indicated that the most important parameters for an AIIR are room pressure, room ventilation rate, filtration, and directed airflow. Streifel et al concluded that self-closing doors and permanently sealed windows are critical for maintaining adequate pressure differential. The American Institute of Architects (AIA), which publishes design guidelines considered to be the standard of care for new isolation rooms, stressed these parameters and others considered essential for construction or renovation of AIIRs. The Centers for Disease Control and Prevention (CDC) also emphasized ventilation controls and recommended infection control procedures that should be implemented when patients require these rooms.

A few researchers have investigated the performance of AIIRs. Using smoke sticks, Fraser et al found that 45% of 115 negative-pressure isolation rooms tested were actually positively pressured relative to surrounding areas. When evaluating tuberculosis...
isolation rooms, Sutton et al\(^7\) determined that 28% of 25 rooms evaluated were positively pressured. Similar qualitative analyses by Pavelchak et al\(^8\) indicated that 38% of the 140 AIIRs they evaluated exhibited outward flow from under the door. One deficiency that contributed to problems in these rooms was that continuous airflow monitoring equipment did not function properly. Using a micromanometer, Rice et al\(^9\) measured pressure differentials for 4 AIIRs for 2- to 3-month periods in both summer and winter. Although the mean pressure difference was \(-0.3\) Pa, measurements ranged from \(-1.3\) Pa to \(+0.7\) Pa. All of these studies indicated that improperly functioning AIIRs are common.

With increasing concerns about bioterrorism and emerging infectious diseases, more attention has been given to the proper functioning of AIIRs in preparation for disease outbreaks. The purpose of this study was to evaluate the operation of AIIRs in hospitals in a post-9/11 environment and in comparison with the most recent recommendations issued by the AIA and the CDC. To fulfill this purpose, the study had 4 specific aims: (1) establish benchmarks to evaluate AIIR performance; (2) develop a questionnaire to provide preliminary information about participating hospitals, their HVAC systems, and their AIIRs; (3) visit each participating hospital to make measurements and record observations; and (4) analyze data from the questionnaires and site visits.

**METHODS**

The first 3 aims were data collection steps. Methods for accomplishing these aims will be discussed first. Approaches for analyzing the data, the fourth aim, will be discussed afterward.

**Data collection**

Benchmarks for AIIR performance were based on what the authors viewed as the most critical parameters in AIA and CDC recommendations\(^4,5\) These 6 “essential” parameters are shown in Table 1.

The next task was to develop an on-line questionnaire for hospitals to complete before site visits. The purpose of this questionnaire was to acquire important information regarding a hospital and its AIIRs before a site visit to help plan the visit and decrease the time needed for the visit. Because the questionnaire was used for broader purposes than the study discussed here, it contained sections not only about AIIRs in emergency departments and other patient care areas but also sections on portable HEPA filter machines, portable anterooms, mobile isolation transport systems, surge capacity areas, and emergency department triage and holding areas.

Performance relative to parameters 2 and 4 in Table 1 was self-reported by the hospitals on the survey. Air changes per hour (ACH) in the AIIRs were self-reported by the hospitals rather than being measured during the site visit because of time considerations. In some cases, the ACH were measured by facility staff. In others, the reported values were design specifications. However, many facilities had no information about the air-change rates in their AIIRs.

Upon completion of the surveys, site visits were conducted. The AIIRs and air-handling units serving them were inspected visually and measurements were taken by the researchers to assess parameters 1, 3, 5, and 6 in Table 1 and to confirm responses for parameter 4. Other nonessential parameters, discussed below, were measured as well.

The pressure differential was measured using a DG-700 Pressure and Flow Gauge (The Energy Conservatory, Minneapolis, MN) sensitive to 0.1 Pa. A 6-inch metal probe was attached to the unit by a 12-inch length of tubing. The probe was inserted through the undercut of the closed door leading to the area that was to be measured. After the instrument came to equilibrium, a 5-second average of the pressure differential was recorded. The pressure differentials for all of the doors leading to the isolation room were measured, including the door from the corridor to the anteroom, when present, and the door from the anteroom to the isolation room. If the AIIR had doors to both an anteroom and a hallway, the pressure differential to the hallway was recorded. When access to an AIIR was strictly through an anteroom, the pressure differential for the AIIR was recorded as the greater of the differential from the hallway to the anteroom or the differential from the anteroom to the isolation room.

In addition to measuring the pressure differential of the isolation room, particle number concentrations were measured inside the isolation rooms using a P-Trak Ultrafine Particle Counter (TSI Inc., Shoreview, MN), which counts particles with diameters ranging

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**Table 1. Critical parameters for benchmarking AIIR performance.**

<table>
<thead>
<tr>
<th>All AIIRs should …</th>
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<tbody>
<tr>
<td>1. Have a negative pressure differential between the isolation room and the surrounding areas of at least 2.5 Pa(^4,5)</td>
</tr>
<tr>
<td>2. Have at least 12 air changes per hour(^4,5)</td>
</tr>
<tr>
<td>3. Have self-closing doors leading into the isolation rooms(^4,5)</td>
</tr>
<tr>
<td>4. Have a permanently installed pressure monitor(^4)</td>
</tr>
<tr>
<td>5. Not have a system installed allowing the room to switch from negative to positive pressure or function as both an isolation room and a protective environment room(^4,5)</td>
</tr>
<tr>
<td>6. Have ASHRAE dust spot tested filters of at least 90% efficiency installed in the supply air unit that serves the AIIR(^4,5)</td>
</tr>
</tbody>
</table>

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\(^1\) Pressure differentials were measured using a DG-700 Pressure and Flow Gauge (The Energy Conservatory, Minneapolis, MN) sensitive to 0.1 Pa. A 6-inch metal probe was attached to the unit by a 12-inch length of tubing. The probe was inserted through the undercut of the closed door leading to the area that was to be measured. After the instrument came to equilibrium, a 5-second average of the pressure differential was recorded. The pressure differentials for all of the doors leading to the isolation room were measured, including the door from the corridor to the anteroom, when present, and the door from the anteroom to the isolation room. If the AIIR had doors to both an anteroom and a hallway, the pressure differential to the hallway was recorded. When access to an AIIR was strictly through an anteroom, the pressure differential for the AIIR was recorded as the greater of the differential from the hallway to the anteroom or the differential from the anteroom to the isolation room.

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\(^2\) Particle number concentrations were measured inside the isolation rooms using a P-Trak Ultrafine Particle Counter (TSI Inc., Shoreview, MN), which counts particles with diameters ranging
from approximately 0.02 to 1 μm. This size range includes individual viruses and smaller bacteria. Particles were measured in occupied isolation rooms by inserting a telescoping wand that adjusts from 18 inches to 3 feet through the undercut of the door. The real-time particle concentrations were observed until the displayed concentration was steady, after which a 10-second average measurement was taken. For AIIRs that were not occupied, the room was entered, the particle counter was allowed to come to equilibrium, and a measurement was collected. Particles were also measured in the corridor outside of the isolation room.

Room parameters relevant to the AIIRs were recorded. The ceiling type of the isolation room, anteroom, and bathroom were observed and recorded as either dropped (acoustic laid in) or solid (hard or plaster). The type of ventilation serving the isolation room, anteroom, and bathroom was also recorded, eg, supply only, supply and exhaust, exhaust only, or none. Whether the door leading to the isolation room was self-closing or not was marked. Finally, whether the room was used as a protective environment for immunocompromised patients as well as an AIIR was recorded.

Air-handling units that served 1 or some of the patient care areas in the hospitals were inspected. The facilities engineer was asked for the percentage of air being recirculated in the system versus fresh air, the ASHRAE-rated filtration efficiency of the installed filters, and the areas served by the air-handling unit. The efficiency of the filters in the air-handling units was measured using the P-Trak. For air-handling units with predrilled service ports, the probe of the particle counter was inserted into the duct and allowed to come to equilibrium. A 10-second average concentration was then measured. For units that did not have predrilled ports, measurements were collected from the downstream side of the filter bank with the access door slightly ajar to allow the probe into the unit. Air downstream from the filter flowed out of the door with sufficient velocity to prevent any contaminant air from the surrounding area to enter and skew the results. Measurements were not collected from the mixing chambers upstream from the filter bank if access ports were not available because of the drawing of air from outside of the system. For sufficiently large ventilation systems, the unit was physically entered and the door closed. Ten-second average measurements were then measured after the P-Trak had come to equilibrium.

Data analysis

The data set included measurements and observations for 678 AIIRs. Only partial data were available for many of the rooms. Summary statistics were calculated for the factors evaluated. For pressure differential and ACH, the percentages of rooms meeting the recommendations, average values, and standard deviations were determined. For self-closing doors, permanently installed pressure monitors, rooms that switched from negative to positive pressure, and air-handling units having ASHRAE-tested filters of at least 90% dust spot efficiency installed, the percentages of rooms meeting the recommendations were determined.

The efficiencies of the filters installed in the air-handling systems measured using the P-Trak were calculated using the equation

$$\eta_{\text{filter}} = 100 \times \left( \frac{c_{\text{pre}} - c_{\text{post}}}{c_{\text{pre}}} \right)$$

in which $\eta_{\text{filter}}$ is the filter efficiency, $c_{\text{pre}}$ is the particle concentration upstream from the filters, and $c_{\text{post}}$ is the particle concentration downstream from the filters.

An initial data set including the first 55 AIIRs visited was evaluated statistically to determine whether any correlations existed between pressure differential or isolation room particle concentrations and various room parameters. Based on these results, the null hypotheses shown in Table 2 were developed and tested with data from as many AIIRs as possible from the full data set.

Hypothesis 1 was tested using both a 2-sample $t$ test assuming unequal variances and the Mann-Whitney $U$ nonparametric test. For hypotheses 2 to 5, relationships between variables were compared using linear regression. $P$ values for slope and intercept were calculated, and correlation coefficients ($R^2$) were determined. Particle concentration data used to test hypotheses 3 and 4 were converted to the logarithm of particle concentration because the readings appeared to be distributed lognormally. For the single data point with zero particles, which would be undefined when its logarithm was taken, a particle concentration of 0.5 particle/cm$^3$ was utilized for conversion to a logarithmic value. Most air-handling units served more than 1 isolation room. Therefore, to test hypothesis 3, the logarithm of particle concentration downstream from an air-handling unit was compared with the logarithm of the average of the particle concentrations in the rooms served by that air handler. For hypotheses 6 to 9, $\chi^2$ analyses were used to determine whether meeting the guidelines for various room variables had a significant impact on meeting the recommended pressure differential of $-2.5$ Pa.

The numbers of rooms for which data were available for each test are listed in Table 2. These numbers are lower than the 678 rooms in the database because of...
incomplete self-reporting of data by the hospitals and, in just a few cases, errors in measurements. The number of comparisons for hypothesis 3 is small because of the aforementioned averaging of particle concentrations for AIIRs served by a single air-handling unit.

RESULTS

The data collected from all hospitals were compared against the current design guidelines\(^4,5\) to determine the percentages of isolation rooms operating according to current standards. These results are presented in Table 3. Only 32% of the rooms assessed were found to have the recommended pressure differential of \(-2.5\) Pa. In addition, 58 rooms, approximately 9% of those evaluated, were positively pressurized.

Isolation rooms with solid ceilings had an average pressure differential of \(-4.4\) Pa, which was significantly higher than the differential of \(-2.0\) Pa measured for rooms with drop ceilings according to the 2-sample \(t\) test with unequal variances (\(P = .0002\)). The difference in the distribution of pressure differentials was also significant by the Mann-Whitney \(U\) test (\(P = .0002\)). The pressure differentials for isolation rooms with solid ceilings were found to have a significantly higher variance, 56.3 Pa\(^2\), than those for rooms with drop ceilings, 12.2 Pa\(^2\) (\(P < .0001\)).

A regression was performed to determine whether \(\text{ACH}\) was a significant predictor of pressure differential (\(\Delta P\)). When this relationship was evaluated for 366 rooms that had data for both \(\Delta P\) and \(\text{ACH}\), a significant relationship was found (\(P = .021\)). However, the relationship with air-change rate explained only a small portion of the variance in \(\Delta P\) for the complete data set (\(R^2 = 0.015\)). Figure 1 shows the data for pressure differential plotted against air-change rate. The regression line for the data is shown together with a dark shaded region representing the 95% confidence band for the prediction of the line. The lighter shaded region represents the 95% prediction band for estimating \(\Delta P\) for a single AIIR if information about its \(\text{ACH}\) already exists.

We conducted \(\chi^2\) tests to determine whether room and ventilation parameters could affect the likelihood that AIIRs achieve the recommended pressure differential of \(-2.5\) Pa. The associations of 2 parameters with pressure differential were significant statistically. Rooms with at least the recommended 12 \(\text{ACH}\) achieved the recommended pressure differential 39.6% of the time, whereas rooms with less than 12 \(\text{ACH}\) achieved the recommended pressure only 22.8% of the time (\(\chi^2 = 9.56, P = .0020\)). In addition, 45.3% of AIIRs with solid ceilings achieved the recommended pressure differential compared with only 28.5% of rooms with drop ceilings (\(\chi^2 = 11.86, P = .0006\)). Significant associations with meeting the recommended pressure differential were not found for having permanently sealed windows (\(\chi^2 = 2.15, P = .14\)) or for the presence of an anteroom (\(\chi^2 = 0.05, P = .83\)).

Airflow relationships were studied further by investigating ultrafine particle concentrations. The relationship between logarithms of particle concentrations in the isolation rooms and logarithms of particle concentrations directly after the final filters in air-handling units supplying the rooms was analyzed. The relationship, shown in Fig 2 for a total of 107 pairs of data, was significant (\(P < .0001\)) with an \(R^2\) of 0.441. The Figure shows the data, a 1:1 line, and a regression line for the data with 95% confidence bands. The AIIR particle concentrations were generally higher than the postfilter concentrations, especially when the postfilter counts were low. The regression line was significantly different from the 1:1 line.

The relationship between logarithms of particle concentrations in hallways or anterooms adjacent to the door of the AIIRs was also compared with the logarithms of particle concentrations in the AIIRs. Results are presented in Fig 3 for the 569 pairs of data. The relationship was significant (\(P < .0001\)) with \(R^2 = 0.817\). The 1:1 line falls within the narrow 95% confidence bands for the regression line.

Although 93% of the air-handling systems assessed had the proper ASHRAE-rated final filters installed, few of these filters performed at the rated filtration efficiency. The filter efficiency calculated according to

<table>
<thead>
<tr>
<th>Table 2. Null hypotheses tested statistically and number of observations used in each analysis</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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equation 1 was less than the rated efficiency for 107 of 112 filter banks tested. A geometric average of the change in particle penetration indicated that filters allowed, on average, 437% more particles to penetrate than ratings would have indicated. This value was significant statistically ($P < .0001$). Figure 4 shows the relationship between measured and rated efficiencies of the filters.

The trend indicating that installed filters are not operating as specified was particularly noticeable for the HEPA filters that were tested. Of 9 filter banks with HEPA filtration, none reached the 99.97% efficiency required for HEPA status, although 1 was close. In fact, only 4 of the 9 filter banks achieved 99% efficiency.

**DISCUSSION**

Results in Table 3 indicate that not all hospitals are operating AIIRs that meet today’s standards. If it is accepted that the current standards reflect essential

<table>
<thead>
<tr>
<th>Functional criteria</th>
<th>Percentage of rooms meeting the functional criteria</th>
<th>($n =$ number of rooms evaluated for a criterion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure differential between isolation room and surrounding areas greater (more negative) than 2.5 Pa</td>
<td>32% ($n =$ 672)</td>
<td></td>
</tr>
<tr>
<td>At least 12 air changes per hour</td>
<td>51% ($n =$ 370)</td>
<td></td>
</tr>
<tr>
<td>Permanently installed pressure monitor</td>
<td>76% ($n =$ 566)</td>
<td></td>
</tr>
<tr>
<td>Ventilation system does not allow room to be used for infectious isolation and protective isolation</td>
<td>90% ($n =$ 560)</td>
<td></td>
</tr>
<tr>
<td>Self-closing doors are installed</td>
<td>36% ($n =$ 621)</td>
<td></td>
</tr>
<tr>
<td>Final filters are rated at $\geq 90%$ efficient</td>
<td>93% ($n =$ 403)</td>
<td></td>
</tr>
</tbody>
</table>

Fig 1. Pressure differential versus air changes per hour. The thick line represents the regression between the 2 variables. The dark shaded region is the 95% confidence band for the mean value of pressure differential at each air-change rate. The light shaded region is the 95% prediction band for an individual room’s pressure differential if the air-change rate for the room is known.

Fig 2. Open triangles represent particle concentrations in the AIIRs versus particle concentrations immediately downstream from the filters in the air-handling units serving the AIIRs. The thick line represents the regression between the 2 variables. The shaded region is the 95% confidence band for the regression line. The 1:1 line is also displayed.
criteria, facility managers should assure the functionality of their AIIRs. Hospitals should strive to achieve the ventilation criteria recommended by the AIA and the CDC, an effort that is sometimes difficult because of the expense of renovations versus the expected risk related to the current condition of their AIIRs. However, a response is too late once an infectious patient enters a health care facility. Best practice includes preparation and response development appropriate to the risk. Although risks are uncertain for many infectious agents, risk management principles are already used to prepare protocols for more common agents, such as *Mycobacterium tuberculosis* , to assure that infectious disease management components are ready at any time.

Although the finding that 9% of rooms were positively pressurized is disturbing, this value is an improvement over the percentages of rooms measured as positively pressured in earlier investigations.5-8 One possible explanation for this reduction in the percentage of positively pressured rooms is that hospitals are learning over time how to make their AIIRs function more effectively. Other potential explanations include the better pressure measurement techniques used in this study and the capabilities and resources of the population of hospitals evaluated in this study.

Rooms with laid-in ceilings are more likely to have air leakage because of wire chases and pipe runs. This may be the reason that AIIRs with solid ceilings have a higher pressure differential on average. Tighter construction in AIIRs may help hospitals attain the desired pressure differential.

The poor correlation between ΔP and ACH suggests that, despite the statistically significant relationship, air-change rate was not a good predictor for pressure differential. In Fig 1, the narrowness of the confidence band indicates that the mean value of ΔP at each ACH is well understood for the AIIRs tested. However, like the poor correlation coefficient, the width of the prediction band indicates that air-change rate is almost useless for predicting the pressure differential for an individual

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**Fig 3.** Open triangles represent particle concentrations in the AIIRs versus particle concentrations in the areas adjacent to the AIIRs. The thick line represents the regression between the 2 variables. The shaded region is the 95% confidence band for the regression line. The 1:1 line is also displayed.

**Fig 4.** Triangles represent measured filter bank efficiency in air-handling units serving AIIRs versus dust spot efficiency reported by manufacturers. The dashed line is a 1:1 relationship between measured efficiency and manufacturer-reported efficiency.
Adequate airflows are important for minimizing air leakage and ensuring the recommended negative pressure differential is achieved, if necessary. Having more airflow to work with should allow a ventilation system balancer to achieve the recommended negative-pressure differential of $-2.5 \text{ Pa}$ by checking for leakage and sealing areas in the room while adjusting the ventilation balance, if necessary. Having more airflow to work with should allow a ventilation system balancer to achieve the recommended negative-pressure differential more easily. In addition, adequate airflows are important for minimizing air migration out of AIIRs when their doors are opened.

Although results from the $\chi^2$ tests show that anterooms may not significantly influence the steady-state pressure differential of AIIRs, their importance in limiting the migration of air from the AIIR to the corridor when doors are opened has been documented. Figures 2 and 3 indicate that AIIR particle concentrations are more closely related to particle concentrations in surrounding areas than to concentrations in the air supplied to the rooms by the HVAC system. Experimental factors may have influenced this result. Some unoccupied isolation rooms were entered, and the measured particle counts may reflect the air that was drawn into the room when the door was opened. For those rooms that were not entered, the probe was inserted through the undercut of the door. The particles sampled in this way may reflect concentrations influenced more directly by air penetrating under the door than concentrations in the rest of the room.

The apparent influence of surrounding area particle levels on the isolation room concentrations is important from an infection control standpoint. The closer correlation between AIIR and surrounding area particle concentrations than between AIIR and postfilter concentrations suggests that more of the air entering the AIIR is coming from the surrounding areas than from the supply air. This, in turn, suggests that typical AIIRs have many leaks where air can enter the room. Such leaks make the attainment of a satisfactory pressure differential difficult, limit the maximum pressure differential that can be attained, and require the use of a greater exhaust flow than would otherwise be necessary. The result also suggests that the areas surrounding AIIRs should be supplied with air that has passed through 90% efficient filters.

The filter efficiencies measured in the air-handling units are typically lower than the efficiencies indicated by manufacturers. Some of the lower measured efficiency may be linked to the utilization of the ultrafine particle counter to evaluate efficiency in this study versus methodology for the ASHRAE dust spot efficiency rating. Although the diameters of particles measured during the dust spot procedure and using the P-Trak overlap, the particle sizes assessed using the P-Trak are smaller on average. Whether this particle size difference has a positive, a negative, or no bias on the relationship of the 2 efficiency measures is uncertain. However, the anticipated extent of any measurement bias cannot account fully for the differences observed in Fig 4.

Much of the reduction in filtration efficiency of the tested filters is likely due to predictable changes in the efficiency of HVAC filters. Raynor and Chae found that, over a 19-week period, filters made from synthetic fibers that carry electrostatic charges exhibited substantial efficiency losses as they became loaded with particles in an operating HVAC system. The findings could also mean that filters are not being installed properly, leaving gaps between filter housing and filter racks through which particles can penetrate. As hospitals install higher efficiency filters, this becomes even more important because of the greater pressure drop across the higher efficiency filters. Increased pressure drop will cause air to bypass the filters via gaps between filters and degraded filter seals more easily than with less efficient filters with lower pressure drop.

For several points in Fig 4, the measured efficiency was found to be less than zero, indicating the possibility of particle resuspension or generation downstream from filter banks. This could be related to unclean ductwork or overly dusty filters.

The finding that even HEPA filters are not reducing particle levels as much as anticipated may have important consequences for those hospitals that use HEPA filtration before recirculating potentially contaminated air exhausted from AIIRs to hospital environments. If this air is not being filtered properly, opportunities for airborne transmission are more likely. In addition, HEPA filters are counted on in other parts of hospitals to reduce levels of infectious agents. For example, HEPA filters are used in operating suites to protect patients from airborne agents. A significant health concern may be posed if users assume these filters collect all particles with at least 99.97% efficiency. The installation of HEPA filters in operating suites must be managed to ensure an aseptic environment for the patient.

CONCLUSION

Not all hospitals are prepared to meet current airborne infectious disease standards. This is not necessarily surprising given the fact that there are no rules or incentives in place for hospitals to make these expensive renovations. The organizations responsible...
for accrediting health care facilities should consider inspecting some of the important ventilation parameters involved with AIIRs.

The majority of AIIRs tested in this study did not achieve the negative-pressure differential of 2.5 Pa recommended by the AIA. In addition, results indicated that AIIRs with drop ceilings are less likely to achieve the recommended pressure differential than those with solid ceilings. The “tightness” of the room should be considered when constructing or renovating AIIRs.

It is a concern that hospital ventilation systems are often not filtering particles at the expected efficiency for the installed filters. Means and methods for facilities and infection control staff should be developed to ensure that the air filters are properly installed in their HVAC systems and that they are changed at regular intervals.

The information obtained from this study is valuable in developing a risk mitigation plan in case of emerging or pandemic infectious diseases. The federal Bioterrorism Hospital Preparedness Program provides incentives for AIIR preparedness because problems are difficult to fix in the middle of an incident.

The authors thank Jeanne Anderson, Kathleen Harriman, Franci Livingston, Fernando Nacionales, and James Loveland of the Minnesota Department of Health for their assistance with this study.

References

An investigation of *Aspergillus* cardiac surgical site infections in 3 pediatric patients

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**Background:** Within a 3-month period, 3 pediatric patients at our hospital developed *Aspergillus* surgical site infections after undergoing cardiac surgery.

**Methods:** A multidisciplinary team conducted an epidemiologic review of the 3 patients and their infections, operative and postoperative patient care delivery, and routine maintenance of hospital equipment and air-filtration systems and investigated potential environmental exposures within the hospital that may have contributed to the development of these infections.

**Results:** Review of the patients and their infections, operative and postoperative patient care delivery, and routine maintenance did not reveal a source for infection. Inspection of operating room (OR) facilities identified several areas in need of repair. Of the 58 samples of air and equipment exhaust in the ORs and patient care areas, 11 revealed 2 to 4 colony-forming units of various *Aspergillus* species per cubic meter of air, and the remaining 47 samples were negative for *Aspergillus*. Eighty-three samples of surfaces and equipment water reservoirs were obtained from the OR and patient care areas. One culture of a soiled liquid nitrogen tank housed between the 2 cardiac ORs revealed 13 colony-forming units of *Aspergillus*.

**Conclusion:** No definitive source was identified, although a soiled liquid nitrogen tank contaminated with *Aspergillus* and kept near the OR was found and could have been a possible source. (Am J Infect Control 2007;35:332-7.)

*Aspergillus* species are ubiquitous fungi causing a wide spectrum of clinical disease in both immunocompetent and immunocompromised patients.1 *Aspergillus* is found in decaying vegetable matter, soil, dust, and air and may contaminate hospital rooms and equipment. Outbreaks of postoperative *Aspergillus* infections including osteomyelitis, graft infection, and endocarditis have been described.2-5 *Aspergillus* surgical site infections (SSI) are rare but have previously been described in immunocompetent adults who have undergone cardiac surgery and have included endocarditis, sternal wound infections, osteochondritis, and mediastinitis.6-14 *Aspergillus* SSI have been described very rarely in children undergoing cardiac surgery.15

*Aspergillus* outbreaks have been associated with ongoing hospital construction.16 When not associated with construction, sources for *Aspergillus* infections have occasionally been identified with intensive environmental sampling and molecular typing.4,5,17 Various infection control measures such as decontamination, high-efficiency particulate air (HEPA) filtering of ambient air, and containment of construction sites can be efficacious in reducing nosocomial acquisition of *Aspergillus*.16

We present 3 pediatric cases of *Aspergillus* cardiac SSI and the subsequent environmental investigation and its results. Our objective in reporting our experience is to provide a framework for others who are charged with investigating similar occurrences in their institutions.

**OUTBREAK DESCRIPTION**

Cases were defined as all patients who had undergone cardiac surgery at our institution between January 2004 and May 2005 and who had at least 1 positive culture for *Aspergillus* or histopathology consistent with *Aspergillus*.

**Case 1**

A 3-year-old female with tetralogy of Fallot and pulmonary atresia underwent Dacron patch closure of her ventricular septal defect and placement of a 12-mm bovine prosthetic right-ventricle-to-pulmonary-artery...
conduit at our hospital in July 2004. She had previously undergone neonatal repair and placement of a large right-ventricle-to-pulmonary-artery patch in her native China prior to being adopted by an American family. She developed sternal erythema and swelling, requiring repeated incision and drainage procedures. Cultures from these procedures grew either coagulase-negative staphylococci or nothing. Echocardiogram revealed a small vegetation on the leaflet of the pulmonary valve conduit, but multiple blood cultures were sterile. Follow-up echocardiogram revealed narrowing at the distal end of her conduit and absent left pulmonary artery blood flow. A pulmonary artery thrombectomy was performed, and the right-ventricle-to-pulmonary-artery conduit was replaced.

Culture of the sternal wound and 4 cultures of the thrombus obtained in December 2004 grew Aspergillus fumigatus. Pulmonary nodules were identified on computerized tomography scan. She received 6 months of intravenous caspofungin and 8 months of oral voriconazole therapy with resultant improvement in her pulmonary nodules and resolution of her surgical wound inflammation.

Case 2

A 6-month-old female born with phenotypic features consistent with Kabuki syndrome and hypoplastic left heart syndrome with partial anomalous pulmonary venous return underwent palliative modified Norwood procedure and placement of a 6-mm polytetrafluoroethylene Sano shunt at 5 days of life. Bovine pericardium was used to patch her pulmonary artery and construct her neoaorta. Her sternum was left open, and her wound was closed with a latex patch sutured to the skin; sternal closure was achieved on postoperative day (POD) 5.

At 6 months of life, in January 2005, she underwent a bidirectional Glenn procedure and removal of the Sano shunt. Because of pulmonary hemorrhage and hypoxemia, she was placed on venoarterial extracorporeal membrane oxygenation (ECMO) postoperatively. Sternal closure was again delayed. She received empiric antibiotics until POD 8 when she was placed on piperacillin/tazobactam for a Pseudomonas aeruginosa bloodstream infection. Despite repeated cardiac catheterization-based attempts to reverse hypoxemia, she remained on venoarterial ECMO, and her condition deteriorated. Mechanical support was withdrawn, and she expired on POD 16 in January 2005.

Autopsy limited to the chest demonstrated diffuse, patchy pleuritis; epicarditis; and mediastinitis and fungal elements with an appearance consistent with Aspergillus. Aspergillus was not isolated from any cultures.

Case 3

A 1-month-old male born with hypoplastic left heart syndrome underwent palliative Norwood stage 1 procedure and placement of a 6-mm polytetrafluoroethylene Sano shunt at 5 days of life in February 2005. Bovine pericardium was used to construct his neoaorta. His postoperative course was unremarkable, and he was discharged home on day of life 19. Follow-up echocardiogram was suspicious for a ventricular pseudoaneurysm; he developed ventricular dysrrhythmias and had difficulty maintaining blood oxygen levels.

On day of life 28, his ventricular pseudoaneurysm was resected and patched with bovine pericardium. Sternal closure was delayed, and his wound was closed with a latex patch sutured to the skin. He underwent 1 echocardiogram in the intensive care unit (ICU) on POD 1 while his sternum was still open; the cardiologists attempted to simulate the operating room (OR) environment with routine sterile technique, gowns, and draping.

Tissue obtained from initial resection of the pseudoaneurysm grew 1 colony of Aspergillus fumigatus on POD 3 in March 2005. Two cultures from the mediastinum, a second culture from the pseudoaneurysm, and cultures from both chest tubes obtained at the time of chest closure on POD 4 also grew Aspergillus fumigatus.

The patient was treated with liposomal amphotericin B from the time Aspergillus was first isolated, and caspofungin was added 1 week later. His clinical status worsened with increasing difficulty maintaining blood oxygen levels and clotting in his revised Sano shunt, requiring placement of an intraconduit stent, vasoactive medications, and venovenous ECMO. Support was withdrawn in the setting of increasing hemorrhage and hypoxemia, and the patient expired on POD 23. Autopsy revealed a mycotic embolus in the right middle lobe artery, mycotic clots in the Sano shunt, and right ventricular epicardial Aspergillus infection.

MATERIALS AND METHODS

Setting

Children’s Hospital and Regional Medical Center is a 250-bed tertiary care pediatric hospital located in Seattle, Washington, with 15 ORs and 6 additional anesthesia suites. A mean of 207 cardiac surgeries were performed annually from 2003 to 2005. All cardiac surgeries took place in ORs 11 and 12, and a cardiac core between them was used as a staging area for cardiac surgeries. Equipment such as ECMO machines, bypass machines, cell savers, and slush machines were stored and prepped in the cardiac core. Perfusion supplies were stored in central supply. Central supply was not HEPA filtered. Supplies were received from a
staging area adjacent to the outdoor loading dock. Shipping containers remained in the staging area. Supplies were removed from packaging and placed on shelving in central supply to await transport to the OR.

A 31-bed pediatric ICU contains 14 beds set aside for cardiac intensive care patients and houses these patients postoperatively. These rooms were not HEPA filtered.

Outbreak response team

Infection control at our institution performs active surveillance for all infections in cardiac surgery patients and, as a result, had been aware of and investigating the *Aspergillus* isolated from the patient in case 1. The autopsy and microbiology results from case 2 and the positive *Aspergillus* culture in case 3 became available simultaneously in early March 2005. At that time, an outbreak response team was formed to identify a source of *Aspergillus* contamination that may have caused the 3 cardiac SSI infections. The team consisted of executive-level hospital administration including the associate medical director of the hospital, the director of the operating room, ICU nursing and administration, the cardiac surgeons, a cardiac intensivist, the director of infection control, the infection control practitioners, the director of building and engineering, and the director of central supply. The team was given the authority to halt cardiac surgery, and, as an initial step, nonemergent cardiac surgeries were postponed until the environment was determined to be free of potential *Aspergillus* sources. The multidisciplinary team reviewed all data from the epidemiologic and environmental reviews and sanctioned the interventions and ensured the timeliness of the process. The infection control professionals took a leadership role in performing the environmental evaluations and investigations mandated by the outbreak response team.

Epidemiologic investigation

The 3 patients, their cardiac procedures (dates, instruments, supplies, equipment, implants, and others), and the postoperative wound management were reviewed to identify any exposures that may have contributed to the development of the infections. This information was evaluated along with the patients’ location within the hospital, the OR in which the procedures took place, and the dates of construction within the hospital. In addition, all other cases of *Aspergillus* infection within the institution were reviewed.

Environmental evaluations and interventions

Thorough cleaning of all involved rooms and equipment was performed during the course of the investigation. This included wiping down all surfaces of rooms and equipment with hospital disinfectant when possible and HEPA vacuuming all areas that could not be wiped down.

The 2 cardiac ORs, the cardiac core between them, the cardiac ICU rooms inhabited by the patients postoperatively, the common spaces in the OR (locker rooms, supply closets, and others), and the central supply rooms that housed equipment used in cardiac surgeries were all inspected for visible signs of mold contamination or damage that might lead to mold growth. Periods of hospital construction were reviewed. Routine scheduled maintenance and changing of equipment and air filters were reviewed.

Cultures were obtained from surfaces inside the ORs and the cardiac core as well as in the cardiac ICU. Cultures were also obtained from OR and cardiac ICU equipment, with particular attention paid to equipment that routinely contains standing water, such as ECMO, heating, and ice machines. Routine air-sampling results were reviewed, and additional air samples were obtained from ORs, cardiac core, central supply, and cardiac ICU. Exhaust from equipment with fans was also air sampled.

Microbiologic sampling and processing

Five-minute air samples were gathered and plated onto Sabouraud agar plates using a SAS Super 100 Microbial Air Sampler (Bioscience International, Rockville, MD). Exhaust from equipment was cultured in a similar manner. Water reservoirs in equipment were cultured and plated onto Sabouraud agar plates.

Surface culture specimens were obtained by swabbing a 6-square-inch area with a sterile 2 × 2-inch gauze pad moistened with sterile saline. The gauze was sent to the laboratory in a sterile container, where sterile saline was added, and the container was vortexed. The saline was drawn off and centrifuged, and the resultant pellet was cultured on Sabouraud agar plates. All plates were processed and read by the Children’s Hospital Microbiology laboratory.

RESULTS

Epidemiologic investigation

The review of the 3 patients and their procedures did not reveal a source of *Aspergillus*. Review of all other cases of *Aspergillus* diagnosed within the institution during 2004 and the first 6 months of 2005 did not reveal other cases of *Aspergillus* SSI. In addition, ongoing surveillance of the oncology population did not reveal an increase in hospital-associated *Aspergillus* (data not shown).

A time line of the cases (surgery, diagnosis of *Aspergillus* infection, and others), the construction within
the institution, and the outbreak investigation was drawn (Fig 1). Construction in the OR was not initiated until several months after the operative procedure of the first case. However, because of the nature of the infections, a thorough evaluation of the OR environment and equipment was performed. In addition, the ICU environment was also investigated because 2 of the 3 patients had delayed sternal closure.

Environmental evaluations and interventions

The initial surgery for case 1 was performed in OR 12, and the initial surgeries for cases 2 and 3 were performed in OR 11 (Fig 1). No structural defects that might have contributed to distribution of fungal spores were identified in either OR. Both ORs were consistently positively pressured both to the hallway and to the cardiac core between them. No structural defects were identified in the area in which perfusion supplies were stored in central supply.

Construction involving installation of a boom to facilitate video and computer functions took place in OR 12 from January to April 2005. During this time, the construction site was routinely inspected and found to be negatively pressured to the cardiac core and hallway with intact construction barriers. Routine air samples from outside the construction barriers were obtained and had no growth. During the investigation, air and surface samples from inside OR 12 were obtained (Table 1). No other internal construction occurred during the time period of the outbreak, although construction of a new outpatient facilities building on the hospital campus was ongoing throughout and for almost 1 year after the time of the outbreak (June 2004–March 2006).

Inspection of the cardiac core identified several areas of concern. There were areas of apparent prior water damage, including damage to a countertop support, a backsplash pulling away from the wall behind an ice machine, and an area of cracked vinyl flooring. The window sealing was failing, reportedly causing leaks after heavy rains. In response, the backsplash and countertop support were repaired, the windows were resealed, and the area was cleaned thoroughly.

There were various pieces of older equipment also housed in the cardiac core, including an ice machine, a liquid nitrogen tank, and a cryotank. The liquid nitrogen tank supplied the cryotank that contained homografts and required replacement weekly. Homografts and prostheses in the cryotank were never close enough to the nitrogen tank to be directly contaminated. However, setup of bypass pumps often took place adjacent to the tank, and the slush machines were stored adjacent to it as well. A new tank delivered during the investigation was noted to be quite dirty, despite the institutional policy calling for tanks to be wiped down with hospital disinfectant on the loading dock prior to their being brought to the OR. In response, the ice machine and nitrogen tank apparatus have been permanently removed and relocated.

Filters were in place and functioning appropriately for both ORs and the cardiac core. Preventive maintenance and filter changes had been performed as required. The OR is not HEPA filtered and is supplied with 95% filtered air.

Two physicians who perform echocardiograms during cardiac procedures were found to be using multiuse containers of lubricant and sharing some equipment between patients. Subsequently, an echocardiogram policy has been developed that calls for the following: appropriate disinfection of equipment shared between patients, including the ultrasound probe; avoidance of the surgical site whenever possible; antisepsis of the skin and use of single-use containers of ultrasound gel when an ultrasound must be performed near an incision; and use of a sterile sleeve if an echocardiogram must be performed on an open chest.

Samples and cultures

A total of 141 samples were obtained from air, surfaces, and equipment in ORs, central supply, and cardiac ICU (Table 1). Air samples were obtained in all areas both before and after thorough cleanings. Most cultures were negative for Aspergillus. When Aspergillus was isolated, it was usually few colony-forming units (2 to 4). The exception was the nitrogen tank, which revealed 13 colony-forming units of Aspergillus.

Follow-up

No further cases of invasive Aspergillus SSI have been detected in the cardiac surgery patients over a follow-up period of 17 months.
DISCUSSION

Aspergillus SSI is a rare but potentially lethal complication of surgery and has been infrequently described in the pediatric literature. We describe Aspergillus SSI in 3 pediatric cardiac surgery patients and the ensuing investigation to identify a source. Our investigation did not identify a definitive source of Aspergillus but did find evidence to suggest possible contamination from a liquid nitrogen tank housed between the 2 cardiac ORs. Aerosolization of Aspergillus spores has previously been implicated as a source for Aspergillus SSI, as in the case of a 54-year-old woman with Aspergillus flavus infection of her aortic prosthesis that was genetically similar to a strain cultured from an OR heater-cooler grill. In the case of our Aspergillus infections, if a soiled nitrogen tank was present in the cardiac core while bypass or slush machines were being prepared, fungal spores could have been transferred to the sterile wrappings of the equipment and carried into the OR. Spores could then have been aerosolized into a wound when the sterile wrappings were opened.

We recovered small amounts of Aspergillus from air sampling of the ORs, the cardiac core, and the various cardiac ICU rooms. Previous studies have recovered small amounts (at minimum, 2-5 colony-forming units per cubic meter) of Aspergillus from non-HEPA-filtered air in various hospital settings including ORs. The few airborne colonies of Aspergillus we obtained in the ORs are therefore expected and unlikely to have caused infection.

Molecular typing methods such as random amplification of polymorphic DNA have previously been used to link Aspergillus strains from patients with sources among hospital equipment. These methods are powerful tools with an ability to demonstrate a clear connection between an outbreak source and infected patients and should be considered in the evaluation of outbreaks. Such methods might have proved useful in linking our cases to Aspergillus species in the environment or on the liquid nitrogen tank but may have been difficult to interpret because the tank was changed weekly.

SSIs should be cultured for potential pathogens. Given its ubiquitous nature, consideration should be given to Aspergillus when cultures are negative and infection is unresponsive to standard antimicrobial therapy. Although thorough investigations may or may not uncover a definitive source for Aspergillus infections, the importance of such investigations cannot be overstated, given the severe morbidity and mortality associated with these infections. Investigations should include review of recent construction and routine maintenance; inspection of all relevant environments and equipment; and culture of air, surfaces, and equipment with particular attention to equipment with water reservoirs and fans. Consideration should also be given to the molecular typing of patient and environmental isolates.

Table 1. Summary of environmental culture results

<table>
<thead>
<tr>
<th>Location</th>
<th>Cultures (n)</th>
<th>Aspergillus growth (n)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface and standing water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR 11</td>
<td>20</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>OR 12</td>
<td>7</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Cardiac core</td>
<td>15</td>
<td>1</td>
<td>12 CFU Asp. sp., 1 CFU Asp. niger from nitrogen tank surface</td>
</tr>
<tr>
<td>Equipment</td>
<td>33</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Central supply</td>
<td>2</td>
<td>1</td>
<td>1 CFU Asp. niger from shelf</td>
</tr>
<tr>
<td>Cardiac ICU</td>
<td>6</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Air and exhaust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR 11</td>
<td>9</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>OR 12</td>
<td>9</td>
<td>1</td>
<td>2 CFU Asp. sp. per cubic meter of air</td>
</tr>
<tr>
<td>Cardiac core</td>
<td>8</td>
<td>1</td>
<td>2 CFU Asp. fum. per cubic meter of air</td>
</tr>
<tr>
<td>OR-general</td>
<td>10</td>
<td>4</td>
<td>2-4 CFU Asp. sp. per cubic meter of air in supply closet, locker room</td>
</tr>
<tr>
<td>Equipment</td>
<td>9</td>
<td>2</td>
<td>2 CFU Asp. fum., Asp. sp. per cubic meter of ICU equipment exhaust</td>
</tr>
<tr>
<td>Central supply</td>
<td>3</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Cardiac ICU</td>
<td>10</td>
<td>3</td>
<td>2 CFU each Asp. fum., Asp. fla. per cubic meter of air from 2 rooms</td>
</tr>
<tr>
<td>Outdoor</td>
<td>3</td>
<td>3</td>
<td>8-10 CFU Asp. fum. per cubic meter of air outside entrance nearest to OR</td>
</tr>
</tbody>
</table>

Asp. sp., Aspergillus species; Asp. fum., Aspergillus fumigatus; Asp. fla., Aspergillus flavus; CFU, colony-forming units.

References


Monitoring the effectiveness of cleaning in four British hospitals

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Cardiff and Bodelwyddan, Wales, United Kingdom

Background: A survey of cleaning effectiveness was conducted in two wards in four acute hospitals in England and Wales. Surfaces were monitored immediately before and after cleaning on three separate occasions using visual assessment, adenosine triphosphate (ATP) bioluminescence, expressed in relative light units (RLUs), and microbiological methods (aerobic colony counts [ACC]), expressed in colony forming units (cfu) per cm².

Methods: Comparison of data from a total of over 3000 assessments showed highly significant differences in failure rates between visual assessment and either ATP or microbiological counts. There was no significant difference in failure rates between ATP and microbiological counts. Using visual assessment, failure rates were significantly lower after cleaning than before. Using ATP or microbiological methods, failure rates were not significantly different after cleaning.

Results: Data obtained using both ATP and ACC, indicated considerable variability after cleaning and that failed surfaces were often well in excess of benchmark values.

Conclusions: Cumulatively, the results indicate that visual assessment is not a reliable indicator of surface cleanliness or of cleaning efficacy. Concerns also arise about the standards of surface cleanliness achieved after cleaning in the hospitals. (Am J Infect Control 2007;35:338-41.)

Hospital cleaning in the UK, and elsewhere, has a high media profile and has attracted adverse comments concerning lack of effectiveness and poor management.¹ ² ³ ⁴ Concerns have been expressed in the UK that cuts in cleaning budgets as a means to save money have led to a deterioration in hospital cleanliness.⁵ The government, in an attempt to improve standards, has launched a number of initiatives.⁶ ⁷ These often make use of “audits” (although most of these should be more correctly described as inspections or checks) to assess standards of cleanliness. However, rather than evaluate how cleaning was undertaken, or take a scientific approach to assessment,⁸ they rely on visual surface inspection and often provide little advice on how surface cleanliness is to be assessed. Cleanliness can be difficult to define⁹ and attempts have been made to make the visual assessment less subjective. Typical guidance found in one UK inspection includes “surface visually clean with no blood or body spillages, dust, dirt, debris, and spillages.”⁶ Other countries have also tried to both define and assess cleanliness. In the Netherlands, a standard (EN 2075) was developed that has more recently become a European Standard.¹⁰ However, this argues that an assessment of cleanliness must always be made in the context of how and when cleaning should have been undertaken. The INST A800 is a Nordic standard for the evaluation of cleaning efficacy and considers “friction, gloss, static electricity and hygienic quality indoors,” again with an emphasis on visual assessment.

In food manufacturing and processing, emphasis is placed on environmental surface cleanliness to control pathogens, and a more scientific approach to assessment has been adopted where routine use of microbiological and rapid test methods are linked to trend analysis.⁹ Concerns have been expressed about relying on visual assessment as the sole means for assessing cleanliness in hospitals,¹¹ and a previous study in one hospital indicated that it may overestimate cleaning efficacy.¹² Although routine environmental microbiological testing is not normally undertaken in hospitals, in the UK, microbiological surface standards have been proposed.⁸

Following on from previously published work,¹² the aims of the present study were to:

• Assess the efficacy of visual methods to assess cleanliness in relation to other techniques
• Compare surface cleanliness of common ward surfaces across four hospitals before and after cleaning

METHODS

The study was conducted across four opportunistically selected acute hospitals up to 250 miles apart in
England and Wales. A paediatric and a surgical ward was studied in each hospital (labeled A, B, C, and D) without discussion with cleaning staff, in order to minimize behavioral changes in cleaning practices. None of the hospitals had a comprehensively documented cleaning strategy. Hospitals were visited on three occasions to evaluate cleanliness of selected environmental sites immediately before and after cleaning. Experimental methods and the selection of environmental surfaces were based on previous research.11,12 In total, 27 surface sites distributed throughout patient sleeping areas, ward kitchens, sluice rooms, treatment rooms, and bathroom areas were chosen for monitoring. Sites were selected to include those with high frequency of contact by staff and patients, with the potential to be involved in cross-infection transmission routes.13 These included hand contact surfaces such as the handles of doors, toilet flushes, trolleys, cupboards, fridges, microwave ovens, faucet handles, the front and central area of bin lid tops, worktops, bedside cabinets, bed frames, and toilet seats. The materials at testing sites were mostly stainless steel or laminate plastic. For each site, general surface condition, the presence of moisture, and visual cleanliness were noted. In general, surface conditions were found to be good. The visual assessments were done by one person using standardized descriptors.12 The presence of adenosine triphosphate (ATP), which is derived from organic soil and microorganisms, at each site was assessed by a rapid hygiene test of ATP bioluminescence, using the BioTrace Cleantrace system (Biotrace Ltd, Bridgend).12 Conventional microbiological tests using dip slides coated with plate count agar were used to produce aerobic colony counts (ACC).12 Colonies were counted and are expressed as colony forming units (cfu) per cm².

### Table 1. Failure rates before and after cleaning using different assessment methods

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Type</th>
<th>Before Cleaning</th>
<th>After Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Visual ATP ACC</td>
<td>Visual ATP ACC</td>
</tr>
<tr>
<td>A</td>
<td>Paediatric</td>
<td>28 94 76</td>
<td>20 97 65</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>27 98 86</td>
<td>15 97 66</td>
</tr>
<tr>
<td>B</td>
<td>Paediatric</td>
<td>24 83 80</td>
<td>3 96 65</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>25 92 75</td>
<td>15 97 66</td>
</tr>
<tr>
<td>C</td>
<td>Paediatric</td>
<td>19 89 67</td>
<td>7 90 90</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>11 88 75</td>
<td>7 90 81</td>
</tr>
<tr>
<td>D</td>
<td>Paediatric</td>
<td>11 100 81</td>
<td>13 100 86</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>15 100 81</td>
<td>6 97 84</td>
</tr>
</tbody>
</table>

ATP, adenosine triphosphate; ACC, aerobic colony counts.

### Table 2. Differences in failure rates after cleaning, between visual and two other assessment methods

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Type</th>
<th>ATP (%)</th>
<th>ACC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Paediatric</td>
<td>77</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>82</td>
<td>51</td>
</tr>
<tr>
<td>B</td>
<td>Paediatric</td>
<td>93</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>82</td>
<td>51</td>
</tr>
<tr>
<td>C</td>
<td>Paediatric</td>
<td>83</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>83</td>
<td>84</td>
</tr>
<tr>
<td>D</td>
<td>Paediatric</td>
<td>77</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>91</td>
<td>77</td>
</tr>
</tbody>
</table>

ATP, adenosine triphosphate; ACC, aerobic colony counts.

According to the manufacturers’ instructions. The ATP measures organic debris and is a measure of cleaning efficacy, whereas microbiological analysis reflects the degree of disinfection achieved. The ATP measurements may or may not correlate with surface microbiological counts.9 Comparing sensitivity of the two methods is not productive, but relating the data to proposed standards8,12 gives more meaningful information in terms of pass and failure rates.

The presence of soil, dust, smears, or stains on a surface were regarded as unclean and constituted a fail. Raw data from ATP bioluminescence and microbiological sampling were interpreted as passes or failures using benchmark values that were obtained after cleaning over 5000 different surfaces using good cleaning practice.9,14 On this basis, ATP values of less than 500 relative light units (RLUs) and less than 2.5 cfu/cm² for microbial counts were considered a pass and measurements of at least 500 RLUs ATP and at least 2.5 cfu/cm² as a fail. The microbiological benchmark values are similar to those proposed in Sweden for surfaces after cleaning in the food industry,15 slightly higher than those proposed for operating theatres in Scandinavia,16 but slightly lower than those suggested for UK hospitals.8 Using this test system, the hospital ATP benchmark value equates to those surfaces after cleaning that are in contact with ready-to-eat foods.17

### Statistics

Percentage failures before and after cleaning were analyzed for statistical significance using Minitab (version12.1) by the Wilcoxon matched paired test. Further comparisons in pass/fail rates used the chi-square test; in all cases significance was at least \( P < .05 \).
RESULTS

Twenty-seven locations within two wards of four hospitals were selected for environmental surface testing, using three different methods. However, structural differences, patient activities, and treatment regimens prevented every site being sampled on every occasion. In total, 993 visual assessments, 1099 ATP measurements, and 1074 ACC determinants were recorded.

Failure rates for surface cleanliness, using the different methods, varied considerably (Table 1). Differences in visual and ATP failure rates (Table 2) were highly significant ($P < .001$) and consistent, and varied from 77% to 91%. The differences between visual and microbiological failure rates were also highly significant ($P < .001$) but more variable and slightly lower, ranging from 45% to 84%. The differences between ATP and ACC failure rates were not significant and varied from 0% to 32%. Within individual hospitals, failure rates were consistent between different wards using each of the three methods.

Using visual assessment, failure rates were significantly lower after cleaning than before. Differences in failure rates before and after cleaning, using ATP, were small and not significantly different, ranging from 0% to 13%, although the majority were within 3%. Differences in microbiological failure rates before and after cleaning ranged from 3% to 20% and were not significantly different.

Failure rates provide an indication of cleaning efficacy in relation to benchmark values but do not provide an indication of the extent of the failure. A summary of the overall ATP and ACC data to illustrate mean values and the range of data points is provided in Table 3. Wide variations in counts, using ATP and ACC, were found between sites and hospitals. The ATP results, after cleaning, varied from 48 RLUs to instrument overload greater than 500,000, with ACCs from less than 1 cfu/cm$^2$ to greater than 200 cfu/cm$^2$. Sites most likely to fail were in kitchens and bathrooms. The data contained in Table 3 indicates that sites that were failing were often well in excess of the benchmark values, with mean RLUs after cleaning ranging from 4818 to 13,775 and mean microbial counts from 14 to 33 cfu/cm$^2$.

DISCUSSION

Reports continue to highlight problems associated with cleaning in hospitals and the results of this study, using a range of assessment techniques, reinforce some of these concerns. However, previous reports were based on visual assessment and the present study indicates that failure rates would have been much higher if other forms of assessment had been used. Cleaning can be defined as the physical removal of soil (which is defined as "matter out of place") or the process which physically removes contamination without necessarily destroying microorganisms. Cleaning does remove some microorganisms but for a greater reduction in surface microorganisms, a disinfectant will need to be used. However, residual surface organic soil can provide nutrients and protection for a range of nosocomial pathogens and reduce the efficacy of disinfection. The present results indicate considerable levels of invisible organic soiling remaining on surfaces after cleaning. While the objectives of cleaning are not contentious, what is clean and acceptable can be difficult to define unambiguously and it has been argued that it is only possible to define cleanliness by including the method of assessment. Acceptable levels of microorganisms on surfaces are likely to be location-specific and depend upon who is making the judgement and why. One approach is to base acceptance on risk, although

| Table 3. Mean values and ranges for ATP and microbiological data |
|----------------------|----------------------|----------------------|----------------------|----------------------|
|                      | Before cleaning      |                     | After cleaning       |                     |
|                      | ATP                  | ACC                 | ATP                  | ACC                 |
|                      | Mean (RLU) n Range   | Mean n Range        | Mean (RLU) n Range   | Mean n Range        |
| Hospital A           |                      |                     |                      |                     |
| Paediatric           | 9032.62 75 66>500,000 23.22 75 <1>200 |                     | 13775.28 75 435-119946 <1>200 |                     |
| Surgical             | 9881.41 68 70>500,000 30.81 64 <1>200 |                     | 10361.27 68 323-46550 <1>200 |                     |
| Hospital B           |                      |                     |                      |                     |
| Paediatric           | 6204.99 72 22-52410 16.58 69 <1>100 |                     | 7922.33 70 181>500,000 <1>100 |                     |
| Surgical             | 8897.90 61 100-24262 23.45 59 <1>100 |                     | 10584.24 59 307-181477 <1>100 |                     |
| Hospital C           |                      |                     |                      |                     |
| Paediatric           | 3155.97 63 135-10124 12.07 65 <1>50 |                     | 4818.31 64 89-27775 <1>100 |                     |
| Surgical             | 7048.25 69 181-45580 18.23 68 <1>200 |                     | 6588.19 66 68-27412 <1>200 |                     |
| Hospital D           |                      |                     |                      |                     |
| Paediatric           | 5364.20 72 565-10319 25.12 69 <1>100 |                     | 4634.27 72 544-15691 <1>100 |                     |
| Surgical             | 11795.32 72 565>500,000 27.62 75 <1>100 |                     | 5440.26 73 48-19469 <1>100 |                     |

ATP, adenosine triphosphate; ACC, aerobic colony counts; RLU, relative light unit.
background information on this is lacking. The values used for pass/fail adopted in this study, although broadly similar to other standards, were derived differently and were benchmark values (i.e., what was attainable on a variety of hard surfaces in good condition) after implementation of good cleaning practice.

The ATP and microbiological results after cleaning were highly variable; this has been previously reported and generally indicates inconsistencies in the quality of cleaning. The sites included in this study were chosen without reference to the cleaning schedules at each respective hospital and it is recognized that some of the sites may have been cleaned at an irregular frequency. In fact the cleaning schedules used at the time of the study did not provide comprehensive instructions on how the surfaces should have been cleaned nor did they require the cleaning process or its efficacy to be monitored.

The results indicate that visual assessment, on its own, was an unreliable indicator of surface cleanliness and as a means for assessing the effectiveness of cleaning protocols. However, it is important for patient/consumer perceptions and can be of use as the first stage in an integrated assessment protocol. Also of concern was the failure to demonstrate a statistically significant difference between ATP and ACC values before and after cleaning at any location in either ward, for any of the four hospitals. The fact that some sites were below benchmark ATP or microbiological values on occasions did, however, indicate they were capable of being cleaned.

Reasons for ineffective cleaning have been documented and it is likely that a number of the higher ATP/microbiological counts after cleaning were as a result of dirt and/or microorganisms being redistributed by cleaning rather than removed. Simple changes to the cleaning processes used in hospitals can achieve substantial improvements leading to a reduction in the residual surface levels of ATP, ACC, indicator organisms, and meticillin-resistant Staphylococcus aureus.

Cumulatively the results do not indicate that the hospitals were obtaining value for money. Moreover, the wide variation in the microbiological and ATP results from specific sites raises concerns over the consistency of implementation, and thus the management of the cleaning process.

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Survival of epidemic strains of nosocomial- and community-acquired methicillin-resistant *Staphylococcus aureus* on coins

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**Background:** The aim of this study was to examine the survival dynamics of several epidemic nosocomial and community-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) strains on copper alloy coins.

**Methods:** Six different phage types of nosocomial MRSA (Irish 1, Irish 2, EMRSA 15, EMRSA 16, distinct type, and untypeable), as well as community-acquired MRSA, were examined in this study. Two isolates of each type were studied, resulting in a total of 14 organisms being examined. Cells were harvested from overnight cultures of Columbia blood agar (Oxoid) supplemented with 5% (wt/vol) defibrinated blood to make a 0.5 McFarland inoculum standard. An inoculum of each MRSA isolate in 5-μl volume was added to washed, dried, and presterilized 1-penny copper-plated steel coins, equating to log10 5 colony-forming units (cfu) and allowed to dry naturally at ambient temperatures in the dark.

**Results:** Recovery experiments were unable to isolate any of the inoculated organisms 4 hours postinoculation. To ascertain whether this was a toxic effect from the copper alloy of the coins or a physical desiccation effect, experiments were repeated on glass and plastic, and similar results were demonstrated. The effect of soil was investigated by repeating the experiment with 60Co-irradiated pus and sterile blood, and we were able to demonstrate the survival of all organisms after at least 2 weeks storage in the dark at ambient temperature, during which the quantitative counts were reduced by approximately 1-log unit and 2-log units for blood and pus, respectively.

**Conclusion:** This study demonstrates that all epidemic nosocomial- and community-acquired MRSA do not survive when no organic protection is offered but survive well when soil (pus and blood) is present, thus offering protection from drying. This study indicates that contaminated coins may serve as potential vehicles for MRSA. (Am J Infect Control 2007;35:342-6.)

Hospital outbreaks due to methicillin-resistant *Staphylococcus aureus* (MRSA) have become a major problem in nosocomial infections, warranting programs to control its dissemination, given the potential of MRSA to produce invasive infections, particularly in vulnerable patients and its multiple resistance to antibiotics, which limits the therapeutic options available. More recently, community-acquired (CA) MRSA has been documented among healthy individuals without any predisposing risk factors, unlike its nosocomial-acquired (NA) relative. The appearance and spread of CA-MRSA represent a new challenge in medicine and have important clinical implications for therapy of infections caused by *Staphylococcus aureus*.1

The survival of nosocomial pathogens in the environment, including MRSA, is of great interest to infection control professionals, including microbiologists.2 Currency in the form of banknotes and metal coinage represents a universal medium for the transmission of bacteria in the environment and among humans. Previous studies by our group3 and others4-6 have reported that monetary coinage was a reservoir for gram-positive organisms including *Staphylococcus aureus*, which were isolated from Canadian and French coins.3 In our previous study,3 25 organisms were identified including *Staphylococcus aureus*, although no MRSA were identified. The source of these organisms on the coins may be attributed (1) to environmental contamination in the case of *Bacillus* species and (2) to *Staphylococcus* species arising from the normal commensal skin flora.

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Given that our previous work highlighted coins as a source of *Staphylococcus aureus*, it was the aim of this present study to develop further this experimental work by examining the survival dynamics of both CA-MRSA (2 isolates) and NA-MRSA (6 epidemic phage types consisting of 12 strains) on monetary coinage.

**MATERIALS AND METHODS**

**Description of CA- and NA-MRSA strains employed in this study**

Fourteen strains of CA-MRSA (n = 2) and NA-MRSA (n = 12) were examined in this study, including representative MRSA phage types (EMRSA 15 [n = 2], EMRSA 16 [n = 2], Irish 1 [n = 2], Irish 2 [n = 2], unique type [n = 2], and untypeable [n = 2]) as well as CA-MRSA (n = 2). All isolates were taken from the MRSA culture collection archived in the Department of Bacteriology, Belfast City Hospital. All NA-MRSA isolates were obtained from clinical cases of MRSA-associated infection presenting at Belfast City Hospital over the period July 2003-December 2004. The CA-MRSA isolates were supplied by Dr. Trevor Winstanley, Royal Hallersham Hospital, Sheffield, England. Initially, the phenotypic identity checks of the isolates were confirmed on revival of each isolate from the archive, including colonial morphology, gram-stain (+ve), coagulase-tube test (+ve), latex slide agglutination assay (+ve), and detection of the presence of the mecA gene locus by polymerase chain reaction (PCR) (mecA PCR +ve), as previously described. All isolates were previously phage typed by the *Staphylococcus aureus* Reference Laboratory, Health Protection Agency (HPA), Colindale, London.

**Determination of optimal nonselective recovery medium for MRSA**

Eight commercially available nonselective basal broth media were examined in this study and included nutrient broth (NB; Oxoid CM0001, Oxoid Ltd., Basingstoke, United Kingdom), nutrient broth No. 2 (NB2; Oxoid CM0067), Todd Hewitt broth (Oxoid CM0189), tryptone soya broth (Oxoid CM0129), tryptone soya broth supplemented with yeast extract (0.5% wt/vol; Oxoid CM0129 + Oxoid LP0021), brain heart infusion broth supplemented with yeast extract (0.5% wt/vol; Oxoid CM + Oxoid LP0021), salt meat broth (Oxoid CM0094), and 0.1% (wt/vol) peptone saline (Oxoid CM0733). All media were reconstituted in accordance with the manufacturer's instruction for preparation of the media.

All 14 isolates were grown individually at 37°C (24 hours) on Columbia Blood Agar (Oxoid CM0331) supplemented with 5% (vol/vol) defibrinated horse blood. Inocula were prepared of each isolate in peptone saline to give approximately $10^5$ cells/mL, of which 100-μL aliquots were added to 100-μL prepared double-strength (2×) media in a 96-well flat-bottomed microtiter plate (Sarstedt GmbH, Nürnberg, Germany). For each treatment series, an equal number of negative controls were established, containing uninoculated media, to check sterility and thus avoid false-positive results. Plates were incubated statically at 37°C for 60 hours with sealed lids to avoid evaporation of water. Plates were examined spectrophotometrically without lids at 0, 20, 40, and 60 hours and were shaken prior to triplicate readings being taken ($\lambda = 405$ nm) on an automatic microtiter plate reader (Emax, Molecular Devices Inc. Sunnyvale, CA) and the mean absorbance values noted.

**Source and preparation of coins**

United Kingdom 1-penny denomination coins (diameter, 20.3 mm, thickness, 1.65 mm; weight, 3.56 g; with a plain milled edge) composed of copper-plated steel were obtained from a local bank. These coins had been in recent general circulation. Coins were washed in detergent (Decon 90) for 30 minutes, thoroughly rinsed in deionized water, and dried and sterilized by conventional autoclaving. Following sterilization, the coins were dried in a dry heat oven and placed face down in a sterile Petri dish in preparation for inoculation with MRSA. Following this, sterility checks were performed on a representative batch of coins from each prepared batch of coins, by culturing the coins in NB2 for 48 hours at 37°C before plating 20 μL of broth onto Columbia Blood Agar (Oxoid CM0331) supplemented with 5% (vol/vol) defibrinated horse blood at 37°C for 24 hours.

**Inoculation and storage of MRSA on coins**

CA-MRSA and NA-MRSA (n = 14 strains) were prepared overnight (t = 17 hours) by growing each strain individually at 37°C (24 hours) on Columbia Blood Agar (Oxoid CM0331) supplemented with 5% (vol/vol) defibrinated horse blood. Cells were harvested into approximately MacFarland 0.5. An inoculum of 5 μL was added to the reverse side of the coins (Portcullis with chains crowned, an adaptation of the badge of Henry VII and now the Badge of the Palace of Westminster), approximating to $10^5$ ($\log_{10}$ 5) colony-forming units (cfu/coin). Coins were then stored in the dark for 14 days. The humidity and temperature of the storage area were approximately 60% relative humidity and 20°C, respectively. Sampling of duplicate coins for each MRSA strain at each time point was performed at t = 0 and daily intervals up to 7 days duration. Sampling of the coins involved aseptically removing each...
coin and placing it in 0.1% peptone saline (9 mL), followed by vigorous shaking/ agitation in an orbital shaker (120 rpm) for 20 minutes, after which cultivable cells were enumerated quantitatively. MRSA were enumerated at each time point on NB2 supplemented with Agar A (15 g/L) by employing the Whitley Automated Spiral Plater (Don Whitley Scientific Ltd, Shipley, United Kingdom) in combination with the Protocol Digital Colony Counter (Don Whitley Scientific Ltd.), in accordance with the manufacturer’s instructions. Bacterial cell counts were expressed as the mean log_{10} cfu/coin of duplicate counts. In addition, cultivable MRSA on stored coins were qualitatively recovered by placing coins into NB2 (9 mL) and incubating at 37°C for 24 hours, followed by plating 20 µL broth onto NB2 supplemented with Agar A (15 g/L) Columbia Blood Agar (Oxoid CM0331).

Inoculation and storage of MRSA on glass, plastic, and cupro-nickel coins

Survival of MRSA strains was also examined on glass and plastic matrices. MRSA cells were prepared, as above, and inoculated onto sterile glass coverslips as well as onto sterile Petri dishes and investigated further, as described above, as for coins. In addition, the survival dynamics were examined for a different metal base, ie, the United Kingdom 5-penny denomination coin (diameter, 18.0 mm; thickness, 1.00 mm; weight, 5.25 g; with a milled edge) composed of cupro-nickel alloy (75% copper, 25% nickel).

Inoculation and storage of MRSA on coins contaminated with pus and blood

Survival of MRSA strains on coins was further examined by the introduction of pus and blood. Fresh pus (100 mL) from a drained abscess from a patient was obtained and prepared for sterilization by irradiation. Pus was placed into universal containers (30 mL) and γ-irradiated to receive a 25-kGy dose. Irradiation was carried out using 60cobalt-60 (in a Gammabeam-650 irradiation unit; MDS Nordion, Kanata, Canada) at a dose rate of 1.5 kGy h^{-1} and at an environmental temperature of 4°C. Two red dosimeters (AEA Technology Ltd., Harwell, United Kingdom) were attached to the outside of each sample receiving 25 kGy to measure the actual dose received by the samples. Following irradiation, the change in absorbance of the dosimeters was measured spectrophotometrically (Spectronic Unicam UV-500) at 603 nm and 640 nm, respectively, and their thickness was measured using a digital electronic micrometer (RS Components Ltd., Corby, United Kingdom). The corresponding dose received was then obtained from a calibration graph provided by the National Physical Laboratory (Teddington, Middlesex, United Kingdom). Following irradiation, sterile pus was checked for sterility by enrichment in NB2, as described above.

MRSA strains were prepared for inoculation onto coins, as described above. Prior to inoculation, each MRSA strain (100 µL) was mixed individually with 500 µL sterile irradiated pus, as well as with 500 µL sterile defibrinated horse blood, after which 5 µL was inoculated onto individual coins and investigated, as described above, with the exception that the time course was extended to 14 days, both for coins that had been inoculated with pus and with blood. The blood/MRSA and pus/MRSA mixtures were applied to the coins, as a single drop, which spread a little on contact with the coin surface before drying.

Statistical analyses

Statistical analyses were performed where appropriate employing the Student t test, and a probability value of P < .05 (5%) was considered significant.

RESULTS

On retrieval from the culture archive, all isolates gave phenotypic results that were consistent with MRSA, and all isolates were meca PCR positive (data not shown). Mean spectrophotometrical values of cell density were calculated for each isolate incorporating the 8 media screened, using the equation:

\[
\Delta \text{Absorbance}_{[t - 60 \text{ h}]} = \text{Absorbance}_{[t - 60 \text{ h}]} - \text{Absorbance}_{[t - 0 \text{ h}]}.
\]

Mean absorbance results of each broth medium were further compared for each strain and statistical analysis of variance allowed the basal media to be ranked into the following order (commencing with the media which gave greatest cell density/proliferation): NB2, brain heart infusion broth supplemented with yeast extract, tryptone soya broth supplemented with yeast extract, NB, Todd Hewitt broth, tryptone soya broth, salt meat broth, peptone saline.

Approximately log_{5} cfu of each of the 14 MRSA strains employed were inoculated onto individual 1-penny coins and stored, as described. Quantitative enumerative counts were not able to detect any cultivable organisms after 24-hour storage with any CA- or NA-MRSA examined. Additionally, qualitative enrichment was not able to detect any cultivable MRSA on coins after 24 hours. It was therefore decided to expand the time course with hourly sampling time points over the initial 12-hour storage period. By employing this alteration to the original experimental design, we were able to demonstrate culturability of all MRSA phage types up to and including 4 hours, after which both quantitative and qualitative evaluations were
unable to detect any culturable MRSA organisms. Similar death dynamics were observed when copper-plated steel coin matrix was substituted with glass and plastic matrices, as well as with cupro-nickel coins.

Survival investigations were subsequently repeated employing the same methodology but incorporating an organic soil component, namely sterile pus or sterile blood along with the MRSA on coins. On these occasions, survival of MRSA was significantly enhanced up to 13 days postinoculation, when the experiment was terminated. Initial counts at $t = 0$ were approximately $\log_{10} 3.5$ cfu/coin for all CA- and NA-MRSA examined ($n = 14$ strains), and survival on both pus and blood was comparable up to 4 days postinoculation, after which time, there was a significantly quicker loss of culturability with MRSA on coins contaminated with pus than with blood ($P = .02$). Overall, quantitative counts were reduced by $\log_{10} 1.16$ cfu/coin and $\log_{10} 2.38$ cfu/coin, in blood and pus, respectively (Fig 1), and there was no significant difference in survival dynamics between the CA-MRSA and the NA-MRSA or among individual strains within these groups.

**DISCUSSION**

The concept of coins as being the source of infectious diseases is not unique to the 21st Century. Historically, coins were believed to transmit infection from person to person. In England, as far back as 1665, this theory of coins being the vehicle for transmission of plague is in existence. In Eyam village, Derbyshire, where the plague struck in August 1665, locals effectively quarantined the infected village to minimize cross infection and left food and other supplies and medicines outside the village. In payment for such goods, coins were soaked in vinegar to kill any contagions on the surface of the coins and left in holes.

Several studies have reported on the contamination of various items of hospital clinical equipment, as well as air in rooms in which MRSA positive patients have occupied. To date, there have been no reports on the occurrence of MRSA on money in circulation among MRSA-positive staff, patients, and visitors in a hospital setting. In such an environment, money may be actively exchanged among these groups of individuals at (1) the hospital mobile ward shop(s), which tours the wards on a daily basis, allowing less mobile patients to purchase newspapers and other items; (2) the permanent hospital shop; (3) the hospital restaurant/canteen; (4) the fixed and mobile hospital pay phones; (5) the car-parking payment machines; and (6) the TV/phone pay card machines; and (7) for the payment of taxis for patients and visitors, arriving and departing the hospital. Given that hands are a major source of contamination of MRSA organisms, it may be postulated that money may thus become contaminated with MRSA in a MRSA-positive hospital environment, as it is manually handled, or, alternatively, it may become cross contaminated because of its cohabitation of pockets with MRSA-positive handkerchiefs. Given that there are approximately 26,359 million coins currently in circulation in the United Kingdom (http://www.royalmint.com/RoyalMint/web/site/Corporate/Corp_british_coinage/CirculationFigures/Coins_in_Circulation.asp), an examination of the survival dynamics of MRSA on money is warranted to help estimate the potential role this novel environment may play as a potential source of these organisms to noncolonized hosts.

Initially, we investigated the optimum nonselective basal medium to employ to maximize recovery of sublethally stressed MRSA on coins because of a desiccation effect. Recently, a laboratory review on the clinical microbiology of MRSA described at least 22 media for the isolation of MRSA from clinical specimens, whereby all the media described were selective in nature, containing a combination of selective agents, including NaCl, oxacillin, methicillin, ciprofloxacin, tellurite, LiCl, and others. Previously, the reduced recovery of sublethally injured cells has been described because of exposure of such injured cells to antibiotic combinations in selective media formulations. Furthermore, employment of a wide variety of selective agents in selective media may lead to variation in recovery rates of MRSA, depending on the selectivity of the medium employed. Because we were conscious that our investigations would lead to the generation
of sublethally stressed MRSA because of varying states of desiccation, we decided to avoid the use of selective formulations to recover MRSA from coins on prolonged storage. However, although we noted that several selective formulations are described for the isolation of MRSA, there are no descriptions of the optimal basal medium to use for the recovery of sublethally damaged MRSA cells. Therefore, our initial objective was to examine which basal medium offered optimum recovery of MRSA. Our findings indicated that that either NB2 or brain heart infusion yeast extract may be employed as suitable basal broth media, and this may be attributed to these media containing higher concentrations of peptones, proteins, and other nutritionally rich meat infusions. Surprisingly, Salt Meat Broth (SMB) with a NaCl concentration of 10 g/L gave the lowest absorbance values of those tested and should be considered less suitable for routine use when other nutritionally rich media are available.

Overall, the ability of MRSA to survive in the environment is an important characteristic for the organism’s survival and success as a nosocomial pathogen. In contrast, a free-living bacterium with a reduced ability to survive in the environment may not be able to persist when environmental conditions are harsh. Free-living bacteria may therefore expend considerable energy in developing environmental survival strategies to allow its survival, ex-host, on sources that are likely to allow reinfection of a new noncolonized host. For certain genera, eg, Bacillus and Clostridium, these organisms have evolved complicated separate physiologic resting stages, namely the bacterial spore, whereas other organisms, eg, the thermophilic campylobacters, Campylobacter jejuni, and the marine vibrios, have developed dormant resting stages, known as the viable-but-non-culturable form. These 2 adaptations have not been described for MRSA. Recently, Walther and Ewald described a hypothesis known as “sit and wait strategy” for pathogens, in an attempt to help elucidate pathogen survival in an external environment and the evolution of virulence. In this hypothesis, these authors postulate that virulence should be positively correlated with durability in the external environment because high durability reduces the dependence of pathogen transmission on host mobility. In other words, sit-and-wait pathogens, including the hospital-acquired pathogens, ie, MRSA and Pseudomonas aeruginosa, have evolved effective mechanisms to allow them to have become troublesome nosocomial pathogens, largely because of their ability to survive in the environment and an increase in their ability to evolve towards higher levels of host exploitation, namely virulence.

Hands are the most important fomite for spread of nosocomial infection. Because money may provide an indirect route for hand-to-hand contamination, it is important to prevent such cross infection by washing hands after handling money if a clinical procedure is to be carried out. Further studies are warranted in comparing the environmental survival dynamics between MRSA and methicillin-sensitive Staphylococcus aureus (MSSA).

In conclusion, this study demonstrates that all epidemic CA- and NA-MRSA strains examined could not survive in an environment in which no organic protection (soil) was offered, but these organisms did survive relatively well in an environment in which soil (pus and blood) was present and can offer the organisms protection from desiccation. This study indicates that contaminated coins may serve as a potential source for MRSA.

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References
Construction: A model program for infection control compliance

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Issue: In the 21st century, one of the most challenging tasks for the infection control practitioner (ICP) is establishing collegiality and trust with contractors, architects, maintenance and engineering personnel. We describe how an urban teaching hospital’s infection control program cooperated with contractors during a large demolition, construction, and renovation project in order to protect its large population of immunosuppressed patients.

Project: Most contractors are not accustomed to taking special precautions during demolition. Because of a previous Aspergillus outbreak in our heart transplant population, we already had an established infection control (IC) training program for contractors. We expanded and codified it in response to a major hospital renovation. The IC, in-house Design and Construction, and outside contractors meet before the initiation of all major renovation projects to anticipate IC concerns and proactively plan for infection control interventions. Now, all contractors and maintenance staff are required to receive IC training at the time of their employment. A hospital identification badge with attached sticker that indicates the IC training date is required. Infection Control Risk Assessments (ICRA) are initiated by project managers and completed jointly with IC. The ICPs make rounds on all projects at least weekly and large projects are visited daily. We established a team comprised of ICP, project manager, construction manager, and area nurse manager to monitor and make recommendations for improvement continually during the project. Staff are educated about construction so they can help monitor airflow and cleanliness.

Results: Our contractors are more compliant with our IC specifications since they now understand why we insist on them. Through the years of major construction, the workers have jumped on the bandwagon. It is not unusual for construction or maintenance staff to contact IC for advice. There were four years of extensive construction without any hospital acquired Aspergillus infections. In the 5th year, after a neighboring institution started demolition and new construction, we identified two possible nosocomial infections and took immediate steps to make more corrections. There have been no further infections.

Lessons Learned: The IC compliance is based on trust, education, and on-going monitoring. Proactive education and collaboration lead to long-term relationships, trust and patient safety.

Objective: This article describes how a large teaching hospital’s infection prevention program achieved compliance from contractors during a large renovation. (Am J Infect Control 2007;35:347-50.)

Immunosuppressed patients, such as organ transplant recipients, and chemotherapy and burn patients, are at high risk for hospital-acquired aspergillosis from construction.1-6 If left undisturbed (as behind a wall), Aspergillus is not a threat to the immunosuppressed. Construction and renovation in hospitals often is associated with dissemination of Aspergillus spores.3-6 Most contractors are not accustomed to taking special precautions when tearing down or renovating buildings.

In 1994, University Hospital had a cluster of Aspergillus infections in heart transplant patients. Construction restriction policies were initiated in response, and, at this time, Infection Control added Aspergillus surveillance to its targeted program. All new positive Aspergillus isolates from the lower respiratory tract, wounds, or sterile sites are investigated.

METHODS
Setting

The University Hospital (TUH) is the largest tertiary-care hospital in Cincinnati, Ohio and its surrounding metropolitan area. As part of the Health Alliance of Greater Cincinnati, it has a level 1 trauma center; 7 intensive care units, including a level 3 perinatal research center and neonatal intensive care unit, and an adult burn unit; and comprehensive outpatient services with 450,000 visits per year. The University Hospital admits more than 26,000 patients per year, has 85,000 emergency room visits, and an average daily
census of close to 400. It is the region’s major solid organ transplant center. Parts of the original hospital were built in 1910, 1927, and 1969. The existing hospital is 1,859,677 gross square feet, excluding the loading dock and garage. At any one time, there are 4 to 6 major renovation projects in operation.

INTERVENTIONS

In January 2000, the hospital began a 5-year expansion project to build a 9-story employee garage, a new postanesthesia care unit, a new cardiothoracic intensive care unit, and to expand existing operating room (OR) space to include 8 new ORs. To start, 5 circa 1910 mostly unused buildings had to be torn down. The safe demolition of the old buildings was the first phase of the project. During demolition, spores in old buildings and in the ground are stirred up and can infiltrate into patient care areas. Because of the size and scope of this 5-year project, the proactive infection control education program for contractors was expanded. One of the Infection Control Practitioners (ICPs) had attended a University of Minnesota Health Care Facility Construction Management Indoor Air Quality Workshop. The hospital project manager also was knowledgeable about the important interventions needed to protect our immunosuppressed patients. Many members of our University Hospital’s Design and Construction Department are engineers and architects and have attended classes on construction and infection control.

Patients could not be relocated away from the area of greatest activity, so all windows adjacent to the demolition site were sealed with plastic. Prevailing wind direction was monitored and extra prefilters were added to all air intakes. Any dust generated during demolition was wetted down. Air curtains were added to doorways directly facing the construction. Immunosuppressed patients were notified to wear N95 protection when entering the hospital.

Although the infection control requirements for performing construction work are described properly in all TUH construction specifications, the ground-level workers on the site had little knowledge of the requirements, which often resulted in lack of adherence to the policy. Typically, the project general contractor did have a cursory understanding of the requirements, but little information was passed on to those who actually were doing the job. In addition, to effectively implement good quality patient protection, the workers needed to understand the reasons for, and the infection control qualities of, a well-managed hospital job site.

During the latter part of 1998, the infection control and design and construction departments created an audiovisual presentation to train our construction contractors. With some additions, the same presentation currently is being used. Contractors are much more compliant with our infection control specifications if they understand why we insist on them. An explanation about *Aspergillus* and its transmission, and the susceptibility of our immunosuppressed population was added. The lesson plan is organized into sections that include precautions to be taken before, during, and after the construction work is executed. Topics discussed primarily address the containment of construction dust. Training closely examines methods of work inside and outside the construction area, including establishing negative airflow and the use of high-efficiency particulate air (HEPA) filtration, tacky walk-off mats, ceiling access, and barriers.

All of our construction personnel are required to receive yearly infection control training. This includes everyone from project managers to helpers. The class takes about 30 minutes, and the project manager
educators, architects, and maintenance and engineering managers, remain financially viable, and update aging infrastructure create renovation. Medical advancements have led to more immunosuppressed patients, such as transplant recipients, in hospitals. The combination of these two factors has led to the increasing role of infection control in construction/renovation projects. Many hospital outbreaks have been documented: most of those outbreaks were related to air contamination as the result of construction and renovation projects.

Although we had excellent compliance with our program to reduce construction-related risk to patients, we did have two cases of Aspergillus infection at the end of the intervention period. We believe that this was secondary to external factors beyond our control, in this case construction in an adjacent, nonhospital building. This demonstrates that hospitals must be aware not only of what is happening inside their own facilities but also what is happening outside, although their ability to intervene may be limited.

One of the most challenging tasks of the “contemporary” ICP is establishing collegiality with contractors, architects, and maintenance and engineering managers. An ICP attends each class to answer any questions.

Further, all construction staff must wear a hospital identification badge per enforced hospital policy. After their education, a sticker is applied on the badge indicating the date that infection control training was received. Any workers who have not had training can be identified with a glance at their badge. It also eliminates excuses and blame should a worker be found not following precautions.

Education and policy compliance with positive outcomes requires good quality assurance. The ICPs make rounds on all projects at least weekly, and large projects are visited daily. For the large project, weekly rounds were established with an infection control manager. It includes the general contractor, project manager, ICP practitioner, and OR nurse planner; others are invited as needed. At one point, the construction site was next to the heart transplant OR. Contractors had to walk through the OR core to get to the project. The team cooperatively established special procedures to make the work possible while still protecting the patients. We built anterooms for contractors to change between clean and dirty sites. They were required to wear hair and shoe covers and bunny suits over their clothing as they walked through the OR areas. Airflow gauges monitor all of our negative airflow. OR staff were taught how to read the gauges and what to do if airflow was found to be positive. Contractors wet-mopped floors several times during the workday to prevent tracking. Construction workers did projects during off hours if possible.

Before construction could commence, the ICP had to inspect and approve the barrier—tagging it with a specially made sticker—and had the authority to stop the project if a breach in practice was found.

As our team met weekly, we continued to explore better options and make adjustments to our interventions. Footprints were still seen down the long hallways toward the OR. A simple rule was initiated that eliminated the problem: contractors were required to wear OR booties over their shoes as they left the site. We dedicated one elevator for construction use to separate workers from OR staff and patients. When a large area was demolished for renovation, we added more HEPA filtration and fans to produce strong negative airflow into the site. All work ceased until the airflow could be corrected.

RESULTS

During the first 4 years of demolition and renovation, TUH had no nosocomial Aspergillus infections.

Similar Aspergillus infection risks are present in the context of large-scale construction projects external to, but near, the hospital. Similar protection methods as described above were used when another large hospital across the street demolished an old, large building. The demolition was near our OR air intakes.

In the fifth year of construction, 2 patients who had possible hospital-infection were identified. An industrial hygienist was brought in to evaluate our interventions and make recommendations. Nothing of concern was found. When the old buildings were first demolished, particulate sampling was performed in high-risk areas to measure our interventions. The sampling was repeated when the first patient was identified. Levels had not changed.

Both possible nosocomial Aspergillus infections occurred after a building that was connected to the hospital, which shared air space with the hospital, began a large renovation project without using infection control prevention. Some of our physicians had offices in the building and walked back and forth between the two. One of the cases was in a patient who never came near any of our construction, but whose physician had an office in the adjoining building. We suspect that these two Aspergillus infections during the fifth year of our project were related to the neighboring construction and renovation. Once again, our team collaborated with the other building’s contractors to make changes. Our infection control training was used to educate their contractors.

DISCUSSION/CONCLUSIONS

Efforts of today’s hospitals to meet increasing demands, remain financially viable, and update aging infrastructure create renovation. Medical advancements have led to more immunosuppressed patients, such as transplant recipients, in hospitals. The combination of these two factors has led to the increasing role of infection control in construction/renovation projects. Many hospital outbreaks have been documented; most of those outbreaks were related to air contamination as the result of construction and renovation projects.

Although we had excellent compliance with our program to reduce construction-related risk to patients, we did have two cases of Aspergillus infection at the end of the intervention period. We believe that this was secondary to external factors beyond our control, in this case construction in an adjacent, nonhospital building. This demonstrates that hospitals must be aware not only of what is happening inside their own facilities but also what is happening outside, although their ability to intervene may be limited.

One of the most challenging tasks of the “contemporary” ICP is establishing collegiality with contractors, architects, and maintenance and engineering managers.
personnel. The ICP now must be knowledgeable in matters of heating and air-conditioning, types of air filters, wallboards, or plumbing. Many possess hard hats and are not shy to use them!

In today's health care atmosphere, multiple regulatory bodies have become heavily involved in regulating projects to protect patients. Contractors have begun to factor in extra infection control interventions when they make their bids. The Centers for Disease Control and Prevention issued the 230-page Guidelines for Environmental Infection Control in Health-Care Facilities in 2003. These guidelines make recommendations for construction, renovation, remediation, repair, and demolition. The American Institute of Architects Academy of Architecture for Health (AIA) also publishes guidelines for design and construction every 3 to 6 years. Shortly after the “turn of the century,” AIA and the Joint Commission on Accreditation of Healthcare Facilities started to require an Infection Control Risk Assessment for all construction and renovation projects. At TUH, the assessment was initiated almost immediately after the first guideline was issued. The need for interventions was already being assessed, but it was often vexing to determine how to document our assessments. The risk assessment provided us with a convenient means. Infection Control and Design and Construction have a joint quality improvement project that monitors and documents contractor compliance with infection control practice.

The important piece of this model (Fig 1) is the trust and good working relationships with all involved. As the physical addition is constructed, so too must the camaraderie be built. As a medical professional, the ICP is entering the world of construction. The ICP must learn how to become a member of the construction society and give feedback, advice, and guidance without seeming critical or demanding. At TUH, this did not happen overnight. Each individual brings his/her special talent to the job and each must be respected and acknowledged for that contribution.

Through the years of major construction, the construction workers jumped on the bandwagon. Our own maintenance personnel were trained and they, too, became infection control advocates. Today, it is not unusual for a maintenance worker to call infection control for advice when working on a repair project. Other contractors keep infection control apprised of smaller projects around the hospital. Design & Construction automatically includes technique sink placements, alcohol hand rub dispensers, and protective equipment cabinets into specifications without infection control needing to advise.

The TUH Infection Control has achieved a collegiality with all physical environmental associates to produce an effective, comprehensive infection prevention atmosphere during construction and renovation.

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A survey of human cases of H5N1 avian influenza reported by the WHO before June 2006 for infection control

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Qingdao, China, and Chicago, Illinois

H5N1 avian influenza has been widely spreading in fowls in the Eastern Hemisphere and caused hundreds of severe human cases. Here, the information of the 224 human cases of H5N1 avian influenza reported by the World Health Organization before June 2006 were surveyed and analyzed. The results suggested that human infections escalated in the past 3 years, and control of animal H5N1 influenza, avoidance of high-risk behaviors, and proper disposal of diseased or dead fowls are vital for the prevention of the human infections. Age distribution of the human cases demonstrated that older people are more immune to the infection, possibly because of the cross protectivity induced by their previous infections with human influenza A viruses. This survey also suggested that live vaccines against human influenza may be of utility in the prevention of the avian influenza virus infections in humans, and new preventive measures should be considered for the control of animal H5N1 influenza epidemics, which are likely more serious than indicated by official reports. (Am J Infect Control 2007;35:351-3.)

The wide spread of H5N1 avian influenza viruses (AIVs) in the Eastern Hemisphere has aroused global concerns about their potential to spark a catastrophic human pandemic.1 The AIVs have caused hundreds of severe human infections since the end of the year 2003. This study presented a survey of these cases to disseminate information useful for our recognition and control of the infections.

The original data of this survey were collected from the serial reports given by the World Health Organization (WHO) on the human cases (http://www.who.int/csr/disease/avian_influenza/en/index.html) except that original data about Chinese cases were extracted from Chinese official reports (http://www.china.org.cn/chinese/zhuanti/qlg/483177.htm), which were more informative than the WHO’s reports. Asymptomatic infections and unconfirmed cases were excluded in this survey.

Totally, 224 human cases of H5N1 avian influenza with 127 fatalities were reported by the WHO before June 2006. The fatality rate, 56.7% (127/224), was high, but the infection rate and the morbidity rate, which are important to assess the risk of the potential human H5N1 influenza pandemic, remain unknown and should be given priority for investigation.

Among the 224 cases, 3 in the year 2003, 46 in 2004, 95 in 2005, and 80 in the first half-year of 2006 were reported. One country (Vietnam) in 2003, 2 countries (Vietnam and Thailand) in 2004, 5 countries (Cambodia, China, Indonesia, Thailand, and Vietnam) in 2005, and 8 countries (Azerbaijan, Cambodia, China, Djibouti, Egypt, Indonesia, Iraq, and Turkey) in 2006 reported the human cases. These data suggested that the human infections escalated in the past 3 years. In addition, more than half of the 224 cases were reported by Vietnam (93 cases) and Indonesia (48 cases).

All the affected countries reported H5N1 avian influenza in domestic fowls, except Djibouti, where the epidemics in animals were poorly understood; and Azerbaijan, where only carcasses of numerous swans were found. Among all 224 infections, infections of 4 cases from Vietnam and 7 cases from Indonesia were suspected from human-to-human transmission, and infections of the remaining 213 cases were all assumed to be from fowls, although exact exposure sources have not been identified for many cases. The infection sources of the 93 human cases from Vietnam were not indicated by the WHO’s reports. Among the remaining 131 cases from the other 7 countries, 37 were linked to close contact with diseased or dead fowls such as having handled dead chickens several days before the
onset of symptom, and 75 were linked to exposure to the environment with diseased or dead fowls (e.g., some chickens in the neighborhood died several days before the cases’ onset of symptoms and touching the dead chickens was not a factor, or the cases worked near to a live poultry market). Among these 75 cases, 70 were linked to exposure to the environment with diseased or dead backyard fowls. These data suggested that control of the AIV infections in animals, avoidance of high-risk behaviors such as contact with diseased or dead fowls, and proper disposal of diseased or dead fowls are vital to prevent the human infections. Actually, the H5N1 AIV infections in humans disappeared in Turkey soon after the government launched an intensive public education campaign on avoidance of high-risk behaviors, as did Vietnam, where most human cases from the year 2003 to 2005 were reported by the WHO, but no any cases occurred in 2006 soon after an intensive nationwide educational campaign.2

Age and sex of 172 among the total 224 human cases were available from the WHO reports. Our statistics on the age and sex distributions of these 172 cases are given in Fig 1. Among the 172 cases, 45 (26.2%) cases were 0 to 9 years of age, 47 (27.3%) were 10 to 18 years of age, 33 (19.2%) were 19 to 27 years of age, 27 (15.7%) were 28 to 36 years of age, 12 (7.0%) were 37 to 45 years of age, and 8 (4.7%) were ≥45 years of age (Fig 1). The age distribution indicated that children and young adults are more susceptible to the virus infection, so they should be better protected. Why are older people more immune to the infection? We hypothesize that it is probably because older people are more likely to have been infected at least once in their lives with human influenza A viruses whose conservative T-cell epitopes can induce cellular immune responses.3-5 As supported by immunologic research,3-5 although the cellular immune responses cannot prevent hosts from being infected with the H5N1 AIVs, they could prevent hosts from severe development if they are infected with the H5N1 AIVs.6 According to this hypothesis, live influenza vaccines such as Flumist (MedImmune, Baltimore, MD) can probably induce the cross-protective cellular immunity against the H5N1 AIVs,6 and thus their utility to protect health care workers and other people at higher risks should be considered and further investigated.

Figure 1 also demonstrated that the male cases were nearly as many as the female ones in all age groups, except that, in the group of ages 4 to 6 years, there were 19 males plus only 1 female, and, in the group of ages 19-27 years, there were 33 males and 33 females. A similar distribution was seen for all age groups. The sex distribution is given in Fig 1.
25 to 30 years, there were 20 females plus only 3 males. The exposure risk stated above could account for the sex differences (both \( P < .01 \) by \( t \) test) because boys of ages 4 to 6 years in the affected countries usually do not go to kindergarten and they are more active outdoors and thus have higher exposure risk, and females of ages 25 to 30 years in the affected countries are likely to be housewives and also have higher exposure risk when they feed their backyard fowls, buy fowls from live markets, or deal with sick fowls.

All the human cases were from developing countries, although some developed countries such as South Korea, Japan, and Germany have also reported circulations of the H5N1 AIVs in wild or domestic fowls. As shown in Fig 2, backyard fowls, which are prevalent in developing countries, greatly facilitate the circulation and transmission of the AIVs, and it is very difficult to prevent and control the epidemics in backyard flocks with vaccination and culling.\(^7,8\) Consequently, culling and immunization are inadequate to control the H5N1 avian influenza in these countries as proved by the realities of the past 3 years. As stated above, our survey also demonstrated that many of the human cases were linked to exposure to diseased or dead backyard fowls. Thus, new preventive measures such as a ban on keeping backyard fowls in the developing countries should be considered.

The animal H5N1 influenza epidemics related to many human cases have not been confirmed through the follow-up investigation, which is probably because the animal epidemics could have disappeared before the investigation. For instance, the animal H5N1 influenza epidemics related to 15 out of the 18 human cases reported by China have not been confirmed, although 7 out of the 15 human cases were linked to close contact with dead fowls. Therefore, the actual animal H5N1 influenza epidemics are probably more serious than indicated by official reports, which usually only report confirmed cases.

In summary, this survey suggested that human infections escalated in the past 3 years, and control of animal epidemics, avoidance of high-risk behaviors, and proper disposal of diseased or dead fowls are vital to prevent human infections. Age distribution of the human cases demonstrated that older people are more immune to the infection, possibly because of the cross protectivity induced by their previous infections with human influenza A viruses. This survey also suggested that live vaccines against human influenza are probably of utility in the prevention of AIV infections in humans, and new preventive measures such as a ban on keeping backyard fowls should be considered for the control of animal H5N1 influenza epidemics.

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Selective decontamination of the digestive tract reduces pneumonia and mortality without resistance emerging

To the Editor:

We welcome the review by Flanders et al.1 on the pathogenesis, diagnosis, treatment, and prevention of nosocomial pneumonia, including ventilator-associated pneumonia (VAP); however, we do not agree completely with the section on selective decontamination of the digestive tract (SDD). Although Flanders et al. are correct in saying that the evidence suggests that SDD significantly reduces the risk for VAP and mortality in patients who are receiving both parenteral and enteral antimicrobials, they cited Dodek et al.’s2 practice guidelines and Collard et al.’s3 systematic review to sustain that evidence.4,5 We would like to support authors’ assertion providing more updated informations.

Fifty-six randomized controlled trials (RCTs)6-8 and 12 meta-analyses of RCTs9-20 have been published during 20 years of clinical research on SDD. The main morbidity end point was pneumonia in 9 meta-analyses,9-16,18 whereas in the remaining 3 meta-analyses it was infection in liver transplantation,17 yeast carriage and infection,19 or bloodstream infections.20 Those 9 meta-analyses consistently demonstrated a significant reduction in pneumonia (Table 1). The recent Cochrane meta-analysis that was published in 2004, which included 6922 patients, showed that SDD with parenteral and enteral antimicrobials reduced the odds ratio (OR) for pneumonia to 0.35 (95% confidence interval [CI], 0.29-0.41).18

Mortality was the outcome measure in 9 of 12 meta-analyses (Table 2).9,15,17,18,20 There was a consistent survival benefit in all meta-analyses that evaluated SDD with parenteral and enteral antimicrobials.10,12,14,15,18,20,26 The most recent Cochrane meta-analysis demonstrated that parenteral and enteral antimicrobials reduced the OR for mortality to 0.78 (95% CI, 0.46-0.81).24 The emergence of resistance was virtually absent in the remaining RCTs of SDD.25 Additionally, resistance was not a clinical problem in 10 SDD studies that monitored resistance over a period of 2 to 9 years.26 Therefore, SDD does not increase resistance, but it does solve the problem of endemicity of resistant AGNB.

The parenteral and enteral antimicrobials of the full SDD package are intrinsically inactive against VRE and MRSA, and they may promote gut overgrowth of these microorganisms.27 Of the 56 RCTs, 7 were undertaken in intensive care units (ICUs) where MRSA was endemic in the unit, and they reported a trend toward higher MRSA carriage or infection rates.28 However, in those circumstances, enteral vancomycin needs to be added to the SDD protocol.29-32 Three studies that used oropharyngeal or intestinal vancomycin added to the nonabsorbable polymyxin-tobramycin-amphotericin B component of SDD, demonstrated that the prevention and the eradication of carriage and overgrowth of MRSA were followed by the control of MRSA infection, transmission, and outbreaks.29-31 In 2 RCTs, severe infections, including MRSA pneumonia, were reduced significantly by using enteral vancomycin.32,33

SDD has been evaluated in two American ICUs with VRE endemicity;34,35 carriage and infections that were due to VRE were similar in the test and control groups. None of the eight RCTs that evaluated SDD, which included enteral vancomycin, reported a problem with VRE.36 Interestingly, recent literature demonstrated...
Table 1. Results of the nine meta-analyses of randomized controlled trials of SDD with the end point of pneumonia

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Number of RCTs</th>
<th>Aggregate number of patients</th>
<th>Number of RCTs by outcome</th>
<th>Number of patients by outcome</th>
<th>End point of pneumonia and subgroup analyses</th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vandenbroucke-Grauls &amp; Vandenbroucke 9</td>
<td>6</td>
<td>491</td>
<td>6</td>
<td>491</td>
<td>Overall</td>
<td>0.12</td>
<td>0.08-0.19</td>
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<td>22</td>
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<td>Overall</td>
<td>0.37</td>
<td>0.31-0.43</td>
</tr>
<tr>
<td>Kollef 11</td>
<td>16</td>
<td>2270</td>
<td>16</td>
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<td>Overall</td>
<td>0.43</td>
<td>0.33-0.56</td>
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<td>NR 2283 Parenteral and enteral</td>
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<td>0.23-0.39</td>
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</tr>
<tr>
<td>Heyland et al. 12</td>
<td>25</td>
<td>3395</td>
<td>12</td>
<td>3395</td>
<td>Overall</td>
<td>0.46</td>
<td>0.39-0.56</td>
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<tr>
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<td>0.30-0.49</td>
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<td>0.22-0.40</td>
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</tr>
<tr>
<td>Hurley 13</td>
<td>26</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>Overall</td>
<td>0.35</td>
<td>0.30-0.42</td>
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<tr>
<td>NR 2583 Parenteral and enteral</td>
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<td>NR 2128 Enteral</td>
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<td>0.24-0.37</td>
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<tr>
<td>D’Amico et al. 14</td>
<td>33</td>
<td>5727</td>
<td>15</td>
<td>2883</td>
<td>Parenteral and enteral</td>
<td>0.47</td>
<td>0.39-0.56</td>
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<td>Nathens et al. 15</td>
<td>22</td>
<td>NR</td>
<td>11</td>
<td>NR</td>
<td>Overall</td>
<td>0.19</td>
<td>0.15-0.26</td>
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<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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Table 2. Results of the ten meta-analyses of RCTs of SDD including the analysis of mortality

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<th>Investigators</th>
<th>Number of RCTs</th>
<th>Aggregate number of patients</th>
<th>Number of RCTs by outcome</th>
<th>Number of patients by outcome</th>
<th>End point of mortality and subgroup analyses</th>
<th>OR</th>
<th>95% CI</th>
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<td>Vandenbroucke-Grauls &amp; Vandenbroucke 9</td>
<td>6</td>
<td>491</td>
<td>6</td>
<td>491</td>
<td>Overall</td>
<td>0.70</td>
<td>0.45-1.09</td>
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<td>SDD Trialists’ Collaborative Group 10</td>
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<td>4142</td>
<td>22</td>
<td>4142</td>
<td>Overall</td>
<td>0.90</td>
<td>0.79-1.04</td>
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<tr>
<td>Kollef 11</td>
<td>16</td>
<td>2270</td>
<td>16</td>
<td>2270</td>
<td>Overall</td>
<td>0.19</td>
<td>0.15-0.26</td>
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<td>0.86-1.32</td>
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<td>Heyland et al. 12</td>
<td>25</td>
<td>3395</td>
<td>14</td>
<td>3395</td>
<td>Overall</td>
<td>0.81</td>
<td>0.71-0.95</td>
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<tr>
<td>Hurley 13</td>
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<td>NR</td>
<td>25</td>
<td>NR</td>
<td>Overall</td>
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<tr>
<td>D’Amico et al. 14</td>
<td>33</td>
<td>5727</td>
<td>17</td>
<td>2543</td>
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<td>0.91</td>
<td>0.71-1.18</td>
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<tr>
<td>Nathens et al. 15</td>
<td>22</td>
<td>NR</td>
<td>11 (surgical)</td>
<td>NR</td>
<td>Overall</td>
<td>0.80</td>
<td>0.69-0.93</td>
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<tr>
<td>NR 11 (medical)</td>
<td>Overall</td>
<td>0.70</td>
<td>0.52-0.93</td>
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</table>

AGNB, Aerobic gram-negative bacilli; NR, not reported. |

*Risk difference. |

Relative risk. 

Continued
that parenteral antibiotics that disregarded the ICU patient gut ecology—rather than high doses of enteral vancomycin—promoted VRE. 37,38

We believe that the addition of enteral antimicrobials to parenteral antimicrobials is a promising practice to maintain the usefulness of antimicrobials and to prolong the antibiotic era.

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ABSTRACTS

APIC 2007
34th Annual Educational Conference and International Meeting
San Jose, CA
June 24-28, 2007

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ABSTRACT AWARDS

William A. Rutala Research Award

Purpose: This award is given in the name of William A. Rutala, PhD, MPH, for the best abstract on the subject of disinfection, sterilization, or antisepsis.

Selection Criteria: To be considered for this award, applicants must: 1) submit an abstract to the APIC Annual Educational Conference & International Meeting in the year the award is to be given; 2) have not received the award within the last 3 years; 3) submit a Format I abstract in the antisepsis/disinfection/sterilization category, written in a clear, logical and concise manner which communicates the principal objectives, methodology, results and conclusions in a straightforward fashion; 4) submit research that is limited to the study and understanding of the principles and practices of disinfection, sterilization, and antisepsis; 5) submit an abstract that will reflect original research or (if not entirely new should supplement existing data), is conducted with appropriate data analysis, and is of major importance to the field of disinfection, sterilization, and antisepsis; 6) abstract is innovative, employs sound methodology, and represents a potentially significant, scientific contribution to the principles and practices of disinfection, sterilization and antisepsis; and 7) the applicant must apply for the Award during the abstract submission process.

Award: A $1,000 stipend, a plaque, recognition in the publication of abstracts in AJIC online, conference CD-ROM, and APIC News.

Sponsored by: Clorox.

2007 Winner:

Publication Number 235
Carla J. Alvarado, PhD
Evaluation of Nasendoscope Sheaths Used as Protective Barriers

Blue Ribbon Abstract Award

Purpose: Blue Ribbon awards are awarded to a limited number of abstracts based upon the scientific and/or educational quality of the work. Blue Ribbon abstracts are considered by the abstract selection subcommittee to be of exemplary quality, and investigators are encouraged to emulate the qualities evident in these submissions when preparing their own abstracts.

Selection Criteria: Among the criteria considered by the committee in awarding Blue Ribbons are: 1) the abstract is presented in a clear, logical and concise format and communicates the major ideas of the work in a straightforward fashion; 2) if scientific research findings are presented, the abstract demonstrates a high quality of research design and methodology and includes sufficient data to support the conclusions; 3) the work is timely, novel, and represents a potentially significant, scientific or educational contribution to the field.

Award: A plaque and recognition in the publication of abstracts in AJIC online, onsite Annual Conference Program, and conference CD-ROM.

2007 Winners:

Publication Number: 15—178
Louise Eutropius, RN, BSN, CIC
Preparing for Mandatory Reporting of Healthcare Acquired Infections (HAI): Comparison of Infection Control Resources and Practices at Rural and Urban Hospitals in Utah

Publication Number: 16—179
Jong Ja LEE, RN
Survey of 229 Japanese Hospitals To Assess Sharps Injury Prevention Programs and Organizational Capacity for Healthcare Worker Safety
New Investigator Award

Purpose: The New Investigator Award encourages research by APIC members by recognizing outstanding scientific research by an APIC member presenting for the first time at the APIC Annual Educational Conference and International Meeting.

Selection Criteria: To be considered for the New Investigator Award, applicants must be: 1) a current APIC member; 2) the first or presenting author on a scientific paper (Format I) selected for presentation; and 3) a first-time presenter of a scientific paper in either an oral or poster session; 4) Authors must indicate they are applying for the New Investigator Award during the abstract submission process by clicking the check box labeled “New Investigator Award.” This is a one-time award, and winners may not apply for this award in the future. However, other individuals from the same institution are eligible to apply for their scientific research.

$1,500, a plaque and recognition in the publication of abstracts in AJIC online, onsite Annual Conference Program, and conference CD-ROM.

Sponsored by: ASP.

Award Winner
Publication Number: 240
Angla J. Recktenwald, MPH
Attributable Cost during Index Hospitalization of Deep Chest Surgical Site Infection Following Coronary Artery Bypass Graft (CABG)

Best International Abstract Award

Purpose: This award recognizes the best abstract from outside the United States

Selection Criteria: Abstracts will be judged on scientific merit, interest, and relevance to the infection prevention and control community. To be considered for this award, applicants must meet the following requirements: 1) the applicant resides outside the United States; 2) the research was conducted outside the United States; 3) the applicant is able to present the paper at the APIC Annual Conference; 4) the applicant follows all online submission procedures; and 5) authors must apply for the Best International Abstract Award during the abstract submission process by clicking the check box labeled “Best International Abstract Award.”

Award: $1,000 travel stipend to APIC Annual conference, recognition in the publication of abstracts in AJIC online, onsite Annual Conference Program, and conference CD-ROM.

Sponsored by: The Research Foundation a Division of APIC

Award Winner
Publication Number: 227
Victoria R. Williams, BSc, BASc, CIC
The Role of Colonization Pressure in Nosocomial Transmission of Methicillin Resistant Staphylococcus aureus
Abstracts were submitted in two Different Formats

FORMAT I

This format is intended for abstracts involving scientific research, such as randomized clinical controlled trials, case-controlled studies, cohort, observational, descriptive studies, and/or experimental design. Abstracts should disclose primary findings and should not discuss works in progress with preliminary results.

- **Background/Objectives:** Outline study objectives, hypothesis tested, or problem addressed.
- **Methods:** Describe study design. NOTE: When using trade names, several companies’ trade names should be used, not just trade names from a single company
- **Methods:** Indicate the setting for the study, study design, sample, sample size, study procedure, outline, subjects, intervention, and type of statistical analysis.
- **Results:** Summarize essential results with appropriate statistical analysis (p-value confidence intervals, odds ratio, relative risk, rate ratio, etc.). Present as clearly as possible the outcome of the study and statistical significance if appropriate.
- **Conclusions:** Conclusions should be supported by the findings. Summarize findings (as supported by results), implications, and conclusions. Emphasize the significance of the results.

FORMAT II

This format is intended for abstracts describing educational programs, observations, case studies, outbreak investigations, or other infection prevention or quality improvement activities, including descriptions of facility- or community-based programs or interventions, infection prevention policies, and prevention models or methods.

- **Issue:** Identify specific problem or need addressed. Provide a brief introduction and include important background information
- **Project:** Describe the setting, intervention, and significant detail of the program
- **Results:** Summarize results
- **Lessons Learned:** Outline lessons learned and implications.
Poster Abstracts

Posters will be on display Tuesday during exhibit hall hours.

The posters are arranged by topic number (see below) and then numerically by Publication Number within each category. Example, Poster 1-1, is in the antimicrobial resistance category and precedes poster 1-18.

Professor Rounds  
Tuesday, June 26, 2007  
Session 1: 11:45 AM - 12:45 PM  
Session 2: 1:15 PM - 2:15 PM

The authors will be attending their posters on Tuesday, June 26 from 11:45 AM - 12:45 PM to answer questions and interact with attendees. Ticket required to be in a professor’s group. Tickets are available at the APIC box office for a $10 donation to the APIC Resource Center.

Poster Categories

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Antimicrobial Resistance

Antimicrobial Susceptibility of Clinical Isolated Methicillin-Resistant Staphylococcus aureus (MRSA) in Japanese Hospitals

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Kotobiken Medical Laboratories, Tokyo, Japan

BACKGROUND/OBJECTIVES: Methicillin-Resistant Staphylococcus aureus (MRSA) has become one of the most problem of healthcare-associated infections worldwide. In Japan, about 60% of the S. aureus isolated in hospitals is MRSA. Intravenous vancomycin was approved in 1991 in Japan and has been widely used for treatment of infections caused by MRSA. In this study, we investigated the susceptibility pattern of 194 MRSA clinical isolates from Japanese hospitals.

METHODS: A total of 194 MRSA isolates were isolated from some Japanese hospitals. MICs were determined for 13 antibiotics listed below by the agar dilution method using Mueller-Hinton (MH) agar according to the Clinical and Laboratory Standards Institute (CLSI).

RESULTS: In vitro resistant rates and median MIC50 in µg/ml for the MRSA isolates were: sulbactam/ampicillin (99.5%, 32), cefazolin (98.5%, ≥256), imipenem (94.8%, 64), gentamicin (58.2%, 16), ofloxacin (97.4%, 64), tetracycline (79.4%, 64), arbekacin (4.1%, 1), vancomycin (0%, 1), teicoplanin (0%, 1), linezolid (0%, 2), daptomycin (0%, 0.5). There was no VRSA among 194 MRSA strains tested but one of the 194 MRSA was heterogeneously vancomycin–intermediate S. aureus (hetero-VISA), which contains cell subpopulation with vancomycin MICs of 4 µg/ml or above at a frequency of 10^{-6} or higher.

CONCLUSIONS: All MRSA strains were susceptible to clinically available anti-MRSA agents, except for the presence of a hetero-VISA strains is tested samples. We have been monitoring the increasing trend of hetero-VISA in the world. Proper use of antibiotics and the observance of standard precautions would remain important in the future as well.

Publication Number 1-2

The Effect of Inadequate Facilities on Methicillin-Resistant Staphylococcus aureus (MRSA) and Vancomycin-Resistant Enterococcus (VRE) Rates in Vascular Surgery Patients

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J Shymanski, RN, BScN
K Suh, MD

E14
BACKGROUND/OBJECTIVES: Few studies quantify the nosocomial infection risk with inadequate facilities. In Jan 01, vascular surgery was amalgamated onto a multi-bed unit with shared toilets. The objective of this study was to evaluate the effect of inadequate facilities on nosocomial MRSA and VRE rates.

METHODS: We prospectively evaluated nosocomial MRSA and VRE rates in vascular surgery compared to other TOH patients. During Period 1 (Jan 01-Oct 03) the vascular surgery unit had only 2 private rooms with a dedicated toilet. The remaining 27 patients shared 7 toilets, for a patient:toilet ratio (PTR) of 4:1. In Period 2 (Nov 03-Jun 04) patients were split between two units with beds blocked to achieve a PTR of 2:1. In Period 3 (Jul 04-Jan 06) patients were reconsolidated onto a single unit with a PTR of 4:1. In Period 4 (Feb 06-Sep 06), patients moved to a renovated unit with a PTR of 2:1.

RESULTS: The nosocomial MRSA risk was significantly higher for vascular compared to other TOH patients during periods when the PTR was 4:1 (157.7 vs 31.9 per 100,000 pt-days; RR = 4.9; 95%CI = 3.8-6.4) but not when the PTR was 2:1 (81.4 vs 49.6 per 100,000 pt-days; RR = 1.6; 95%CI = 0.9-3.1). Similarly, nosocomial VRE risk was significantly higher for vascular compared to other TOH patients during periods when the PTR was 4:1 (42.6 vs 6.2 per 100,000 pt-days; RR = 6.9; 95%CI = 4.1-11.5), but not when the PTR was 2:1 (0 vs 7 per 100,000 pt-days; RR = 0). There were no differences in patient population, patient days, staff and physicians, procedures performed or severity of illness.

CONCLUSIONS: Improving the PTR ratio had a significant impact on nosocomial MRSA and VRE. These data suggest that hospitals should strive to maintain a maximum PTR of 2:1.

Publication Number 1-3

Characterization of Methicillin-Resistant Staphylococcus aureus Strains Isolated in a Japanese Geriatric Hospital in Early 1980s

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BACKGROUND/OBJECTIVES: Infection control practice has been developed recently in Japan. However, MRSA cross-transmission remains one of the unsolved problems at most of hospitals. We have developed a Multiplex PCR system to assign types of SCC mec element. In this study, we have examined types of SCC mec elements carried by MRSA strains, which were isolated from the patients with blood stream infection.

METHODS: MRSA strains isolated in the 1980s, at a geriatric hospital were kindly provided by the hospital. Four sets of Multiplex PCR system to identify mec, ccr gene complex and subtyping type I, III, V SCC mec element and typell, IV SCC mec were used. The carriage of Panton-Valentine leukocidin(PVL) gene were tested by PCR.

RESULTS: All of MRSA strains were assigned by Multiplex PCR; 20 strains (47.6%) carried SCC mec type I, 13 strains (30.9%) type II SCC mec, (11 of 13 SCC mec type II.1.(IIa), 9 strains(21.4%) carried type IV1(IVa). SCC mec. Ten strains (23.8%) of 42 MRSA were PVL positive.9 of 10 were found among strains which carried type IV SCC mec.

CONCLUSIONS: Type of SCC mec could be assigned by multiplex PCR. Majority of MRSA strains, which were isolated in the 1980s at a geriatric hospital, were type I SCC mec. In addition, the strains in this study predominantly harbored type I or IV SCC mec, differing totally from recent isolates in Japan which harbor type II SCC mec.
Treatment Recommendations for *Clostridium difficile*, Treatment Failures, and Impact on Active Diarrheal Days

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ISSUE: Much like many health care facilities, the VANJHCS had experienced an increase in the incidence rate of *Clostridium difficile* associated diarrhea (CDAD). We had gone from an average of 3 cases per month in previous years to as high as >10 cases for one month. Current recommendations to control the spread of CDAD include contact isolation, environmental cleaning, and stopping antibiotics. Oral metronidazole for 14 days is the drug of choice for initial CDAD episode. Oral vancomycin is an option for patients who cannot take or fail treatment with metronidazole. However in a number of the patients it had been noted that they were failing these recommended antibiotic treatments, thus the adequacy of the 14 days treatment regimen was questioned. The treatment failures also are challenging for Infection Control Professionals because this prolongs the need for contact isolation and hospital stay thus increasing hospital cost.

PROJECT: We conducted a retrospective review of CDAD cases at the VANJHCS in 2005 and 2006. There were 686 patients who had diarrhea and stool specimens were sent to the laboratory for *Clostridium difficile* Toxin A & B. Risk factors and duration of treatment were reviewed.

RESULTS: Of the 686 patients with diarrhea there were 121 patients (17.64%) positive for *Clostridium difficile* Toxin A & B. Of the 121 *Clostridium difficile* positive cases, 41 had ICU stay during their hospital course. Thirty-six (36) of the 121 patients with *Clostridium difficile* (30%) required prolonged treatment. The average duration of therapy for these patients was 67.03 days. Most of these patients had other serious infections that stopping antibiotics was not an option. For those patients who were treated more than 14 days, the average age was 73 with a range of 46 to 92 years.

LESSONS LEARNED: This review highlights the potential need for longer duration of therapy and the necessity for clinical trials necessary to define the appropriate effective therapy for initial CDAD that produces lower recurrence rates compared to the current recommended therapies.

Prevalence and Risk Factors Associated with Antimicrobial Resistant Nosocomial Infections

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BACKGROUND/OBJECTIVES: The frequency of antibiotic-resistant, health care–associated infections has gradually increased. However, the emergence of antimicrobial-resistant pathogens has made treatment of infections more difficult. Infections with antibiotic-resistant organisms have been linked to increases in morbidity, length of hospitalization, increased healthcare costs, and increased mortality. This study evaluates the prevalence and risk factors associated with antimicrobial resistant nosocomial infections in intensive care unit (ICU).

METHODS: A retrospective cohort study was conducted at medical and surgical ICU in a 2,700-bed tertiary referral medical center. 244 patients admitted to the ICU who had developed nosocomial infection were eligible. The definitions of the Centers for Disease Control and Prevention were used to categorize specific nosocomial infections as bloodstream infection, respiratory tract infection, urinary tract infection, surgical-site infection, or others. The survival analysis and multiple regression analysis were used to estimate statistical significance.

RESULTS: During 3 years period, gram-negative bacteria accounted for 53.1%, gram-positive bacteria 34.1% and fungi 12%. Of gram-positive bacterial isolates, the most common were Staphylococcus aureus (71.1%), Enterococcus spp (16.6%), and coagulase negative Staphylococci (8.5%). Gram-positive bacterial isolates included oxacillin-resistant S. aureus (94.8%), oxacillin-resistant CNS (95.8%), and vancomycin-resistant Enterococcus (3.9%). The five most common gram-negative bacterial isolates were Acinetobacter baumannii (36.3%), Pseudomonas aeruginosa (13.7%), Escherichia coli (12.8%), Klebsiella pneumoniae (8.2%), and Burkholderia cepacia (7%). Gram-negative bacterial isolates had resistance to third generation cephalosporins ranging from 41.1%-68.6%. One third of gram-negative bacterial isolates had multi-drug resistance. The Kaplan-Meier estimator analysis, the median survive time was on day 13 after onset of oxacillin resistance after admission to the ICU, and on day 16 after onset of gram-negative bacteria had acquired resistance to at least one type of antibiotic. There were statistically significant difference by log rank test (p < 0.001). After covariates were adjusted for in the Cox regression analysis, use antibiotic before ICU admission (Relative Risk [RR] 5.31, 95% confidence interval [CI] 2.18 - 9.32), insertion of central venous catheter (RR 2.85, 95% CI 1.28 - 7.02) were independent factors which influenced the development of antimicrobial resistance.

CONCLUSIONS: We found nosocomial infection patients who had higher prevalence of antimicrobial resistance in ICU. In addition, patient of nosocomial Infection with antimicrobial resistance had a longer length of stay in ICU. The independent risk factors also included use antibiotic before ICU admission and insertion of central venous catheter.

Patterns of Antimicrobial Resistance in Bacteremia Caused by Staphylococcus aureus in ICU and Non-ICU Patients

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BACKGROUND/OBJECTIVES: Bloodstream infections caused by Staphylococcus aureus create a serious health problem in hospitals all over the world. This microorganism is one of the most virulent species. In addition, has the capacity to be resistant to multiples antimicrobials. In consequence, the management of these types of infections is particularly harmful in developing countries since expensive second line drugs are not readily available. We study the antimicrobial resistance behavior of all S. aureus isolated from blood in patients from ICU and non-ICU in a tertiary hospital in Bogotá-Colombia.
METHODS: A descriptive retrospective study of antimicrobial resistance was performed from January 2001 until December 2006 for all *Staphylococcus aureus* isolated from blood culture obtained for each patient hospitalized in the ICU and non-ICU. The bacterial identification and the antimicrobial susceptibility were determined by the MicroScan system. The data was transferred to the program WHONET 5.4 with the aid of BacLink software. The information of susceptibility was classified as sensible, intermediate and resistant according with the criteria of the CLSI (Clinical and Laboratory Standards Institute). Analysis was performed by the program of the World Health Organization called WHONET 5.4 under the condition as one isolate per one patient. Differences in proportions between antimicrobial resistance patterns in non-ICU and ICU bacteremias were compared by $\chi^2$ test. The statistical significance was set at the level $p < 0.05$. All statistical analyses were performed using EPISET.

RESULTS: 562 S. aureus were obtained from 2001 to 2006. The 71% of the isolates in the ICU were resistant to oxacillin and the 56% from non-ICU were resistant to oxacillin. The rates of oxacillin resistance through 2001 to 2006 in ICU and non-ICU are represented in Figure 1. The comparison of antimicrobial resistance patterns between both wards showed that Clindamycin, Gentamicin, Ciprofloxacin, Erythromycin and Oxacillin tend to be higher in the ICU ($p < 0.05$). None of the *Staphylococcus aureus* isolated were resistant to vancomycin.

CONCLUSIONS: These results show the higher and progressive increase percentages of resistance of *Staphylococcus aureus* in both ICU and non-ICU settings through these 6 years. These findings have important implications for the selection empiric therapy in our institution who has suspected *S. aureus* bacteremia. In addition, this work would help to guide the resources of our institution in programs of bacteremia surveillance and in the improvement of measures of hand hygiene, patient isolation and antimicrobial use.

**Antibiotic Stewardship Success: Targeting Physicians Prescribing Habits**

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E Raia  
C Young-Ruckriegel  
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ISSUE: Infection Control strategies to control resistant organisms in the acute care setting include isolation of the patient, hand hygiene, proper wearing of personal protective equipment and judicious antibiotic use. Education of the healthcare worker is paramount. Antibiotic prescribing habits of physicians is one area not easily controlled. This abstract describes one acute care hospital’s success in controlling the use of the antibiotic, levofloxacin.

PROJECT: In 2005, our 620 bed acute care hospital discovered a dramatic increase in *Klebsiella pneumonia* and *E. coli* resistance. 31% of *E. coli* and 34% of *Klebsiella pneumonia* were resistant to the quinolone class of
antibiotics (specifically levofloxacin). As compared to 2002, nationwide, 4.5% of Klebsiella pneumonia and 5.4% of E.coli were known to be resistant to levofloxacin. Our data suggested a serious and rapidly developing gram negative organism resistance to quinolones within our facility. The antibiotic task force was re-convened at this time to address this problem. The task force consisted of pharmacy; specifically a Pharm D, infectious disease physicians, infection control, pathologist and head microbiologist. Attending physicians were targeted to persuade
them to change their prescribing habits. An antibiotic stewardship poster was developed by the task force with recommendations for treatment of GI/GU infections and community, healthcare and vent associated pneumonia. The poster was presented to senior management which consisted of vp of patient safety and chair of surgery; and all department heads. The poster was distributed to all departments and nursing units. A letter explaining the program was signed by the president of the medical staff and chair of the Infection Control Committee (ICC) and sent to all attendings. The Chair of ICC discussed this antibiotic program informally with the hospitalists and resident physicians.

RESULTS: From May 2005 to November 2006, the pharmacy calculated the number of levofloxacin doses per month. The goal was to reach 50% usage reduction of levofloxacin from 2250 doses per month to 1125 doses per month. In August, 2006, at the end of the campaign, 964 doses were ordered. Reinforcement of the campaign was needed when an elevation in doses occurred in September and October. By the end of December, 2006, doses were again down to 1362/month. Antibiotic resistance has leveled off for this particular antibiotic.

LESSONS LEARNED: Education through committees/presentations/conversations needs to be on a continual basis. Antibiotic posters are an efficient way to accomplish this. Recognize the efforts that result in positive infection control outcomes; for their efforts, the medical staff received the annual infection control award.

Publication Number 1-8

Investigating an Increase in Methicillin Resistant *Staphylococcus aureus* (MRSA) Infections in a Free Standing Outpatient Hemodialysis Center

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*Division of Infectious Disease, Washington University School of Medicine, Saint Louis, MO, USA*

BACKGROUND/OBJECTIVES: In September of 2006, 3 MRSA positive blood stream infections (BSI) were identified among the chronic hemodialysis patients at Barnes-Jewish Dialysis Center. Despite dialysis patients being at high risk for MRSA, there had only been 2 identified MRSA BSI’s in the previous 12 months. Because hemodialysis patients are at higher risk for serious comorbidities and prolonged colonization following a MRSA infection, surveillance cultures on the entire dialysis center population were obtained in October of 2006. The purpose of this study was to determine the prevalence of MRSA colonization among patients receiving dialysis at Barnes-Jewish Dialysis Center.

METHODS: Barnes-Jewish Dialysis Center is a free standing outpatient center providing over 22,000 dialysis treatments each year. The dialysis center is divided into 4 pods with 8 stations in each pod. Two swabs were taken from each patient, one from the nares and one from the axillae of 144 chronic hemodialysis out-patients. Axillae and nasal samples were cultured in the same medium. All *Staphylococcus aureus* (SA) isolates were tested for methicillin resistance using oxacillin screening plates. Molecular typing of bacteria using repetitive sequence PCR was used to determine clonality. Clonality was determined by the similarity index (SI).

RESULTS: Thirty two of the 144 patients (22%) cultured were found to be SA carriers. Of the 32 SA carriers, 14 (43.7%) were found to be MRSA. Among the 14 MRSA carriers, all positive cultures were collected from nares with the exception of 1 patient who had positive MRSA cultures from both the nares and axilla. All MRSA strains were sensitive to Vancomycin. We initiated a decolonization protocol on the 14 MRSA positive patients. Molecular typing of MRSA isolates demonstrated the presence of two highly related clusters. The first cluster (SI = 99.4%) consisted of 7 MRSA positive patients. The second cluster (SI = 97.9%) also consisted of 7 MRSA positive patients. Evaluation of the placement of MRSA patients in the dialysis center failed to identify a common pod or cluster by shift. Mupirocin intranasal ointment and 4% Chlorhexidine (CHG) solution were provided to each patient. Patients were educated to complete a 5 day course of mupirocin intranasally and shower every other day with chlorhexidine. A
MRSA BSI was identified in a patient that was previously colonized but failed to complete the decolonization protocol.

CONCLUSIONS: *Staphylococcus aureus* colonization rates at our outpatient dialysis center were similar to previously reported rates. Almost half of these isolates were methicillin resistant. Only two distinct molecular types were found among the 14 MRSA colonized patients indicating that patient to patient transmission occurred likely through healthcare worker (HCW) contact. This underscores the need for continued education of healthcare workers on infection control and hand hygiene policies.

BC Camins, MD, MSCR, Ethicon, Inc., Research Support, Research Funds.

**Do Drugs Eradicate MRSA?**

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*JA Kieller, BSN, RN, CIC*

*C Plante-Jenkins, MLT, BSc, CIC*

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BACKGROUND/OBJECTIVES: Eradication of Methicillin Resistant *Staphylococcus aureus* (MRSA) carriage is not clearly understood. Infection prevention and control and infectious diseases services formulated a standardized MRSA decolonization treatment regimen for our 804 bed tertiary care community hospital and monitored the effectiveness of this therapy.

METHODS: Patients are screened according to our screening for high risk inpatients for antibiotic resistant organisms’ protocol. The MRSA decolonization protocol includes doxycycline 100 mg PO BID ×5 days and rifampin 300 mg PO BID ×5 days and topical fucidin TID ×5 days to the nares and/or wounds and consult Microbiologist as required. Microbiology automatically includes the suggested MRSA decolonization protocol on all positive screening culture reports. A full 48 hours after date of treatment completion, the first set of screening specimens including nasal, rectal, open wounds or ulcers, and indwelling devices that have been in place for more than 48 hours are collected. Three sets of post-treatment screening specimens collected one week apart that are negative for MRSA are considered successful decolonization for that patient. No further culture follow-up was included for the purpose of this paper. MRSA colonized patients that remain colonized after two courses of decolonization treatment are considered a treatment failure. There were 589 patients that experienced a new event of MRSA from March 1, 2005 to October 31, 2006. All colonized or infected patients with a new event of MRSA are entered into our Automated Infection Control Expert (AICE) computer data system for analysis.

RESULTS: From the total of 589 patients, 326 were discounted due to being discharged or expired prior to treatment or prior to determining decolonization status or were an out-patient and 59 received a different treatment regimen. The remaining 204 colonized patients received the standardized MRSA decolonization protocol. From the 204 patients, 83 were discounted due to being discharged or expiring prior to treatment or prior to determining decolonization status, leaving 121. Of the 121 remaining patients, 111 (92%) were decolonized, 7 (6%) were treatment failure and 3 (2%) required decolonization twice.

CONCLUSIONS: Based on our data, the 5 day standardized MRSA decolonization treatment regimen has proven effective. It is important to periodically audit treatment outcomes and make recommendations accordingly. Infection prevention and control recognizes that decreasing the burden of colonization, reduces the risk of nosocomial spread.
Extreme-Drug Resistant *Acinetobacter baumannii* in the Hospital Setting: Infection Versus Colonization

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**BACKGROUND/OBJECTIVES:** *Acinetobacter baumannii* (Ab) resistant to all penicillins, cephalosporins, monobactams, carbapenems, quinolones, and aminoglycosides is defined as extreme-drug resistant (XDR). Patients with cultures positive for XDR-Ab were routinely treated with antibiotics in our institution. Isolation of XDR-Ab from a clinical specimen may not necessarily reflect infection but, rather, colonization. The objectives of this study were to define the sites of isolation of XDR-Ab in our institution, the proportion of cases representing infection versus colonization, and the most common site of nosocomial infections produced by XDR-Ab.

**METHODS:** This was a retrospective observational study of 50 XDR-Ab isolated from May 2005 to September 2006 at a long term care facility in Louisville, Kentucky. The medical records of the 50 patients were reviewed to evaluate if an infection was present at the time of XDR-Ab isolation. CDC criteria were followed to define the presence of infection.

**RESULTS:** The sites of isolation and the presence of infection versus colonization are depicted in the following table:

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<tr>
<th></th>
<th>Respiratory</th>
<th>Wound</th>
<th>Urine</th>
<th>Blood</th>
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<tbody>
<tr>
<td>Total number of isolates</td>
<td>23</td>
<td>17</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Infection</td>
<td>14</td>
<td>9</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Colonization</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>0</td>
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</table>

From the total of 50 patients, infections were documented in 29 patients (58%). In one of the six patients with a positive blood culture, there was no evidence of infection. The case was considered to indicate transient bacteremia or skin contamination.

**CONCLUSIONS:** Hospital-acquired pneumonia is the most common infection produced by XDR-Ab. Antibiotics with in vitro activity against XDR-Ab such as tigecycline or colistin are regularly used for treatment of XDR-Ab infections in our institution. Data from our study indicates that is critically important to define the presence of infection before starting antibiotics for XDR-Ab since approximately half of the patients will be only colonized and will not require antibiotic therapy.
BACKGROUND/OBJECTIVES: Methicillin-resistant *Staphylococcus aureus* (MRSA) infection is increasingly common and tremendously costly in hospitals today. In 2006, APIC supported a nationwide prevalence study to identify the magnitude of this problem. We used data submitted to the national study from a 13-hospital healthcare system to determine the prevalence of MRSA.

METHODS: We used prevalence data collected for the APIC National MRSA Healthcare Facility Inpatient Survey to determine characteristics of MRSA patients in our hospitals. Ten of thirteen system hospitals completed the APIC Survey. Data was evaluated by system, large vs. small and urban vs. rural hospitals.

RESULTS: Six of ten hospitals are performing active surveillance cultures (ASC) in targeted populations, but no one hospital cultures transfers from LTCF, and only one cultures patients admitted from other healthcare facilities. We determined the average age for MRSA patients was 62.2 (range 18-94 years). The majority of patients were on medical wards (65%, 64/99). MRSA was identified within 48 hours of hospitalization 68% of the time, 60% by clinical cultures, 31% by surveillance cultures. We assessed small (bed range 22-152; n = 6) vs. large facilities (bed range 354-1106; n = 4) and discovered some interesting differences. In small hospitals, females accounted for 80% (12/15) of MRSA inpatients; in large hospitals, females made up 45% (38/84) of the study patients (p = .03, 95%CI = 1.1-23.5). In both groups, skin infections were most often identified as the MRSA site: 47% in small hospitals, 18% in large hospitals (p = .04, 95%CI = 1.1-14.8). The lower rate of MRSA skin infections in large hospitals may be due in part to twice as many large hospitals performing ASC in selected populations (4 large, 2 small hospitals). In small hospitals, 26.7% (4/15) of all patients had been transferred from LTCF; by contrast, transfers from LTCF to large hospitals were 15.5% (13/84) (p > .05). Diabetes was present in 73% (11/15) of small hospital MRSA patients, and 52% (44/84) in large hospitals (p > .05). Other health conditions did not differ significantly. Large hospitals recorded multiple courses of antibiotics in 52% (44/84) of study patients, while in small hospitals the rate was 27% (4/15) (p > .05). There was not enough data to determine differences between urban and rural facilities.

CONCLUSIONS: Our data suggests that MRSA is more prevalent in elderly women for patients admitted to small hospitals vs. those admitted to large hospitals. A significant number of MRSA patients were transferred from LTCF. These findings may be associated with the facts that women live longer, have more opportunity to reside in LTCFs, and to be hospitalized at an elderly age. One strategy to control the spread of MRSA is to identify colonized patients and isolate them. We recommend small hospitals that wish to begin or modify active surveillance programs include elderly women and transfers from LTCF. Additionally, further inquiry into the epidemiology associated with higher MRSA concentration in females at small facilities vs. males at large facilities may be warranted.

KF Woeltje, MD, PhD, Pfizer, Speakers’ Bureau, honorarium, Merck, Speakers’ Bureau, honorarium.

Publication Number 1-12

**Prevalence of Methicillin Resistant *Staphylococcus aureus* (MRSA) Colonization: A Patient and Employee Study in a 270-Bed Regional Referral Hospital**

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BACKGROUND/OBJECTIVES: Over 50% of *Staph aureus* infections occurring in U.S. hospitals are resistant to methicillin. Infection with MRSA is associated with increased length of stay, ICU stay and morbidity. The incidence of healthcare-associated MRSA infections increased from 0.15 to 0.81 cases per 1000 patient days over a 5-year period. The purpose of this study was to understand the burden of MRSA colonization in our patient and employee populations. This study was also conducted to compare MRSA colonization rates using traditional culturing techniques and rapid PCR technology.

METHODS: A period-prevalence study was performed to include all hospital inpatients and hemodialysis patients (n = 217), and volunteer health care employees (n = 304) over a 3-week period. The patient study was conducted using traditional culture and rapid PCR technology methods. The employee study utilized rapid PCR technology. All patients who occupied an inpatient bed in the Intensive Care, Ambulatory Telemetry, Medical and Surgical units were asked to participate in a prevalence study and have a one-time nasal swab performed of both nares. Patients were informed they would not receive the test results. The following risk features were collected from a medical record review: age, gender, diagnosis of diabetes, prior hospitalization or long-term care stay within the last year, prior antibiotic (treatment or empiric; excluded surgical prophylaxis), or receipt of hemodialysis. The employee study included employee volunteers from various disciplines grouped in the following categories (i.e. nursing, providers, support, and non-clinical staff). Individual test results were not reported. Standard specimen collection technique was used. Age, gender, and discipline were collected at the time of nasal swab.

RESULTS: The overall MRSA colonization rate among patients was 7.8% using traditional culture method and 11.7% using the rapid PCR technology. Sensitivity was 94%. Specificity was 96%. Highest colonization rates were noted in patients with a diagnosis of diabetes or who were receiving hemodialysis. Patients who were hospitalized or who had a long-term care facility stay in the last year documented a lower colonization rate. General medical unit patients and patients who received outpatient hemodialysis had the highest colonization by unit. The employee MRSA colonization rates ranged from 1.3% - 17.2%, with an overall rate of 7.2% and were found to be higher in the male gender. Refer to the following graphs.

CONCLUSIONS: The study documented an overall *Staphylococcus aureus* colonization rate of 32% of which 7.8% were MRSA positive. This finding is consistent with other rates that have been reported in the literature. Results documented PCR sensitivity higher than the traditional culture method. The ICU had the lowest MRSA colonization rate among patients. The most intriguing finding of the employee study was the highest colonization rate was found in the provider group. Significance of this of this finding is unknown.
Evaluation of Chlorhexidine Gluconate (CHG) Delivered to the Skin Following Standard Pre-Op Prepping Protocols of 4% CHG Solution Versus No-Rinse 2% CHG Cloth

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BACKGROUND/OBJECTIVES: Chlorhexidine gluconate (CHG) is a skin antiseptic available in a 4% formulation that is rinsed off after use in a bath or shower and a 2% CHG impregnated no-rinse cloth. The residual CHG after use may influence efficacy. This study sought to evaluate delivery of CHG to the skin by each of these CHG formulations.

METHODS: A total of 24 subjects were randomly assigned to Group A or B and were tested on days 1 and 8 utilizing one of four protocols. On day 1, Group A was instructed to shower using 4% CHG. Group B was instructed to shower with 4% CHG both the night before and the morning of testing. Between days 1 and 8, subjects resumed their normal showering routine to remove any residual CHG. On day 8, Group A was instructed to wipe down with the no-rinse 2% CHG and Group B was instructed to wipe down with the no-rinse 2% CHG the night before and the morning of testing. At the time of testing, the cloths and the 4% CHG bottles were weighed to determine how much product had been used. Sampling for CHG residual was done 3 and 10 hours after showering in Group A (morning shower). Sampling for Group B (night-before and morning shower) was done 3 hours after the morning shower. The abdomen, behind each knee, and the left and right forearms were sampled for CHG residual. A premoistened sterile swab was used to sample the skin. Cetyltrimethylammonium bromide and sodium hypobromite were used as the reagent to create a color response used to determine the amount of CHG residual. The swabs were compared to swabs inoculated with known amounts of CHG and tested with reagent.

RESULTS: There was no significant difference in the mean amount of product used between the 4% solution and the 2% no-rinse subjects (P = .63). In subjects using the 2% no-rinse product, the amount of product used correlated with the amount of residual (P = .0003), but there was no correlation in the 4% solution subjects. Subjects who prepped twice with the 4% solution showed no more residual than those who prepped once (P = .137). Subjects who prepped twice with the 2% no-rinse product showed more residual than those who prepped once (P = .016). Subjects using the 2% no-rinse product had significantly more mean CHG concentration on their skin than the 4% solution subjects at all sampling sites (all P < .05).

CONCLUSIONS: The use of the no-rinse 2% CHG Cloth results in higher residual CHG on the skin after both 1 and 2 applications at all body sites as compared to the equivalent use of the 4% solution. The lack of correlation between the amount of 4% solution used and the residual on the skin suggests most of the CHG is rinsed off after the application of the 4% CHG product.
The Many Roles of Silver in Infection Prevention

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ISSUE: With increased concern about Methicillin Resistant Staphylococcus Aureus, Pseudomonas and other organisms resistant to commonly used disinfectants, silver, with its three mechanisms for controlling the growth and spread of microorganisms is being readied for greater control of harmful bacteria, viruses, and fungi. By binding with cell DNA prohibiting reproduction, or by binding with enzymes that control respiration and other cell functions, or by binding with chemical functionality on the cell wall, and with combinations of these, silver is very effective against many otherwise intractable infectious organisms.

PROJECT: An extensive survey was made of both the published scientific literature on the infection control properties of silver and of the commercial products that make use of silver’s antimicrobial qualities. Antimicrobial silver is available in the form of sprays, coatings, gels, and as a constituent of polymeric laminates. These many forms of antimicrobial silver offer professionals concerned with infection control many new effective and economical options.

RESULTS: Silver is already widely adopted in wound care dressings, gowns and drapes, and for catheters. Silver is also expected to become part of the patient contact area in these and other medical devices such as endotracheal tubes. Other items that are effectively treated with silver are portable objects such as pens, clip boards, and stethoscopes. Silver can also be on the surface coatings of walls, floors, and climate control ductwork. Silver in carpeting and in other textile products such as bedding will also control odor-causing as well as infectious organisms, thus reducing the amount of maintenance required. Silver is generally considered to be environmentally benign, and, unless ingested, not harmful to patients. If not within the Food and Drug Administration (FDA) jurisdiction, products containing antimicrobial silver do come under the regulatory jurisdiction of the Environmental Protection Agency (EPA).

LESSONS LEARNED: The research literature on the use of silver shows that it is highly effective in controlling infectious organisms. The recent proliferation of commercial products containing silver for infection control shows that the health-care industries are taking advantage of this capability. With many medical and disinfection uses already allowed by regulatory agencies, and with the wide ranging nature of the many protective applications being researched, it is certain that silver will become an increasingly important component of products designed for the control of infectious organisms.

Operating Room Environmental Cleaning – An Evaluation Using a New Targeting Method

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BACKGROUND/OBJECTIVES: Infection control interventions to minimize transmission of viral and bacterial pathogens as well as to minimize the risk of surgical site infections have long been recognized as an integral part of
patient safety enhancement in the operating room. Despite AORN standards which mandate disinfection cleaning of areas possibly contaminated by transmissible pathogens as part of daily terminal cleaning and the CDC’s recommendation that hospitals “Ensure compliance by housekeeping staff with cleaning and disinfection procedures” (Guidelines for Environmental Infection Control in Healthcare Facilities. MMWR. June 6, 2003/52, RR 10: Environmental Services IV. B. 2. - Category IB), there are currently no means to objectively evaluate such activities programmatically. Following the effective use of a novel targeting method to evaluate and improve disinfection cleaning of high touch objects in patient rooms as part of discharge cleaning, this tool was used to evaluate the thoroughness of daily disinfection cleaning in operating rooms.

METHODS: The thoroughness of cleaning of a standardized group of objects was evaluated in operating rooms used regularly for device implantation related to cardiac, vascular, orthopedic and neurosurgical procedures. A translucent targeting solution which fluoresces when exposed to black light was used to confidentially mark fourteen objects in the near patient operating room environment chosen on the basis of AORN standards as well as the CDC’s recommendation that “enhanced cleaning activities” should be directed at “high touch objects which would be expected to be frequently contaminated with hospital associated pathogens”. The targeting material was placed on areas easily accessible to cleaning and the thoroughness with which it was removed was evaluated following two or more terminal cleanings of the operating room suite.

RESULTS: 59 rooms and 783 objects were evaluated in four acute care teaching hospitals. The mean proportion of objects cleaned was 46.6% (range 30.8% to 54%). While side tables were relatively well cleaned (77%), other objects including over table lights, door knobs and pushplates, and equipment control panels were cleaned less than half the time (mean = 37.8%, range 0-48%) (p = <0.004).

CONCLUSIONS: The use of an objective targeting method to evaluate daily disinfection cleaning in 49 operating rooms documented opportunities for improving terminal environmental cleaning in each of the hospitals studied. Interestingly, the overall proportion of objects cleaned (46.6%) was similar to that found in a study of post discharge room cleaning of 1,054 patient rooms in 22 hospitals (47.6%) evaluated using the same targeting method.

Publication Number 2-16
Zone of Inhibition Study of CHG-Containing Antiseptic Devices

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BACKGROUND/OBJECTIVES: There are approximately 8 million central venous catheters (CVCs) and 160 million peripheral IV catheters (PIVs) placed in the U.S each year. Catheter-related bloodstream infections (CR-BSIs) resulting from intravenous catheters are a serious medical problem. There are two major sources of contamination which may lead to infection: 1. extra-luminal (e.g., contamination where skin flora from the patient or healthcare personnel are introduced into the bloodstream), 2. intra-luminal (e.g., where bacteria are introduced with the infused fluid or due to non-aseptic manipulations). Most short term CVC-related infections are produced by extra-luminal colonization. A catheter secure device has been developed consisting of a gel pad composed of CHG dissolved in a soft polyglycerol gel pad as an integral part of a transparent adhesive dressing (TAD). This study explored the antimicrobial activity of the new experimental device versus a commercially available CHG-containing device using the zone of inhibition method. Two considerations influence efficacy - whether the CHG is in a dry or dissolved solution-like-state and how the sustained release of CHG is affected.

METHODS: Two devices were tested: one commercially available dressing (Integra LifeSciences BioPatch® Antimicrobial Dressing with CHG) and one experimental dressing (3M™ Tegaderm™ CHG Dressing). Samples of each dressing (n = 3 per arm) were transferred daily to fresh agar plates inoculated with S. epidermidis (ATCC 12228). When antimicrobial is available and active, it will diffuse into the agar and inhibit the growth of the bacteria outside the dressing producing a “zone” around the dressing that can be measured (in mm), commonly referred to as a “zone of inhibition”.

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RESULTS: The results of the study are shown in Figure 1. The average of the 3 samples is reported for each dressing at each time point with the standard deviation (noted by the bars) for the 3 samples. Zones of inhibition were observed for both dressings on all 10 days.

CONCLUSIONS: The experimental and commercial dressings showed similar activity in vitro as shown by the zones of inhibition produced over 10 days. However, the commercial dressing requires absorption of moisture prior to dissolving the CHG leading to its release. We believe CHG is more readily available from the experimental product because the CHG is pre-dissolved and immediately available for delivery while maintaining an adequate reservoir of CHG to provide continued release for 10 days. Need clarification from APIC of copyright policy per telephone message from 3M’s Teri Oberle 651-737-3456.

DL Schwab, BA, 3M Company Medical Division, employee, employment; LK Olson, BS, 3M Company Medical Division, employee, employment.

Publication Number 2-17

Antimicrobial Effectiveness of an Alcohol-Based Hand Sanitizing Spray Against an Expanded Panel of 62 Different Bacteria and Fungi

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BACKGROUND/OBJECTIVES: To determine the antimicrobial efficacy of an alcohol-based hand sanitizing spray against a broad range of bacteria and fungi, including those required by the Food and Drug Administration (FDA) Tentative Final Monograph (TFM) 1994, called “Topical Antimicrobial Drug Products for Over-the-Counter Human Use; Tentative Final Monograph for Health-Care Antiseptic Drug Products.” In addition, clinically relevant microbes not required by the FDA TFM were also tested.

METHODS: Clorox® Commercial Solutions® Clorox Anywhere™ Hand Sanitizing Spray was tested for efficacy. In vitro testing of the product was conducted according to the ASTM E 2315 Standard Guide for Assessment of Antimicrobial Activity Using a Time Kill Procedure. The product was tested against 50 microbes (46 bacteria and 4 fungi), as required by the FDA TFM. Twelve additional organisms not required by the FDA TFM, selected for their clinical relevance, were also studied in vitro (10 bacteria and 2 fungi). In addition, ASTM International (E1174) Standard Test Method for Evaluation of the Effectiveness of Health Care Personnel or Consumer Hand Wash was used to conduct an in vivo study. Human subjects were used to test the product on hands, and Serratia marcescens was the test organism.
RESULTS: A 99.999% (\textgreater{}5 \text{Log}_{10}) reduction was achieved on all FDA TFM required bacteria and fungi in 15 seconds \textit{in vitro}. Eleven of the 12 additional organisms also showed 99.999% (\textgreater{}5 \text{Log}_{10}) reduction in 15 seconds. One organism, \textit{Mycobacterium bovis}, showed a 99.99% (4 \text{Log}_{10}) reduction in 15 seconds. In \textit{vivo} tests exceeded the FDA TFM requirements for health care personnel hand washes (\textgreater{}4 \text{Log}_{10} \text{ reduction after application 1 and } \textgreater{}3 \text{Log}_{10} \text{ reduction after application 10}).

CONCLUSIONS: The alcohol-based hand sanitizing spray was effective at producing a $>5 \log (>99.999\%)$ reduction \textit{in vitro} for all FDA TFM required organisms tested. Eleven of 12 additional clinically relevant organisms not required by the FDA TFM also showed a $>5 \text{Log}_{10} (>99.999\%)$ reduction. \textit{In vivo} testing showed that the product exceeded FDA TFM requirements for health care personnel hand washes. Further, clinically important organisms were tested \textit{in vitro}, including methicillin-resistant \textit{Staphylococcus aureus} (MRSA), \textit{Escherichia coli} O157:H7, \textit{Salmonella enterica}, \textit{Listeria monocytogenes}, vancomycin resistant \textit{Enterococcus faecalis} (VRE), and the product was found to be effective against these organisms as well.


Investigation of a Surgical Hand Antiseptic Containing 70\% Ethanol and a Polyquaternium Polymer Synergist: Antimicrobial Efficacy, Skin Tolerance and End User Acceptance

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BACKGROUND/OBJECTIVES: There has been a recent trend toward the use of alcohol-based products for hospital hand antisepsis due to rapid bactericidal activity, ease of use, and better skin tolerance compared to traditional surfactant-based products. Although alcohol is generally better tolerated than antiseptic hand washes, the presence of secondary antimicrobials such as chlorhexidine gluconate (CHG) or preservatives can cause skin irritation or sensitization. A surgical hand antiseptic based on 70\% ethanol, formulated with a synergistic level of polyquaternium polymer has been developed. In this study the antimicrobial efficacy, skin performance and end user acceptability has been evaluated.

METHODS: \textit{In vivo} efficacy studies were carried out using criteria for Effectiveness Testing of Surgical Hand Scrubs as described in the Tentative Final Monograph for Healthcare Antiseptic Drug Products (TFM). Evaluation of skin irritation potential in humans was performed by applying fresh product over a 21 day period. Product acceptability was evaluated by a hospital field trial carried out in 4 O.R. locations in Northeast Ohio. Eighty-eight ($n=88$) surgical staff members over a four week period evaluated the prototype product. Comparator products were a 61\% ethanol, 1\% CHG surgical hand antiseptic gel and a 62\% ethanol based aerosol foam surgical hand antiseptic.

RESULTS: The 70\% ethanol test formulation exhibited enhanced antimicrobial efficacy over 70\% ethanol control formulations lacking the polyquaternium synergist. The test product met all immediate microbial kill and persistence requirements dictated by the TFM when 2 applications of 2 ml were applied. When 3 applications of 2 ml were applied, the product met the day 5 requirement (a 3 log reduction) on the first wash of day 1. \textit{In vitro} time-kill experiments demonstrated that the test formulation exhibits broad spectrum bactericidal activity in a 15 second...
exposure time. The test product was found to be mild to the skin (average irritancy score = 0.02 on a 4 point scale) by a 21-day cumulative irritancy study; and was statistically superior to 3 commercial alcohol-based surgical hand antiseptics (average irritancy scores = 0.28, 0.49, and 0.54; P < 0.05). The hospital field test revealed statistically superior overall product acceptability (97% vs. 79% for comparator products) and statistically improved aesthetic attributes of mildness, skin dryness, irritation and feel, ease of gloving, and drying time.

CONCLUSIONS: A new surgical hand antiseptic based on 70% ethanol has been formulated to meet the antimicrobial and persistence requirements of the TFM without the use of CHG or secondary antimicrobials. The product is mild to the skin and was preferred over current surgical hand antiseptics. Because application volumes are lower than currently marketed surgical hand antiseptics, pre-surgical hand hygiene prep time can be reduced.

Publication Number 2-19

**Anti-Microbial Efficacy Comparison of Two Oxidizers**

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BACKGROUND/OBJECTIVES: Sodium hypochlorite (SH) has long been used in clinical settings, however there is little published data available on its anti-microbial effectiveness. There is considerably more data published on the efficacy of peracetic acid (PAA), but frequently the experimental conditions preclude the ability to directly compare the efficacy of PAA with that of SH. In a day when infection control is known to have serious impact on healthcare, it is important to understand the options available and have data allowing for direct comparison.

METHODS: The commonly used SH solution in healthcare is commercial bleach diluted prior to use to a 1% or 10% concentration. The commonly used PAA solution contains ~500-750 ppm peracetic acid in equilibrium with hydrogen peroxide and acetic acid. These three solutions were tested as liquids (suspension tests and hard surface carrier tests) and also in conjunction with pre-saturated wipes for efficacy against _B. atrophaeus_ endospores and _S. aureus_. Thiosulfate-catalase was used to neutralize the active ingredient following the exposure periods. Exposure (contact) times ranged from 30 s to 90 s with _S. aureus_. Contact time in a spore suspension test with _B. atrophaeus_ ranged from 3 min. to 7 min. All experimental work was conducted at room temp., ranging from 20°C to 25°C. Inoculation levels were 5 logs ± 1 log for all organisms and all conditions tested.

RESULTS: PAA solutions demonstrated total kill at 7 min. in spore suspension. The solution demonstrated 0 of 30 positives at 60 seconds with _S. aureus_ on penicylinders in liquid testing and 0 of 10 positives on glass slides at 60 seconds with wipe testing. Wipe testing on ceramic tiles using _B. atrophaeus_ showed ~3 log reduction. SH demonstrated total kill at 7 min. in spore suspension at 10% commercial bleach preparation, but showed less than a 3 log reduction at all time points at a 1% commercial bleach preparation. ~5000 ppm SH had 1 of 30 positives at 60 seconds with _S. aureus_ on penicylinders in liquid testing and 2 of 10 positives on glass slides with wipe testing, as well as positive growth on the subcultured wipe following treatment. 10% commercial bleach used to prepare wipes showed a 3-4 log reduction on ceramic tiles of _B. atrophaeus_.

CONCLUSIONS: PAA at a concentration of 500 to 750 ppm has equivalent efficacy compared to SH at a concentration of 5000 to 7000 ppm (~10% commercial bleach). Lower concentrations of SH show reduced efficacy, particularly related to spore forming organisms. Caution should be used in preparing SH solutions to ensure that effective concentrations are achieved. This is not the case with PAA solutions, as they are available in ready to use solutions.

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Publication Number 2-20

Microbiologic Evaluation of a Silver Antimicrobial Disinfectant Spray

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BACKGROUND/OBJECTIVES: Environmental contamination by MRSA, VRE and other pathogens is a problem in healthcare settings. Certain areas can be potential sources for environmental contamination due to the volume of patient encounters. There is often insufficient time and staff to clean surfaces and bathrooms frequently. A new silver disinfectant was recently marketed at a local infection control meeting. It is odorless, colorless, non-corrosive and requires no protective equipment. It claims to be effective against bacteria, such as MRSA and VRE, viruses and fungi and kill 99.99% of harmful microbes for a full 24 hours after sprayed onto a non-porous surface. A microbiologic challenge using Staph aureus and E.coli was performed to document the effectiveness of the product.

METHODS: A 4 oz sample of product was obtained and a microbiologic study was prepared. The study design included a 5 McFarland broth solution of Staph aureus and E.coli, a template for organism and silver spray application and blood agar contact plates. An empty patient room was used for the study and six areas were marked. It included the room’s four corners and two controls in the middle. 1) On the left side of the room each organism was swabbed in the center of a marked floor tile and allowed to dry. 2) On the right side of the room the silver spray was applied to the center of a marked floor tile and allowed to dry. 3) The silver spray was then applied directly onto the organisms and allowed to dry. 4) The organisms were then applied directly onto the silver sprayed tiles and allowed to dry. Contact plates were used over the six areas: 2 plates for controls, 2 plates for the organisms/silver, 2 plates for the silver/organisms. The room was sealed off and all were repeated at 24 hours. After culturing, the room was thoroughly cleaned with a phenolic disinfectant. Five room samples were obtained over a four week period totally 30 contact plates.

RESULTS: Samples from all five controls of Staph aureus and E.coli were TNTC in the samples obtained immediately after they dried. Results of the contact plates obtained immediately after application showed: 5 samples in the organisms/silver group - no growth; 5 samples in the silver/organisms group - no growth. Repeat cultures obtained at 24 hours: three samples continued to be no growth and two samples had 1 colony in the silver/organism group.

CONCLUSIONS: A new silver disinfectant was studied and results demonstrated that organisms were killed immediately upon contact and the action sustained over a 24 hour period. The product can be used on objects such as chairs, stretchers, toilet seats, telephones, bed tables, computer keyboards, gym surfaces, radiology equipment and other areas that may become contaminated during heavy patient volume and get cleaned infrequently. Other advantages could be decreased exposure to and use of chemical disinfectants and increase protection in areas underserved by housekeeping.

Publication Number 2-21

Eradication of Methicillin-Resistant Staphylococcus aureus (MRSA) and Clostridium difficile in Hospital Mops and Wiping Cloths by Ozone Cold Water Laundering in the United Kingdom – Comparison of Ozone and Standard Laundering Procedures

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BACKGROUND/OBJECTIVES: Both MRSA and Clostridium difficile are resistant to many cleaners, disinfectants and institutional laundering techniques. One route of continued transmission of these microorganisms is the laundering system for hospital/nursing facility linens and bed clothing. An evaluation of cold water (ambient temperature) ozone laundering was conducted at the Queen Elizabeth II Hospital in Welwyn Garden City, Herts., UK during 2005.

METHODS: Under the supervision of Microsearch Laboratories (Mytholmroyd, Halifax, UK), samples of actual cleaning cloths and microfibre mops, both before and after laundering, were removed, refrigerated and submitted for microbiological analysis at Microsearch Labs. Wash liquor testing was performed in a washing machine containing 30-L of water at ambient temperature. The water was challenged with at least 10^8 cfu/mL of each of the target organisms – C. difficile, MRSA and A. niger. Ozone laundering was conducted for 47 minutes, and standard thermal laundering (Mediclean thermal disinfection program) for 1 hour. Laundering loading matrices of 20 microfibre mop sections and 40 cloths per laundered bag were used. Samples were taken at 1 minute intervals during laundering and analyzed for total viable counts (TVC) of the target microorganisms. Comparative testing was conducted weekly during the period July through October, 2005. Similar laundering comparative tests were conducted on soiled linens contaminated with C. difficile.

RESULTS: It was demonstrated that the then-current recommended laundering technique (71 C = 160 F) for 15 minutes) does little to disinfect microfibre mops and cleaning cloths contaminated with MRSA and/or C. difficile. After three minutes of ozone cold water (ambient temperature) laundering, there was no viable trace of any test organisms, including MRSA and C. difficile. With soiled hospital linens contaminated with C. difficile, similar results were found – C. difficile was eradicated by ozone laundering within three minutes, whereas standard thermal/bleach laundering had little effect.

CONCLUSIONS: Ozone laundering of microfibre mops and cleaning cloths using ambient temperature water eradicates MRSA, C. difficile and other microbes tested within three minutes. Data obtained indicate that microfibre mops and cleaning cloths laundered by the current hot water/bleach cycles still contain these microorganisms. Their use after standard thermal laundering thus contributes to the spread of MRSA and C. difficile around the buildings. Ozone laundering eradicates these microorganisms and prevents their spread by soiled/laundered mops and cleaning cloths.

ACTIONS TAKEN: The Queen Elizabeth II hospital, after 6-months of evaluating ozone laundering, adopted ozone laundering throughout this hospital in December 2005. More than 1100 institutional ozone laundering systems have been installed in the UK alone since 2002.

RG Rice, PhD, ClearWater Tech LLC, A client of my firm, A fee to review UK data and write a detailed paper on ozone laundering and its benefits.

Publication Number 2-22

Cross-Contamination of Clostridium difficile Spores on Bed Linen During Laundering

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BACKGROUND/OBJECTIVES: Healthcare-acquired infections caused by Clostridium difficile are a major concern in hospitals worldwide. A possible route of transmission is via contaminated bed linen. The aim of this study was to
evaluate the potential for cross-contamination of C. difficile spores on hospital bed linen during a standard laundering procedure. The effect of hot air drying on C. difficile contaminated bed linens was not evaluated in this study.

METHODS: A C. difficile spore crop was created by streaking C. difficile ATCC 9689 on Brain Heart Infusion (BHI) agar with supplemented with 5% sheep blood and incubating for 10 days at 35 ± 2°C. Cells were rinsed off agar plates, washed and resuspended in minimal media. Coupons (2.5 cm × 5.0 cm) of bed linen were inoculated with 100μL aliquots of cell suspension. The initial inoculum level target for each coupon was at least 4 log10 CFU per coupon. Five coupons for each laundering cycle were prepared. The inoculated coupons were attached to a larger square of fabric using a Tach-It™ gun. Ten sterile coupons of the same size and material were attached in the same manner to a different square of fabric. The squares of fabric were laundered together in an open pocket commercial washing machine. A wash cycle typical for hospital bed linens was used. The bleaching agents used were 50 ppm chlorine, 54 ppm peracid, 100 ppm peroxide, and a water control. The detergent, alkali, sour and softener operations, as well as chemical amounts, drain/rinse and extraction times all remained the same for each bleach treatment. In addition, an entire laundry cycle was run with only water. After laundering, each coupon, both inoculated and sterile, was incubated in BHI broth for 3 days at 35 ± 2°C to determine if survivors were present.

RESULTS: C. difficile spores were detected on sterile coupons after being laundered in the same washing machine as contaminated coupons. This was evident in the chlorine and peracid bleach treatments, and in the water only cycle.

CONCLUSIONS: Spores of C. difficile are capable of surviving the temperatures and chemical treatment of typical hospital laundering cycles. Cross-contamination of C. difficile spores can occur on bed linen during a wash cycle, especially if the treatment does not eliminate all spores. Currently, there are no registered laundry products with efficacy claims for C. difficile spores. The persistent nature of this organism must be considered by infection control personnel when implementing programs for processing soiled linen.


Publication Number 2-23

The Safe and Effective Fumigation of Hospital Areas with a New Fumigation Method Based on Vaporized Hydrogen Peroxide

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BACKGROUND/OBJECTIVES: The patient environment can play an important role in the acquisition of hospital-acquired infections. Environmental disinfection is recommended in particular to reduce the risk associated with surface contamination. This is traditionally achieved by localized application of liquid disinfectants, which can be variable depending on the mode of application, level of antimicrobial efficacy, compatibility and safety in use. Fumigation has not been traditionally employed due to safety and efficacy concerns. An alternative fumigation system based on vaporized hydrogen peroxide (VHP) delivery and control has recently been approved by the EPA for disinfection of enclosed areas. This report investigated the ability of VHP to decontaminate areas within a hospital in the control of nosocomial pathogens.

METHODS: Two hospital rooms, a general patient room (210 ft³) and an operating theatre (6,230 ft³) were chosen and included any intrinsic furniture or equipment. Other adjacent rooms remained in clinical use during testing. Coupons were inoculated in triplicate with ~10⁵ of each test organisms in their growth media, dried and distributed.
around each test room. Test organisms were methicillin-resistant *S. aureus*, vancomycin-resistant *Enterococcus*, *A. fumigatus*, *C. albicans*, *A. baumanii* and *S. marcescens*. The effectiveness of all test cycles was also monitored by distributing chemical and biological (at $10^6$ *G. stearothermophilus* spores) around each area. Fumigation consisted of four stages (dehumidification, conditioning, disinfection and aeration) that were automatically controlled by a VHP Unit. Following fumigations all chemical indicators were collected and examined for the required color change, all biological indicators and sample agents were collected and quantitatively analysed for growth, and each room was evaluated for any physical and visual changes.

RESULTS: The fumigation processes were successfully completed within both areas, ranging from a total cycle time of 2.5-3.0 hours. Detectable VHP concentrations were below safety levels (<1 ppm) in all areas adjacent to the rooms being fumigated during testing and were also confirmed to be below safety levels in each test area on completion of cycles. Inspection following test cycles showed no damage to the rooms or any components. All electrical equipment was fully functional. Directly following fumigation all areas were immediately available for clinical use. All chemical indicators demonstrated the required color change and confirmed the distribution of VHP in both areas. A greater than 4-log reduction was achieved with test biological indicators (G. stearothermophilus spores) and for *S. aureus*, *Enterococcus*, *A. fumigatus*, *C. albicans*, *A. baumanii* and *S. marcescens*.

CONCLUSIONS: A new fumigation process based on VHP was found to be effective to significantly reduce surface microbial contamination levels in typical hospital areas. This process could be safely and effectively applied during routine environmental disinfection practices within healthcare facilities and in particular in outbreak situations.

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Publication Number 2-24

**Virucidal Performance of Various Professional Hand Hygiene Products Against Avian Influenza A H5N1**

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**BACKGROUND/OBJECTIVES:** Influenza A is a pathogen of substantial public health concern worldwide. The evidence for human-to-human transmission of Influenza A H5N1 has identified it as a strain with pandemic potential, which would present significant challenges to the healthcare infrastructure in terms of both infection control and patient volume. While standard hand hygiene practices are recommended to prevent transmission by leading public health organizations like the CDC and WHO, quantitative data on the effectiveness of hand hygiene products against these strains are not readily available. In an effort to determine the virucidal performance of hand hygiene products on the potential pandemic strain Avian Influenza A H5N1, we evaluated the virucidal efficacy of various professional hand hygiene products commonly used in healthcare settings against Avian Influenza A NIBRG-14 [H5N1] using *in vitro* techniques.

**METHODS:** Avian Influenza A NIBRG-14 [H5N1] was procured from the reference collection of the National Institute for Biological Standards and Control, London, England. Cytotoxicity assays were performed to determine the detection limit for each test substance, 40 μL of virus was added to 360 μL of test article and incubated at room temperature for 15 seconds. The reaction was terminated by 10-fold (v/v) dilution in MDCK infection media, supernatant was titrated 10-fold (v/v) across a 96 well plate, and cells were incubated for 1 hour. After incubation, cells were washed twice with PBS, fresh infection media was added and cells were incubated for 3 days. After the
final incubation period, the Hemagglutination Assay (HA) was used to determine the presence of virus, where the presence of agglutination indicated virus presence. HA results were used to calculate the virus titer using the Karber Calculation.

RESULTS: Three currently marketed 62% ethanol instant hand sanitizers (2 gel, 1 foam) exhibited complete kill (≥3log reduction above the detectable limit) after an exposure of only 15 seconds. A 70% ethanol surgical hand antiseptic and a 0.5% Triclosan, foaming handwash also exhibited complete kill after a 15 second exposure.

CONCLUSIONS: These data demonstrate that the well-formulated 0.5% Triclosan, foaming hand wash and the four 62-70% alcohol-based hand antiseptics evaluated in this study are in fact capable of rapidly inactivating Avian Influenza A H5N1. Although Influenza A is an enveloped virus, and thus generally considered susceptible to various anti-microbial agents, these data provide scientific support for the CDC and WHO position on hand hygiene as the primary prevention measure for Influenza infection in healthcare and other congregate settings.

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Bioterrorism/Disaster/Emergency Preparedness

From Katrina to Pandemic – Business as Unusual – Applications of a Proven Response Model

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ISSUE: As Hurricane Katrina approached the Gulf coast of Louisiana, Mississippi, and Alabama in Sept 2005, no one expected it would effect the lives of the residents of Fort Worth, Texas. Hurricane Katrina created disaster conditions that required a new sustained, phased approach response with decentralized resource management for the health care needs of evacuees.

PROJECT: JPS Health Network (JPS) is an integrated county health care organization including a 459 bed hospital, 24 Community Health Centers, and 10 pharmacies throughout the county. Phase 1 - Evacuation (6 days) The Federal Emergency Management Agency (FEMA) activated the Emergency Operations plan in 6 surrounding states to assist in evacuation of Gulf Coast residents. Over 4,500 evacuees were transported to Tarrant County. Critically ill patient were transferred directly to hospitals. Noncritically ill patients were transferred to shelters established in community centers. Phase 2 - Stabilization JPS was requested to provide medical care for the initial shelters. JPS Health Network reacted to an influx of medically displaced evacuees from Hurricane Katrina by adapting and using the power of outpatient clinics for triage and treatment to produce a patient centric catastrophic tactical response. Health needs included treatment of leg and foot wounds, infections, chronic conditions, and dehydration. “Off site” clinic location were used in the initial triage and coordination of healthcare during a phased disaster response in order to provide resource protection for hospitals in the county. Phase 3 - Normalization (Week #2-3) Medical care/ follow-up care in community health clinics Evacuees were moved to housing/hotels. Phase 4 - New Life in Texas (Oct. 1, 2005).
RESULTS: Over 1,700 evacuees were seen by JPS for health care. 4,075 prescriptions were given. Over 250 JPS staff were involved in the response. This strategy has been identified as a best practice model by Joint Commission on Accreditation of Healthcare Organizations (JCAHO). Source: The Official Joint Commission Environment of Care News Source, November, 2006, Vol. 9, Issue 11.

LESSONS LEARNED: Tailoring this surge response provides an opportunity to implement the Centers for Disease Control (CDC) and World Health Organization (WHO) recommendations for a Pandemic/Bioterrorism event. By using small shelters and treating patients through a central clinic rather that the hospital, this approach of protecting the hospital could be effective in controlling outbreaks and cross-contamination.

Publication Number 3-26

**Improved Respirator for Protection Against Exposure to Airborne Viruses**

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BACKGROUND/OBJECTIVES: With any emergency situation, the role of healthcare workers and first responders is of paramount importance and often exposes them to various unidentified hazards. In recent years, several threats to human health have involved emerging viruses unknown to the human immune system, therefore causing severe diseases with high fatality rates. Examples of such diseases causing viral agents include the SARS coronavirus and the avian influenza A/H5N1, as well as Variola major (smallpox), considered a highly potent bioterrorism tool. All have dramatically amplified the menace pending over these responders and their increasing need for proper respiratory protection, well illustrated by the SARS Commission Final Report on the Toronto outbreak, which concludes that healthcare workers were inadequately protected by authorities. Because of their role, respiratory protection for healthcare workers is of utmost importance and requires the highest possible level of protection, provided by such devices as Self-Contained Breathing Apparatus (SCBAs) or Powered Air Purifying Respirators (PAPRs). However, this type of equipment does not allow for easy stockpiling, and their use might not be realistic in all situations. Most occupational health authorities thus recommend the use of NIOSH certified N95 respirators in situations suspected of involving an airborne infectious hazard. N95 certification requires particulate filtration efficiencies of 95% against an aerosol of inert particles with a mean particle size of 0.3 μm. Considering that most viruses of pathogenic concern are smaller than 0.3 μm, and that the most penetrating particle size through charged fibers shifts towards the nano-sized range, this represents insufficient protection. We combined an iodinated bioactive polymer to the mechanical filtration equivalent of an N95, developing a respirator offering enhanced protection against airborne viruses.

METHODS: Viral Reduction Efficiency (VRE) of respirators was evaluated by full-sized device testing against a viral surrogate, MS2 coliphage (0.25 μm), and an animal virus, human influenza A/H1N1 (0.08-0.12 μm). Collison nebulizers generate a bioaerosol containing 10^4 to 10^6 PFU/m³ of air, which is then drawn through the respirators at a flow rate of 85 LPM. Effluent is recovered in All Glass Impingers containing phosphate buffer. Studies are usually performed in ambient conditions, although some tests were done at various environmental conditions.

RESULTS: The Iodinated Polymer-containing (IPC) respirator was assessed for its VRE alongside commercial NIOSH-certified respirators in ambient conditions. Against both viral challenges, the IPC demonstrated higher VRE values than other respirators, reducing the viral concentrations by an additional 1 to 3 logs. Similar results were obtained at various environmental conditions.
CONCLUSIONS: The inclusion of a biocide has been shown to improve the VRE performance of the respirator. Our method does not account for fit factor; fit testing should be performed to ensure a proper fit, and thus efficacy of the respirator.

Publication Number 3-27

**Developing a Hospital Template for Implementing Pandemic Influenza Recommendations Using a Regional Infection Control Workgroup**

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ISSUE: The Southwest Texas Regional Advisory Council (STRAC) is an organization responsible for the operation of a comprehensive emergency response system in a twenty-two (22) county, 26,000 square mile area of Southwest Texas. This organization has recognized the importance of Infection Control prior planning and coordination in the rapid facility responses needed in the event of a wide-scale epidemiologic event such as Pandemic Influenza.

PROJECT: There are 53 hospitals covering the STRAC region: 38 general acute care hospital facilities including 3 major trauma centers and 15 specialty facilities. In order to best use limited fiscal resources of the area, and meet the state objectives for pandemic influenza planning, an existing IC workgroup including infection control practitioners from civilian, military and federal facilities as well as representatives of city and regional public health organizations turned its collective resources to developing a unified regional pandemic influenza plan that could be adapted by health care facilities (HCF).

RESULTS: Using the World Health organization (WHO) phases, a hospital template for Pandemic Influenza was developed in coordination with local and regional health authorities. This Pandemic Respiratory Infectious Disease Readiness Plan addressed facility access control, influenza vaccination, surveillance, screening and triage, infection control precautions, communication, education and preparedness efforts was developed for each specific phase. A screening tool was developed that could be used in all facilities for the triage process. Signage and educational materials for both health care providers and patients were developed for just-in-time training and distribution. The template was shared with members at their monthly planning meetings and the documents are posted to the STRAC website.

LESSONS LEARNED: 1) Without prior planning and the development of specific tools, the implementation phase of an established response plan would be delayed in a crisis setting 2) Facility agreement and buy-in to the process can produce a cohesive community approach to health care crisis response.

Publication Number 3-28

**Ingredients for a Successful HDVRT Drill Using the Influenza Vaccine**

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ISSUE: Advocate Illinois Masonic Medical Center, Chicago, Illinois, is a trauma center and community teaching hospital licensed for 551 beds. The hospital receives HRSA (Health Resources and Services Administration) funds which stipulate that hospitals develop a Hospital Dispensing Vaccination Response Team (HDVRT) and conduct drills. Although the Masonic Team had not previously participated in a drill, it had conducted mass vaccination of Katrina volunteers. For years, the hospital has offered the influenza vaccine at no charge to its 2600 healthcare workers (HCW). Administering the vaccine in an efficient manner to a maximum number of personnel has been a challenge. The hospital, therefore, decided to conduct a drill using the influenza vaccine to immunize healthcare workers. The following is a presentation of the essential elements that made this emergency preparedness drill successful.

PROJECT: Infection Control spearheaded the drill by learning from the experiences of other facilities, assembling a multi-disciplinary team to perform the drill, organizing preparatory meetings, and conducting a post-drill critique. The HDVRT initially met on September 22, 2006, and voted to conduct the drill. Since a maximum of 350 HCW had previously been inoculated with the influenza vaccine in one day, the Team set a goal of immunizing at least 500 personnel. Tasks were assigned and completed by the second meeting on October 12, 2006. The drill was held on October 17, 2006, from 7 am to 5 pm in a cordoned off area of the cafeteria. Syringes with retractable safety needles were used.

RESULTS: During the 10 hour drill, 977 healthcare workers were vaccinated: 685 employees including resident physicians, 81 attending physicians, 70 personnel from other Advocate facilities, 141 others (volunteers, students, contract workers, etc.).

LESSONS LEARNED: 1. Assemble a multi-disciplinary team of interested and responsible members. 2. Clearly specify and assign tasks. Remind team members about their assignments in writing (e-mail). 3. Begin preparing for the drill at least 6 weeks ahead of time to allow for 3 weeks of planning and advertising time. 4. Use the public address system to promote the availability of the vaccine throughout the day of drill. 5. Hold the drill in an area convenient to personnel (e.g., cafeteria). If mass vaccination (smallpox) or prophylaxis (anthrax) is necessary, a secure location is necessary. 6. Schedule the maximum number of vaccinators during peak time, which was 7 am to 11 am, rather than lunchtime. 7. Allow adequate time to fill syringes with vaccine. Single dose influenza vaccines are not commercially available. 8. Secure needles to syringes before each injection to prevent inadvertent disconnections. 9. Recruit nursing students to be vaccinators. 10. Schedule two shifts for drill administrators to prevent exhaustion. Assign vaccinators 1.5 hour shifts. 11. Allocate additional funds for drills. 12. Critique the drill and record lessons learned. 13. Acknowledge HDVRT participants for their efforts and broadcast success of the drill to create enthusiasm for future drills.

Phasing It Out: An Acute Rehabilitation Hospital’s Experience Conducting a Pandemic Influenza Tabletop Drill

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ISSUE: The threat of an Influenza Pandemic looms on the horizon and presents an enormous challenge to medical professionals and facilities. Although it is impossible to predict the exact strain and virility of a pandemic, healthcare workers, including Infection Control Professionals (ICP), need to strategize probable scenarios and protocol for their institutions to be as prepared as possible. Our facility, consisting of a 170-bed acute rehabilitation hospital with an additional 9 outpatient clinics on and off the main campus, initiated a plan to assess our preparedness for a pandemic event (PE).

PROJECT: A sub-committee of the Environment of Care (EOC) committee composed of the ICP, Chief Operating Officer, Directors of Security, Plant Operations, and Support Services was formed to plan and execute a Pandemic Influenza Tabletop Drill for the department leaders (DL) of our facility. A risk assessment of our facility considered our location, type of facility and patient population, and partnership with a hospital group organization. An inventory of current space, supplies, and staff was conducted to establish perceived needs. The PE scenario was divided into 3 phases: I. Warning and early onset; II. Weeks 2-6; III. > 6 weeks with possible vaccine delivery and distribution, including the recovery process. We divided the DL into 3 groups, each one critiquing a phase and the hospital’s needs and ability to meet the presumed demands. In addition to DL, each group was assigned a facilitator, a physician and a psychiatrist. After the ICP’s inservice on PE and its predicted effects, the groups had 1½ hours to mitigate and discuss their phase. Strategies, needs, and possible solutions were recorded and summarized by each group.

RESULTS: The groups identified processes already in place that would facilitate action in an actual PE, such as employee call lists, an information phone line, cross-trained individuals to provide coverage, and supply storage. Discussion included unresolved issues, such as incentives for staff to respond and remain at work for extended periods; providing long-range accommodations and food; ability to provide child, pet, or eldercare to maintain adequate workforce; payroll and other economic issues; security; personnel and patient screening; and psychological aspects of a PE. Post-drill evaluations showed a positive response to the tabletop experience, with 100% of participants stating it increased their knowledge of ramifications of a PE and provided them with tools to assess/improve their department readiness.

LESSONS LEARNED: A tabletop drill is an excellent way to determine preparation for an emergent event. Dividing the exercise into phases enables participants to focus on details and provides input from staff that would be affected by the event. The group summaries give an overall view of the plan and an opportunity to critique results. Due to our drill, we identified several areas needing resolution and accomplished proposed plans of action. The knowledge gained has assisted the EOC in planning a live drill for 2007.

 Publication Number 3-30

Rapid Influenza Vaccination Clinic for All Hospital Employees in the Setting of a Simulated Pandemic: Lessons Learned

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ISSUE: Pandemic influenza will require hospitals to rapidly vaccinate employees to prevent and control infection. If influenza vaccination is not implemented rapidly, the transmission of virus could lead to severe disruption of all hospital services. Members of all disciplines (e.g. patient care, engineering, finance, etc.) should be eligible to
become vaccinated and support the hospital mission. The project’s goal was to simulate an influenza pandemic and develop an influenza vaccination strategy to capture all 3,667 hospital workers over 10 calendar days at our 500 bed teaching facility. In reaching this goal, a process needed to be developed that allowed minimal disruption of normal daily services.

PROJECT: After administrative approval was obtained and timely influenza vaccine delivery was verified, a multifactorial rapid influenza vaccination strategy was developed. The strategy’s cornerstone was the refinement of two easily accessible vaccine clinic sites. These well publicized clinics were staffed by nurses, volunteers, and students and were available to all shifts. A publicity campaign highlighting the simulated pandemic and vaccination campaign was initiated using pay check envelope stuffers, hospital newsletter, and electronic communications. A combined “Intent to be Vaccinated/Declination of Vaccine” form was created for all employees to return to their managers several weeks prior to the vaccination clinic. Potential reasons for vaccine refusal were included on the form.

RESULTS: The average clinic wait time ranged from 1-10 minutes. Twenty-six hundred declination forms were returned (71% response rate), and 2100 employees agreed to become vaccinated. Fifteen hundred influenza vaccinations (41% of the total work force) were administered within the 10 day goal. The 2005 employee vaccination total compliance rate was 47% during the entire influenza season. Concern with side effects was identified as the top reason for refusing vaccination. Three hundred and twenty-six employees, who originally agreed to be vaccinated, were not vaccinated during the 10 day vaccination period.

LESSONS LEARNED: Rapid influenza vaccination of a large number of hospital employees can be accomplished through a multifaceted approach. Using a simulated influenza pandemic, one can test the various challenges of implementing this vaccine strategy. The intention/declination form assisted with increasing employee influenza vaccine compliance from the prior year. Variable enforcement in completing the intention/declination form may hamper future clinics. Drawing up vaccine from multidose vials is very labor intensive and not practical when resources are limited. Preprinting vaccinator’s names on the consent form can expedite the vaccination process. Providing written community resource information of vaccine availability for HCW family members should be readily available. Language that strongly emphasizes the risk of influenza transmission to patients will be added to the intention/declination form.

Publication Number 3-31

The SHEA/APIC Communication Network – Taking the Pulse on Infection Prevention and Control and Hospital Epidemiology Issues through Surveys and Technical Advances

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ISSUE: The SHEA/APIC Communication Network, is funded via a cooperative agreement with DHQP, CDC. Its goal is to provide real-time, two-way communication between infection prevention and control/healthcare epidemiology professionals (IPC/HE), and CDC/public health (PH) systems in emergent and non-emergent times on IPC/HE issues.
PROJECT: Surveys were e-mailed to SHEA and APIC members who joined the Network. Priorities for 2006 included: recruiting/educating members (via discussion groups, informational sessions and presentations at meetings, calls and society newsletters), strengthening liaisons with other organizations and PH system (via calls/correspondence) and building the technical infrastructure for real time, two way communication (via the membership database, designated Network web pages on APIC and SHEA websites and electronic survey entry).

RESULTS: Since 9/05, 1401 SHEA and APIC members joined the Network (from >1150 facilities, 50 states and 5 foreign countries). Contact information was obtained (98% e-mail, 94% fax numbers). Since 9/05, 2337 SHEA and APIC members have responded to Network activities at least once. Outreach at annual meetings of SHEA and APIC and 2 state programs reached > 350 participants via presentations/discussions and > 2000 via handouts/informal discussions. Conference calls were held with > 40 APIC chapter presidents. The Network initiated dialogue with: National Healthcare Safety Network, Council of State and Territorial Epidemiologists, state/local health departments, Emerging Infections Network, and Infectious Diseases Society of America. Due to the mumps outbreaks in the US, DHQP, CDC asked the Network to assess healthcare facility experience and capacity for mumps care. A survey was developed, responses collected from 339 Network members (50 states), data aggregated and disseminated within 1 month, 04/06-05/06 demonstrating a timely response to a national issue. Almost 200 network members in 39 states piloted an electronic Influenza survey. About 38-40% (n = 487) US network members visited the new web pages in the 5 business days between 12/21/06-01/1/07 during the busy holidays and 839 visitors as of 1/15/07. Preliminary survey results (as of 1/10/07, n = 358) indicate 92% offered influenza vaccine onsite for the past 3 years to all health care providers including volunteers (HCP) while only 70.5% had improved vaccination rates. Only 57% require a declination statement (9% required by licensing agency). Delays in vaccine supplies were reported by 36.5%, leading to prioritization/delays in HCP vaccination more often than patient vaccination. Of note 51.3% indicated unequal vaccine distribution in community with stores receiving vaccine prior to hospitals and doctor’s offices.

LESSONS LEARNED: The Network provides the infrastructure to take the pulse on current IPC/HE topics and quickly disseminate information and resources (recently illustrated by the mumps survey quickly deployed/accomplished in response to outbreaks and the technical pilot confirming ability to communicate over holidays).

Push Point of Distribution (POD) Drill Increases Compliance with Influenza Vaccinations and Evaluates Hospital’s Emergency Preparedness

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ISSUE: Hospital administration convened a multidisciplinary team in 2004 to promote compliance with influenza vaccine among our employees. During the next two influenza seasons, a five percent increase in vaccinations was noted (27 % to 32 %). In 2006, the team incorporated a Push POD drill as part of the comprehensive influenza vaccination program. This would help us determine our ability to reach all employees in case a public health emergency required prophylactic treatment of our staff. The influenza team worked in conjunction with the hospital’s Emergency Management team which was chaired by the same administrator. There were two major goals: 1) evaluate the hospital’s ability to reach 80 % of the employees during a distinct time period and 2) increase vaccination rates to 50 %.

PROJECT: The team developed a comprehensive schedule for a specific 10 day period during October and November at each of our two facilities. The project included four nearby faculty practices. The schedule included
coverage on evenings, nights and weekends. There were more than 100 departments between these locations. All
departments were contacted by a team member to alert them to the program and to schedule a visit(s) from a
mobile vaccine team or to a centralized vaccine station. Employees who declined the vaccine were asked to sign a
declination form. On the ninth day of the POD drill, a special mock disaster code lasting two hours was called
requiring all staff members on duty to report immediately to the central location.

RESULTS: Of the approximately 5,500 employees, 57 % were reached during the ten day POD exercise. One third of
the departments exceeded the goal of reaching 80 % of the staff; an additional 34 % of the departments reached 60-
79 % of the employees. Of the 3,157 employees who were reached, sixty-six percent were vaccinated. During the
two hour disaster code, 98 and 194 people were evaluated at the two sites, respectively. Declination forms were
available for 1,068 staff members, 57 % with direct patient care. The vaccination campaign continued after the POD;
as of 11/30/06, 49 % of all staff was vaccinated representing a 53 % increase from the previous year.

LESSONS LEARNED: Although we did not reach 80 % of the staff during the POD, several factors were identified to
improve emergency preparedness. This includes maintaining a more accurate telephone contact list, more
coordination of POD stations, development of a priority algorithm and pre-designated POD team members. In terms
of vaccine compliance, the volume of vaccines administered during the POD surpassed our goal of 50 % and
suggests that focused interaction with staff increases compliance. Departmental administrative support was crucial
for success. The reasons for declining the vaccine are being analyzed so we can develop educational programs for
targeted groups.

Exercising the Urgent Transport of Clinical Laboratory Biothreat and Pandemic Influenza Specimens to the Oregon State Public Health Laboratory

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ISSUE: The Oregon Department of Human Services and the Oregon State Public Health Laboratory (OSPHL) -
Laboratory Response Network, is a recipient of the Centers for Disease Control and Prevention Public Health
Preparedness Cooperative Agreement grant. A grant requirement for exercising the after-hours urgent transport of
potential specimens of public health significance (such as biothreat or pandemic influenza specimens) from clinical
laboratories to state public health laboratories was implemented in Oregon, but was challenging to achieve.

PROJECT: Using the OSPHL packaging and shipping plan and a local health department urgent transport of
specimens after-hours plan, the OSPHL in 2005 and 2006 attempted to functionally exercise the urgent transport of
simulated biothreat and pandemic influenza specimens to the OSPHL from Oregon clinical labs both during
business hours and after-hours.

RESULTS: After multiple functional Oregon clinical lab exercises, the objective of physically transporting and
tracking simulated specimens urgently during business hours was accomplished, but after-hours transport could
not be met. Planning gaps involving the roles and responsibilities for the urgent transport of laboratory specimens
to the OSPHL were determined. Health department epidemiologists activate the OSPHL after-hours and on
weekends so that rapid testing on specimens of critical public health significance can be performed, but
standardized health department plans for the urgent transport of specimens to the OSPHL were not available. Other
challenges identified during the transport exercises were: the vast Oregon expanse of 97,000 square miles together
without a statewide OSPHL courier service; 35 local health jurisdictions, and 60 hospitals and clinical labs with
reluctance to allow staff to exercise the transport of simulated specimens after hours due to cost and liability
issues.
LESSONS LEARNED: Communicating with local health departments by key hospital and clinical laboratory staff was identified as central in order to facilitate an efficient and rapid transport of specimens during a pandemic, an outbreak, a bioterror event or any event of public health significance. The following were identified as key participants in the urgent transport of these specimens: local and state health department epidemiologists, preparedness coordinators and on-call staff; hospital medical, laboratory, emergency department and infection control staff; local emergency management and law enforcement staff. The after-action results of the OSPHL exercises can facilitate Oregon statewide and local health department standardized emergency preparedness plans for urgent transport of specimens, and provide documentation for states with the same exercise challenges. OSPHL exercise templates will be available after the 34th Annual APIC Conference at: https://lrn.hr.state.or.us/login/login.cfm User name: lrnx Password: Irn

Publication Number 3-34

Drill Down: Increasing Influenza Vaccination Rates While Testing for Pandemic Preparedness

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ISSUE: A Midwestern health system consisting of 5 metropolitan hospitals employing approximately 6500 employees needed to improve their influenza vaccine compliance. Due to the impending threat of Pandemic Influenza, there was also a need to test the plan for employee symptom assessment and vaccination of all of these employees within a short amount of time.

PROJECT: A task force consisting of occupational health, infection control, unit directors, security and administrative personnel met to address the issue. We considered 1) staff notification 2) process to vaccinate employees already in the building 3) standard identification process to identify vaccinated employees 4) limited employee entry points to facilities 5) nurses and space available to vaccinate mass quantities of employees 6) availability of adequate vaccine and supplies, and 7) access for all shifts. A 2-3 day full-scale exercise was implemented on Nov. 1-3. Prior to the event, seminars, posters, emails and meeting announcements were used to communicate the importance of employee participation in the exercise.

RESULTS: All employees were directed to 1 or 2 entrances for assessment and seasonal influenza vaccination. ID badge stickers were used to identify those who received vaccine and those who signed declinations. Reasons for declination were also required. Vaccination teams were deployed to nursing units at the start of the exercise. Vaccination stations were also implemented for all other employees in the building and all employees entering the building. Approximately 89% of those entering the building participated in the exercise. 75% of them were vaccinated. This rate compares to a 2005 total season rate of 50% of employees vaccinated.

LESSONS LEARNED: Careful planning and staff involvement was imperative in making this project successful. Staff greatly appreciated the process of having the vaccine available to them on their units. Vaccination rates increased due to the availability and the strong support from administration and infection control. ID badge stickers helped managers easily identify which employees were compliant. The event was so well received that visitors and physicians asked to participate in future exercises. The opportunities for improvement that we identified throughout this drill were: 1) Process to pay vaccinating nurses during a drill 2) A need for a process to quickly identify the employees within each facility at a specific moment in time 2) Need follow-up education to those who signed declinations for invalid reasons 3) Vaccination teams deployed to all units, not limited to only nursing areas 4) Disaster recall lists could become useful in alerting employees of a change in routine access to their facilities.
Going beyond Bioterrorism...What the Infection Control Professional Needs To Know for Emergency Preparedness

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ISSUE: In 2005, there were 26 named Atlantic hurricanes, 13,000 earthquakes and 110 tornados. Not to mention floods, storms and power outages. The St. Louis Metropolitan area experienced firsthand the affects of power outages combined with excessive heat during a five day period in July 2005 when nearly one-third of the population lost electrical power and seventeen hospitals were impacted as a result of a cluster of thunderstorms. Issues consisted of loss of electrical power, boil water orders and a drop in water pressure. One major strain on hospital resources was the influx of nursing home residents and those patients needing dialysis. This required the immediate opening of beds that had been closed because of construction and/or lack of staff. Healthcare facilities were reporting an increase in gastrointestinal complaints to the local public health agencies. Hospitals activated their Hospital Incident Command System (HICS). Many infection control professionals (ICPs) were not even aware of the total impact this event had on their own facilities. Clearly, each of the above issues has an impact on the environment in which employees work and patients receive care.

PROJECT: To better plan for the next event, a 20 item Infection Control Emergency Preparedness survey was developed. 23 (82%) of the ICPs’ from a large, multi-hospital system completed the survey. Addressed were three main areas surrounding hospital emergency preparedness: (1) ICP involvement, (2) syndromic surveillance and (3) facility issues that have the potential to lead to deterioration in environmental conditions, thus impacting infection control.

RESULTS: 40% of those surveyed indicated that power outages, medical supplies/suppliers and alternate care sites were applicable to their role during an emergency event at their facility. HVAC issues, loss of water pressure, water availability, toileting facilities, food safety, garbage/waste disposal and surge capacity was applicable for 60%. Nearly 100% indicated that a mass vaccination program did apply to their role. Results were shared with survey participants and with corporate level emergency response team members where preparedness efforts are supported. This same survey was given to members of the local Association for Professionals in Infection Control and Epidemiology (APIC) chapter and results were similar.

LESSONS LEARNED: Early notification of the ICP allows for expert evaluation of the event as it pertains to environmental conditions and the effect on the health of patients and staff. Survey results indicated that further education on their role in emergencies is needed. Education now includes basic facilities management and the potential consequences any disruptions would have on the environment of care. This same survey will be to given to the environmental health and safety professionals followed by education in basic infection control and prevention, thus leading to greater collaboration in overall emergency preparedness.
Norovirus Outbreak Management Applied to Pandemic Influenza Planning

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ISSUE: A community wide outbreak of Norovirus resulted in hospital transmission during a time of limited infection control staffing. The Emergency Operation Center (EOC) was utilized to assist in outbreak management. Lessons learned from the experience were applied to pandemic influenza planning.

PROJECT: The EOC was activated by the Infection Control Practitioner (ICP) and the Emergency Preparedness Coordinator (EPC) when clusters of ill patients and employees with similar symptoms were reported in multiple patient units and the hospitals nursing home (NH). EOC consisted of the hospital director, ICP, EPC, NH director, managers from Occupational Health (OH), inpatient units, patient and employee food services, housekeepers, police, human resources (HR), and public relations (PR). The EOC met daily to assess new cases and determine additional interventions. An all staff electronic bulletin was posted after each meeting to communicate recommendations. Contact Precautions were used with all suspected patients. A bleach solution was used for cleaning areas with symptomatic patients. The NH closed to new admissions and visitors. Employees called OH if ill or if family members were ill. HR supported 48 hours of paid time off after last symptom for self or family member. PR communicated with local media. An inpatient isolation unit was established to cohort symptomatic patients with designated staff. Outpatients were screened at check in for symptoms to triage ill patients to an isolation room. Group eating was discouraged. The EPC provided Incident Command management expertise during EOC meetings and recorded decisions to analyze post outbreak to determine applicability to influenza planning activities.

RESULTS: The nursing home outbreak lasted for 4 weeks, with 30 patients and 30 employees affected. The sustained nature of the outbreak contributed to a decrease in employee desire for overtime and forced the need to consider contract employees. Enforcing a no visitor policy was challenging in the nursing home; signage and ability to lock the facility were identified as needed improvements. Other clusters were less than 6 patients or employees; they occurred in dialysis, psychiatry, and dental units and were more manageable. The isolation unit had no transmission to other patients or staff. Specific supplies were exhausted: isolation carts, gowns, gloves, and waterless hand gel. These specific supplies were increased for a pandemic stockpile. Communication was difficult to make understandable to all staff without increasing anxiety. As the outbreak continued, communication improved. OH surveillance resulted in identification of several clusters of ill employees. Bed management went well but would have been challenging had the outbreak been larger or more sustained.

LESSONS LEARNED: Utilizing the EOC and an Incident Command strategy is an effective way to support infection control during a widespread outbreak. The Norovirus outbreak provided practice and insights for pandemic influenza planning.

Are All Disasters Created Equal? A Survey of Nurse’s Ability and Willingness To Work during a Healthcare Crisis

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BACKGROUND/OBJECTIVES: Healthcare facilities must develop strategies to deal with potential staffing shortages in an effort to prepare for disasters. The objective of this study was to consider potential staffing shortages at an urban, tertiary care, teaching hospital by assessing both the ability and the willingness of nurses to report to work in the event of a local biological or non-biological disaster.

METHODS: Descriptive information was obtained through a survey distributed to a non-randomized sample of nurses working on high-risk units. High-risk units were identified as those most likely to be heavily impacted during a disaster. The survey described local disaster situations such as an explosion at a sports arena, an earthquake, and pandemic avian flu. The participants were asked to first indicate if they would be able, and then to indicate if they would be willing to report to work during each disaster scenario. On a four point scale the participants were also asked to rate their level of concern regarding exposure to disease and terrorist-related chemical agents while at work. Motivations and barriers to reporting to work were specifically addressed in the survey.

RESULTS: Ninety-three surveys were completed and returned. The potential of “suffering from a personal health problem” was found to be a significant barrier to the perceived ability to report to work (OR 20.33, p = 0.02) as well as perceived willingness to report to work (OR 9.286, p = 0.04) during a disaster. Out of all the disaster scenarios, nurses were least willing to report to work during an avian flu pandemic (51%, n = 47). Correlations between willingness to report to work during a crisis and significant concern/fear for self (OR 6.067, p = 0.017) or family (OR = 4.731, 0.0031) were also found.

CONCLUSIONS: A healthcare organization’s ability to deliver care, treatment or services may be jeopardized if it is not prepared to respond to an emergency that threatens the staff’s willingness and ability to report to work. It is critical to ascertain the motivators and barriers that may affect a nurse’s likelihood to work during a disaster. A survey that includes scenarios unique to the area where the healthcare facility is located may provide useful information for further disaster planning.

Publication Number 3-38

**Hospital-Wide Emergent Influenza Vaccination Exercise Takes a Shot at Improving Influenza Vaccine Acceptance Rates**

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ISSUE: Infection Control, Employee Health Services (EHS), Emergency Management Team, Nursing Educators, and Public Health collaborated on a new approach to stimulate healthcare workers (HCW) to participate in the annual influenza vaccine campaign by testing the organization’s ability to rapidly execute an emergent mass vaccination clinic. Our exercise had three objectives: 1. Increase influenza vaccine acceptance numbers and rates; 2. Elicit reasons HCW refuse/decline influenza vaccine; 3. Assess performance of the Hospital Incident Command System (HICS) and Emergency Operations Center (EOC) in dispensing mass prophylaxis.

PROJECT: A series of E-mail Exercise Messages unveiled a severe influenza scenario* culminating in the EOC requesting all on-duty HCW to participate in a mandatory 3-day Mass Influenza Vaccine Clinic (Clinic) starting that morning. HCW reported to the centralized Clinic location and either accepted or declined vaccine. Managers initiated department call trees to encourage participation of off-duty staff. *Adapted with permission from S. Holley, University of Iowa Hospitals and Clinics.

RESULTS: Of the 70% HCW (2246/3187) who participated in the 3-day Clinic, 74% (n = 1659) accepted and 26% (n = 587) declined vaccine. After the Clinic exercise EHS continued offering vaccine during routine walk-in office hours. The two strategies we used in 2006 resulted in a 36% increase in the HCW influenza vaccine acceptance rate from 47% in 2005 to 64% in 2006, and the largest actual number of doses administered to HCW (n = 2036) we have observed. The most frequent reasons HCW reported for declining influenza vaccine include the following: “I never
get the flu” (22%), “I had a reaction from previous flu shot” (22%), “I know someone who had a reaction so I don’t want to take flu shot” (14%), “I choose to decline/don’t want” (11%), “I received the flu shot elsewhere” (7%), and “The flu shot can cause the flu” (5%). The HICS and EOC effectively managed the Clinic which was held in an unoccupied patient care wing. Staffing included registrars, traffic controllers, vaccinators, and supply coordinators. Electronic badge scanners tracked real-time participation. During peak Clinic times six vaccine stations were open. Clinic participation was highest on Clinic Exercise Day One (58%), followed by Day Two (29%) and Day Three (13%).

LESSONS LEARNED: We plan to kick off next year’s influenza vaccine campaign with advance promotion of a non-emergent centralized mass vaccine clinic due to positive feedback from administrators and staff and in order to hardwire the mass prophylaxis process into our culture. The manual influenza vaccine declination surveys used this year were too labor intensive so we will use information from our 2006 declination data to develop a mandatory combined computer-based learning module and vaccine intent statement to elicit intent to accept vaccine and reasons for declining vaccine. Pandemic influenza planners will use exercise results to forecast dispensing and treatment center locations, staffing and other resource requirements for large-scale bioemergency events.

Publication Number 3-39

Utilization of Seasonal Influenza Vaccine To Test Readiness To Provide Mass Prophylaxis or Vaccination in a Bioterrorism or Pandemic Event

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ISSUE: We had never tested the ability to provide mass prophylaxis or vaccination to all workers in a short period of time. As part of our Bioterrorism and Pandemic Plans this would be critical once medication or vaccine is made available.

PROJECT: Proposals were presented to Leadership with the decision to make participation in the seasonal flu vaccine program mandatory by either taking the vaccine or signing a declination form, but mandatory attendance at the drill was cost prohibitive. Infection Control, Employee Health and the Education Department collaborated to develop a medication dispensing vaccine clinic model that could be used in any mass casualty event. Literature search provided all needed references to develop a plan. We structured the plan into the HEICS model developing job action sheets for all clinic positions. Vaccinators completed mandatory competencies for injection technique. We worked with Public Health for the evaluation and after action report of the drill. Educational sessions on pandemic and seasonal influenza were conducted, emphasizing attendance at the drill. Flyers were posted and verbal reminders frequently. Letters were sent to each employee explaining the drill and asking for participation. Door prizes were given. The drill was conducted for 2 days, 13 hours each day, with times overlapping into all shifts. Mobile vaccine clinics were also deployed.

RESULTS: During the 2 days, 1084 vaccinations were administered, 1322 people were processed. This resulted in a 23% increase in vaccination rates of staff from 42% to 65%. Of those, 10% were first time recipients. We found that 32% of people declining did so due to never having had flu, and feeling it was not necessary. We also used this opportunity to collect information for ordering purposes next season, to determine the number of healthcare workers household members who would need prophylaxis if indicated and available, and collection of information required by JCAHO on influenza vaccination. This drill established a sense of teamwork and allowed the largest bulk of vaccines to be given in a 2 day period as opposed to workers reporting to Employee Health randomly to get vaccine. We now have an up to date manual and online copy, with job action sheets, medication protocols, clinic supply list, emergency orders, clinic designs, and a pool of staff that have completed competencies for vaccine administration which will be updated at least annually. We have tested our process and strengthened it based on this exercise.

LESSONS LEARNED: We performed an FMEA on the process and discovered issues critical to smooth operation in a true mass casualty event. We had no method of rapid notification of staff, and no centralized photo ID data base for restricting access to a vaccine dispensing clinic. Both of these are currently under review for action. As a result of
the FMEA, we have developed an organizational wide policy for the safe handling, storage, and administration of influenza vaccine, as we realized processes were varied across the organization.

Cost-Effectiveness/Cost Benefit Analysis

Publication Number 4-40

Clinical and Economic Benefit to Surgical Patients with the Use of an Antimicrobial Impregnated Surgical Dressing

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BACKGROUND/OBJECTIVES: The CDC estimates that 14% to 16% of the 500,000 annual hospital associated infections are attributed to Surgical Site Infections (HA-SSI). Despite advances in infection control practices, surgical site infections remain a substantial cause of morbidity and mortality, leading to prolonged hospital stays, increased cost for patients, providers and hospitals. By reducing HA-SSI, hospitals could recognize an estimated savings of $15,646 per infection in addition to improving patient outcomes. The purpose of this investigation was to determine the clinical and economic outcomes of Gynecological (GYN) surgical and Neurosurgical (Neuro) patients whose surgical wounds were dressed with an antiseptic impregnated gauze containing 0.2% Polyhexamethylene Biguanide (PHMB).

METHODS: Sterile non-antimicrobial dressings were replaced with the corresponding sterile PHMB impregnated dressings for a period of six months throughout the hospital. Matched surveillance was done for the baseline and evaluation periods on all Neurosurgical and Gynecological procedures excluding Caesarean section. Suspect cases were identified and confirmed by the Infection Control Department utilizing CDC criteria for HA-SSI. Cost was assessed by applying a figure of $15,646 to each infection.

RESULTS: The baseline HA-SSI rate for GYN procedures was 1.35% (9/669 cases). During the evaluation period the rate was 0.4% (3/742 cases). Similarly the Neurosurgical HA-SSI rates were 1.8% (3/166 cases) in the baseline compared to 0.5% (1/205 cases) in the evaluation period. A projected annual cost savings of $230,990 was observed.

CONCLUSIONS: In this application, the infection rates of GYN and Neurosurgical procedures were reduced by 70% and 73% respectively while the antimicrobial dressing was in use. This improvement in surgical outcomes was also accompanied by a potential annual cost savings to the institution of $230,990. In this era of managed care and cost containment, this figure is compelling. The prevention of surgical site infection, which is a costly outcome, is an important improvement in patient care. Further study and usage of the antimicrobial dressing in this institution has been implemented and supported by the results of this study.

Publication Number 4-41

Non-Bronchoscopic Bronchoalveolar Lavage, Implementation and Success in a Surgical Intensive Care Unit

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ISSUE: Diagnosis of ventilator associated pneumonia (VAP) is difficult. Inaccurate culture results can lead to delayed diagnosis, selection of inappropriate antibiotic therapy, and the emergence or selection of resistant microorganisms. Evidence supports quantitative respiratory cultures, obtained by NBBAL, as a sensitive and specific diagnostic technique for VAP.

PROJECT: In April 2004, a mid-western medical center SICU introduced NBBAL, using BAL CATH® (Ballard Medical Products, Draper, UT, USA), as the preferred specimen collection tool for diagnosis of VAP. Respiratory therapists performed the lavage procedure. Non-quantitative culture specimens collected by endotracheal aspiration could still be sent. The medical center is a level one-trauma center with a forty-four bed SICU. Prior to completion of a new affiliated heart hospital in November 2004, cardiovascular patients were included in the SICU patient census. Comparison of fiscal year (FY) 03 and 05 shows a 7% decrease in patient days with an increased length of stay (LOS) from 4.6 to 5.72. Cardiovascular post operative patients with short LOS have been replaced by trauma, burn and neurosurgical patients with longer LOS. A statistical review of patient days and LOS showed no significant difference from FY 03 to FY 05. Review of SICU unit specific antibiograms from 2004-2006 shows a slight decrease in the prevalence of Staphylococcus aureus resistant to methicillin (MRSA), minimal difference in enterococci resistant to vancomycin but an increase in gram negative organisms resistant to multiple antibiotics. The SICU antibiogram was compared to the hospital antibiogram and was similar except for an increased hospital MRSA rate. Volume of antibiotic use in the SICU remained unchanged.

RESULTS: Quantitative respiratory specimens sent for culture in 2005-2006 increased by 65%. The rate of quantitative cultures per 1000 ventilator days increased by 89.4% (p-value 0.0708). While the rate of non protected respiratory specimens sent for culture decreased 73%, a highly significant (p-value 0.0006). Decrease in cultures per 1000 patient days. Between 2005 and 2006 the total number of respiratory specimens collected in the SICU decreased by 440, for an estimated savings of approximately $200,000.

LESSONS LEARNED: Implementation of a new practice such as NBBAL quantitative respiratory culture to replace the commonly employed endotracheal aspirate culture requires time. Not only must a new technique be learned and implemented but an old practice must be unlearned. Practice change occurred largely in the third year of NBBAL implementation in our SICU. NBBAL use is associated with a 73% decrease in non-quantitative cultures and fewer total respiratory cultures sent for a significant savings in laboratory cost. Impact of this new procedure on patient outcomes is yet to be determined.

Device-Related Infections and/or Site Specific Infections

Publication Number 5-42

A Look at Recommended Evidence Based Management for CVC (Central Venous Catheter) Care and CR BSIs (Catheter Related Blood Stream Infections) as Compared to Current Practice in a Regional ICU

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ISSUE: A look at recommended evidence based management for CVC (central venous catheter) care and CR BSIs (catheter related blood stream infections) as compared to current practice in a regional ICU.

PROJECT: This thesis examines the recommended evidence based management for central venous catheter care and related blood stream infections in a regional intensive care unit as compared to current practice. Literature was reviewed to assess the current evidence based recommendations in relation to central venous catheter insertion, management, and removal. A comparison was made to current practice in a regional ICU and differences to best practice explored. The regional ICU concerned, from observation, is a unique unit and has a zero infection rate in relation to catheter related blood stream infections. The reasons behind this have been explored and recommendations have been made.
RESULTS: The importance of nosocomial transmission in the ICU cannot be overemphasized. In many healthcare settings, evidence-based clinical practice guidelines have been developed but bridging the gap between best evidence and best practice has been a struggle. Simple cost effective evidence based measures can be implemented to maintain a zero infection rated as demonstrated by this regional ICU. Although patients’ intrinsic risk factors for developing infections are difficult to modify, the risk of transmission of microorganisms can and should be reduced to a minimum. Practice can no longer be based on tradition and needs to be based in evidence. Clinicians have a responsibility to continually review existing practice and be open to considering new ways of providing care. They should continually question their practice and accept that what they do may not always be the most appropriate action. The healthcare organisation has a responsibility to ensure that there is a sustainable culture that is based on learning and education. Health care is rapidly changing and information is quickly becoming outdated and therefore no longer provides an adequate base for practice. A culture that supports patient safety should be nurtured and encouraged throughout all disciplines within the health care facility.

Publication Number 5-43

**Prospective Sampling of Patient Bath Basins in an Acute Care Setting: Qualitative Evaluation of Bacterial Colonization**

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**BACKGROUND/OBJECTIVES:** Hospital–acquired infections (HAIs) occur in 5% to 10% of patients annually and are the fifth leading cause of death in acute-care hospitals, with annual costs exceeding $6.5 billion. Potential sources of infection during patient bathing include hospital water supplies and skin of patients. Because mechanical friction during bathing releases skin flora into water, including potentially harmful pathogens, patient bath basins may be a potential etiology for HAIs. This nonrandomized, blinded, prospective study identified pathogens in patient bath basins to determine if they can be a source of bacterial colonization and increase patient risk for HAIs.

**METHODS:** Over a 30-day period, patient bath basins from critical care units (CCUs) and medical-surgical (med-surg) units in a community-based hospital were sampled. Basins were in rooms of patients admitted ≥ 48 hours

<table>
<thead>
<tr>
<th>Organism</th>
<th>CCU basins</th>
<th>Med-surg basins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase-negative Staphylococcus</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Bacillus spp</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Micrococcus spp</td>
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<td>2</td>
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<tr>
<td>Corynebacterium spp</td>
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</tr>
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<td>Enterococcus spp</td>
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<tr>
<td>Streptomycetes</td>
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and used at least once. An infectious disease specialist swabbed the interior perimeter and walls of each basin utilizing 2 swabs, which were streaked on a 5% blood agar Petri dish and cultured, and results were recorded.

RESULTS: A total of 25 basins (10 from CCUs and 15 from med-surg units) were swabbed. Of the 13 (52%) basins that showed organism growth on culture, 8 (62%) demonstrated growth of multiple organisms. CCU basins were less likely than med-surg basins to show organism growth overall (40% [4/10] vs 60% [9/15], respectively), but were more likely to show growth of multiple organisms (75% [3/4] vs 56% [5/9], respectively). Neither of these differences was statistically significant, but this small study lacked sufficient power to determine differences between groups. However, when organism growth rates in the basins from both units were analyzed with respect to a basin showing no bacterial growth, the increased bacterial growth rates were all statistically significant at both the 0.01 and 0.05 level (P < 0.0001 for all results). The 3 most common organisms cultured were coagulase-negative Staphylococcus, Bacillus spp, and Micrococcus spp (Table 1). All basins belonging to asthma (n = 5) and post-surgical (n = 3) patients demonstrated organism growth (Table 2).

CONCLUSIONS: Based on the statistical analysis in this study, it is probable used patient bath basins are a source of bacterial colonization, and increase the potential for HAIs. As a result of these findings, this institution has investigated alternative bathing options, and now uses disposable bathing cloths to eliminate the use of bath basins for patient bathing purposes. To further document bath basins as a source of bacterial colonization, additional basin sampling studies should be performed in larger quantity, and should demonstrate both qualitative and quantitative results of microorganism growth.

Publication Number 5-44

Biofilms in Medicine: Evolution, Structure, Function, Pathogenesis, Treatment and Prevention

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ISSUE: Over 4,000 articles have been written addressing biofilms in medicine; 3,000 since the year 2000. It is estimated that biofilms are responsible for approximately 65% of all treated infections in developed countries. In the United States, this includes 95% of all nosocomial urinary tract infections, 86% of pneumonias associated with mechanical ventilation and 87% of bloodstream infections. Almost all implant infections are caused by biofilms which explains the difficulties encountered in diagnosis and treatment. Fatalities due to device-biofilm related infections range from approximately 5 to 60%. Biofilm-related infections also include cystic fibrosis, osteomyelitis, chronic sinus infections, nail infections, heart valve colonization to name a few. The MIC has been reported to have been increased up to 2,400 times that of the same microbe in its free or planktonic state.

PROJECT: Understanding the nature of biofilms is not only essential for research purposes, but also for care providers endeavoring to reduce patient risk and healthcare-associate infections. To accomplish this, a literature study was undertaken and interviews were conducted to develop a sound basic program addressing the evolution, structure, function, pathogenesis, treatment and prevention of biofilms in medicine. Biofilm enhancers and
contributors were also researched including the role of particle contamination, antiseptic-inaccessible skin pore habitats, poor endoscope care, contaminated humidifiers, bad water lines, and environmental contamination with subsequent micro-community development exhibiting increased resistance to disinfectants, etc.

RESULTS: An in-depth educational program was created to provide the care-giver with: an understand of the role of biofilms as an infection control deterrent; a practical perspective on the means and contraindications of some methods of prevention, and; an insight into the research avenues currently being pursued that may greatly reduce biofilm-related infections, or at least make them more susceptible to treatment.

LESSONS LEARNED: Tremendous knowledge has been acquired over the last several years into the nature of biofilms that impact almost every area of medicine. Research has elucidated actions we can take today to make a difference in patient outcomes. These include the use of lock solutions, antimicrobial coated or drug eluting devices, reducing particle contamination, and the use of low alternating polar pulses to enhance the penetration of antibiotics. New areas of research have demonstrated that knocking out quorum sensing, interfering with their means of communications, thwarts effective matrix and community formation, enhancing susceptible to antibiotics.

W Truscott, PhD, Kimberly Clark Corporation and Safe Life Corporation, Former employee, salary.

Publication Number 5-45

**Reducing the Number One Health Care Acquired Infection with the Goal of Zero Tolerance by Utilizing a Silver Alloy-Impregnated Foley with Bacteriostatic Tubing/Bag System**

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**BACKGROUND/OBJECTIVES:** To achieve zero tolerance of the leading HAI (urinary tract infections). The use of technology was implemented by conducting an evaluation comparing a standard Foley/drainage system (baseline) and the silver alloy-impregnated Foley catheter with antiseptic-impregnated drainage system (intervention).

**METHODS:** A baseline HCA-CAUTI (health care acquired catheter associated urinary tract infection) was established over a 4-month time period using standard latex catheters and drainage systems. Retrospective review was conducted of all qualifying positive urine cultures during December 1, 2004 through March 31, 2005. Definitions used were those presented at the APIC 2004 in the abstract by Ritter, Watson, et al, Redefining Catheter Associated UTI (CAUTI: Are New Definitions Necessary? The Bardex I.C. Complete Care System (Bard Medical, Covington, GA) with the antiseptic Foley catheter and antiseptic drainage system was the product used for the intervention time period of January 1, 2006 through April 30, 2006. The same qualifying criterion was used for the retrospective review of medical records for the intervention time period.

**RESULTS:** 147 medical records qualified for review in the baseline time period (standard Foley catheter). 73 HCA-CAUTI’s were identified. 26,890 patient days was the denominator resulting in a rate of 2.7 per 1,000 patient days. 97 medical records were reviewed for the intervention time period, with 29 HCA-CAUTI’s being identified among 25,084 patient days. Establishing a rate of 1.2 per 1,000 patient days. This represents progress toward zero tolerance by achieving a reduction of 55.6%. (RR 0.426; CI upper limit per 1000 = −0.81, lower limit per 1000 = −2.31; p-value Fisher’s Exact = 0.0000602).

**CONCLUSIONS:** Implementation of the Bardex I.C. Complete Care System was beneficial toward our goal of achieving zero tolerance by reducing HCA-CAUTI’s within our facility by the prevention of 44 HCA-CAUTI’s during the evaluation time period. Projected annualized reduction would eliminate 132 HCA-CAUTI’s. Secondary bacteremias were also reduced from 4 (baseline) to 1 (evaluation). A cost avoidance of $402,763.08 was also achieved.
Reducing Blood Stream Infection (BSI): A Multidisciplinary Approach

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ISSUE: Henry Ford Hospital, a 903 academic medical center in Detroit Michigan, experienced a marked increase in blood stream infections (BSI) in 2003. Addressing the BSI increase, required the involvement of a Henry Ford hospital multidisciplinary team that included administration (senior vice-president), physicians (surgery, medicine, anesthesia, interventional radiology, and emergency medicine), senior nursing representation, senior system analyst, and infection control practitioners.

PROJECT: Our goal was to reduce the rate to less than half NNIS 10th Percentile. Process Measures Line placement bundle compliance GPU & ICU BSI rates Plan Developed Blood Stream Prevention Team with continuous feedback to providers Developed reliable processes for Central line (CL) insertion, care, and removal; Revised existing policies and procedures in regard to line insertion, care, and maintenance; Standardized education process for medical and nursing staff; Developed guidelines for line selection Changes Created line placement kits and CL insertion audits; Removed valve based needle-less system; Created communication plan with expectation that Infection Control Practitioners would notify clinical staff of BSI in their care areas; Revised and updated nursing policies for CL maintenance and care and provided three phases of nursing education; Developed interactive educational CD ROM for CL placement, maintenance, and removal, with pre and post test; Piloted simulation lab for training CL placement.

RESULTS: Significant decrease in ICU BSI rate (1.04/1000 CL days in 2005 versus 4.04/1000 CL in 2003).

LESSONS LEARNED: Multidisciplinary team essential for success in reduction of BSI. Ongoing feedback from Infection Control Practitioners to individual providers on patient specific infections increased awareness and adaptation of bundles. New education and widespread sharing of infection control data increased compliance with effective management of CL.

Publication Number 5-47

ICU and Hospital Wide Improved Patient Outcome Following Critical Care Based Interventions To Eliminate Central Line Associated Bloodstream Infections

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BACKGROUND/OBJECTIVES: 48% of patients receiving critical care have a central venous catheter (CVC) accounting for 15 million CVC days annually in the United States. In ICUs there are approximately 5.3 Central Line-Associated Bloodstream Infections (CLABs) per 1,000 CVC days. With an attributable mortality rate of 18%, CLABs results in up to 28,000 deaths per year. Our Lady of Mercy’s (OLM) goal was to eliminate CLABS from ICU and develop hospital-wide systems.
METHODS: In the second quarter of 2005 a multidisciplinary team including nursing, critical care, administration, infection control, infectious disease, environmental services, materials management and pharmacy were assembled to evaluate current practice, staff knowledge, equipment, policies and procedures in the ICU. The team met regularly to review how evidence based approaches to eliminate CLABs could be incorporated into practice in the critical care unit. Meetings were focused on setting and achieving reasonably obtainable goals. Barriers to incorporation of best practices were identified. Presentations were made on the unit for the nursing staff, at medical ground rounds, surgical ground rounds and the medical staff meeting. Meetings were held with the CEO and CMO of the hospital.

RESULTS:

<table>
<thead>
<tr>
<th>Year</th>
<th>No of CLABs</th>
<th>CLABs rate</th>
<th>Attributable Deaths</th>
<th>Additional Costs</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>35</td>
<td>22.4</td>
<td>7</td>
<td>$1,225,000</td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td>12</td>
<td>10.4</td>
<td>2.4</td>
<td>$420,000</td>
<td>$501,313</td>
</tr>
<tr>
<td>2005-2006 (16 months)</td>
<td>3</td>
<td>1.8</td>
<td>&lt;1</td>
<td>$505,000</td>
<td>$1,146,660</td>
</tr>
</tbody>
</table>

*Based on estimated additional $35,000 in health care cost and 1% attributable mortality per CLAB.
*Insertion days introduced. •Critical Care based interventions starting June 2005.

Table 2: Number of CLABs outside the ICU by quarter before and after ICU-based interventions.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Quarter</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Second Quarter</td>
<td>23*</td>
<td>9*</td>
</tr>
<tr>
<td>Third Quarter</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Fourth Quarter</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>
| Total 2nd-4th Quarters | 63  | 31   *

*Critical Care interventions began in 2nd quarter of 2005.

Table 3: Lives and Monies Saved

<table>
<thead>
<tr>
<th>PATIENT LOCATION</th>
<th>DECREASE IN HEALTHCARE COSTS 2006 vs 2003</th>
<th>LIVES SAVED PER YEAR 2006 vs 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
<td>$1,146,400</td>
<td>5.0</td>
</tr>
<tr>
<td>NON ICU</td>
<td>$1,295,000</td>
<td>6.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$2,441,400</td>
<td>11.6</td>
</tr>
</tbody>
</table>

CONCLUSIONS: A multi-disciplinary approach resulted in an 89% reduction in the rate of CLABs at OLM. Root cause analysis of infections since initiating a multi-disciplinary team, revealed that all infections occurred with femoral catheters. We had expected a reduction in CLABs in our ICU, but an unexpected finding was a 45% reduction in CLABs outside the ICU. We attribute the improvement to a “spillover” effect with residents applying skills and knowledge acquired in the ICU to care for patients elsewhere in the hospital. By comparing 2006 to 2003 it is possible to evaluate the impact of our interventions. Compared to 2003, our interventions are preventing 12 deaths per year and decreasing our hospital costs by $2.4 million. Recent interventions such as strict enforcement of the removal of the femoral CVCs within 24 hours and the use of the Bio-Patch until the femoral CVC is removed, has provided a sustained rate of 0 CLABs since July, 2006.

WASHINGTON UNIVERSITY IN ST. LOUIS, 12/15/2006

What Is Black and White and Gray All Over? CDC Nosocomial Infection Definitions!

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ISSUE: Virginia Commonwealth University Medical Center is an 820-bed tertiary care referral center that has participated in the National Nosocomial Infection Surveillance (NNIS) since 1992. The 4 Infection Control Practitioners (ICPs) have greater than 35 years of combined experience in infection control. Changes in our patient population have made identifying a catheter related bloodstream infection (CR-BSI) an increasing challenge. Today, patients have complex co-morbidities that make it difficult to distinguish a CR-BSI from a secondary BSI. For example, a trauma patient with an open abdominal wound has a central venous catheter and blood cultures positive for gram-negative rods. Without supporting bacteriological evidence, how does one directly identify the source? What if the central line was a femoral line? There are cases in which a bloodstream infection is irrefutably present, but the source is questionable. A positive blood culture in the presence of a central line does not necessarily mean it is a CR-BSI. With the simplicity of the Centers for Disease Prevention and Control (CDC) definition, how do we accurately ascertain what is truly catheter related? As we enter the age of mandatory reporting, how do we fairly compare higher acuity patients to lower acuity patients?

PROJECT: We implemented the Central Line Bundle Initiative using the Johns Hopkins model in 2005 in our 6 ICUs where active surveillance is performed. Although we decreased our CR-BSI rates, we did not achieve our goal of zero. As a result, ICPs conducted a collaborative review of all 2006 BSIs to validate the accuracy of applying the CDC definitions.

RESULTS: While all primary BSIs identified by the ICPs met the criteria for a Laboratory Confirmed Bloodstream Infection per CDC definition; questions arose as to whether some of the complex cases were truly CR-BSIs or secondary to infections that may be present but undiagnosed at other sites. For 2006, 17\% (7/42) of our cases were questionable as to whether they were CR-BSI or secondary BSIs.

LESSONS LEARNED: When applying CDC definitions, we may never achieve zero CR-BSI because in some patients the source of the BSI is undefined. In the wake of mandatory reporting, if we, as experienced ICPs, are questioning the definitions how will ICPs new to the NHSN system accurately apply the definitions? Thus, will institutional comparisons be accurate and will those gray areas cause some institutions to be unfairly scrutinized?

Healthcare-Associated Infection Rates, Extra Length of Stay and Mortality in a Hospital of the Philippines. Findings of the INICC

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I Asetre-Luna, MD\textsuperscript{2}  
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BACKGROUND/OBJECTIVES: Our goal was to determine the rate, extra length of stay (ELOS) and extra mortality of the healthcare-associated infections (HAI) in one intensive care unit (ICU) of a hospital member of the INICC in the Philippines.

METHODS: An open label, prospective cohort, active HAI surveillance study was conducted on adult patients admitted to one tertiary-care ICU of the Philippines. The protocol, forms, and methodology implemented were
developed by the INICC. The data collection was performed in the participating ICU. Data uploading and data analysis were conducted at INICC headquarters on proprietary software. Rates of HAI were recorded through applying the definitions provided by the Centers for Disease Control and Prevention (CDC) National Nosocomial Infection Surveillance (NNIS) system. We analyzed the HAI rates, ELOS and extra mortality of patients with central vascular catheter-associated bloodstream infection (CVC-BSI), mechanical ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CA-UTI). Adult patients with HAI were considered cases, while those without HAI were considered controls. We calculated ELOS subtracting average length of stay (ALOS) of patients with and without HAI.

RESULTS: From 2005 to 2006, we enrolled 115 patients, representing 908 bed days. The overall HAI rate was 25.2 (29/115) per 100 patients and 31.9 (29/908) per 1000 bed days. The CVC-BSI rate was 14.0 (5/356) per 1000 CVC days, the VAP rate was 27.4 (15/548) per 1000 device days, and the CA-UTI rate was 16.2 (9/557) per 1000 catheter days. Overall 50.0% of all HAI were caused by Enterobacteriaceae—30.8% of which were resistant to ceftriaxone, 25.0% and were resistant to ceftazidime; 25.0% were caused by Enterococcus sp.; and 25.0% by Corynebacter sp. The LOS of patients without HAI was 5.3 days; the LOS of patients with CVC-BSI was 18.0 days (RR, 3.37; 95% CI, 2.63-4.31; P, 0.00001), representing 12.7 extra days; the LOS of patients with VAP was 15.6 days (RR, 2.91; 95% CI, 2.41-3.51; P, 0.00001), representing 10.2 extra days; and the LOS of patients with CA-UTI was 8.8 days (RR, 1.64; 95% CI, 1.16-2.31; P, 0.0045), representing 3.4 extra days. A total of 15 out of 86 (17.4%) patients without HAI died; 1 out of 4 patients (25.0%) with CVC-BSI died, the extra mortality of CVC-BSI being 7.6%, (RR, 1.43; 95% CI, 0.19 - 10.85; P, 0.7259); 2 out of 9 patients (22.2%) with VAP died, the extra mortality of VAP being 4.8%, (RR, 1.27; 95% CI, 0.29-5.57; P, 0.7470); none of the 4 patients (0.0%) with CA-UTI died, and because of this there was no extra mortality for CA-UTI.

CONCLUSIONS: This study identified that CVC-BSI, VAP, and CA-UTI rates were high, and increased the length of stay of patients in ICUs from 3.4 to 12.7 days.
designed to assist in reducing the risk of bloodstream infections. The same work group met in 2006 to review and update the guidelines, which were subsequently redistributed.

RESULTS: At the initiation of the guideline implementation project the national KP Adult Medical Surgical ICU BSI rate was: 3.9 infections/1000 device days. After implementation the national KP Adult Medical Surgical ICU BSI rate was 1.9 infections/1000 device days, and has continued to decrease since then to a rate of 1.2 infections/1000 device days for the 3rd quarter of 2006.

CONCLUSIONS: The reduction in BSI rate over time since the deployment and implementation of standard guidelines for vascular access device care and insertion, supports the practice of standardizing efforts to improve patient outcomes in this arena.

Publication Number 5-51

**Ventilator-Associated Pneumonia Rates Plummet Using a Standard Protocol and New Technology**

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**Infection Control, Regional Medical Center Bayonet Point, Hudson, FL, USA**

ISSUE: In 2004, hospital officials became concerned with an upward trend in ventilator-associated pneumonia (VAP). Investigation showed that the facility lacked an established standard of care for intubated patients and practice varied. The Performance Improvement Team referred to the latest VAP reduction guidelines from the Centers for Disease Control (CDC) and the American Association of Critical Care Nurses (AACN).

PROJECT: Special Projects and Infection Control Coordinators partnered to set the VAP reduction plan in motion by gathering information on the products recommended by the AACN and CDC; a subglottic suction endotracheal tube (Nellcor Hi-Lo Evac) and a suction tooth brush (Sage). They met with key pulmonologists to discuss the new products and develop ventilator management orders. A proposal was conditionally approved by the Product Evaluation Committee for product use on patients anticipated to be intubated longer than 24 hours. An order set and nursing policy were developed that included performance and documentation of the long-known interventions of: hand washing, head-of-bed elevation, no routine circuit changes, turning every 1-2 hours, securing the ET tube, as well as the additions of using the Ramsay Scale to assess the sedation level of intubated patients, post-pyloric feeding tube evaluation and insertion, if appropriate, and completing a wake-up assessment each shift to determine any neurological changes. An information letter was sent to staff pulmonologists and an educational toolkit was distributed to the nursing staff. Unit-by-unit in-services were performed by the respective sales representatives to answer any device-related questions. Initiation of the protocol began January 2005.
RESULTS: Results were not instantly visible. A six-month learning curve ended with the nursing and physician staff embracing the changes and the infection rate falling dramatically. From July 2005 to October 2006, there was only one incidence of VAP decreasing our VAP rate/1000 ventilator days from 2.7 to 0.28. (figure 1)

LESSONS LEARNED: This is a perfect example of the improvement that can be made when “all the little things are done right.” Most of the interventions are not new discoveries, but until everything was pulled together in a “package,” these little things were not done consistently. The process was adjusted a few months into the project to incorporate the protocol into the ventilator orders thus insuring the protocol is used on every ventilated patient. Also, all other ET tubes were removed from the ED and ICU to allow only the subglottic tube selection. One of the previously skeptical pulmonologists stated that he felt it was the subglottic suction tube that was making the difference in the low VAP rate. Nurses enjoy the easier mouth care using the suction toothbrush. But again, it’s a consistent application of the “little things that count.”

Publication Number 5-52

72-96 Hours Peripheral Venous Catheter Replacement
Recommendation: Is a Single Reference Enough?

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BACKGROUND/OBJECTIVES: Insertion of peripheral venous catheters (PVC) is one of the most common invasive procedures performed in hospitalized patients. For PVC, phlebitis is the most common complication (3-5%) and the risk of bacteremia is extremely low (0% to 0.2%). In 2002, the CDC Guideline for the Prevention of Intravascular Catheter-Related Infections changed their recommendation for CVC site rotation from 48-72 hours to 72-96 hours. After changing our local policy, we identified peripheral venous catheters (PVC) as an increasing cause of primary bloodstream infections: FY02 (50%, N = 52), FY03 (67%, N = 52) and FY04 (100%, N = 4). To define risk factors for peripheral venous catheterization complications in a veteran population.

METHODS: We performed a case control study of patients with PVC. Complete data on PVC-related parameters were collected for 19 cases and 141 controls (patient-related parameters were not assessed). Cases were patients with PVC who developed primary bacteremia infection from April 2002 to June 2005 and no other infection risk identified. In addition, cases were also defined as patients with PVC who developed other complications, phlebitis and exit site infections, between May 2005 and May 2006. Controls were patients with PVC without complications; this data was collected May-June 2004 and May-June 2005. Chi-square or Fishers exact test were used for categorical variables and Students t-test was used for comparing means. Multivariate analysis was performed using logistic regression. All two-tailed P values <0.05 were considered significant.

RESULTS: Of 160 patients reviewed, the following PVC-related factors were significantly higher among the cases than controls: PVC duration greater than 72 hours, presence of multiple PVCs, and PVC that was capped for intermittent or access use (P < 0.05). Staff inserting CVC (RN vs. LPN) was not significantly different between case and controls.

CONCLUSIONS: PVC site rotation greater than 72 hours may increase the risk of bacteremias. Our results do not support recent studies showing that the duration of catheterization can be safely prolonged to 96 hours. We changed the hospital policy for PVC site rotation from every 72-96 hours to every 72 hours and there has been a reduction in PVC related primary blood stream infection during fy05 (33%, N = 1) and fy06 (0%, N = 0).

N Safdar, MD, MSPH, Society of Critical Care Medicine, PI, $50,000.
Laminar Flow Air: A Comparison of Operating Room Air Purity in Rooms Equipped with Laminar Flow Air Versus No Laminar Flow Air

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ISSUE: Until 2003 CDC recommended Laminar Air flow in the Operating Rooms where Joint Replacement surgeries were performed. In 2003 this recommendation was eliminated. However, at our hospital knee replacements are continuing to be performed in laminar air flow rooms only. Our Ortho surgeons expressed interest if the clean air rooms actually are an advantage over non laminar flow rooms. There was no data available on air purity colony counts obtained in the operating rooms. A brief project was performed to compare operating room air contamination in rooms equipped with laminar flow versus rooms not equipped with laminar flow.

PROJECT: The project consisted of sampling the air in rooms with laminar flow and without laminar flow. Two plates were used in each room for 4 consecutive days. The plates were exposed to the air for 20 minutes before any cases were started in the above rooms. The plates were hand carried to the laboratory for incubation and colony counts.

RESULTS:

<table>
<thead>
<tr>
<th>ROOM#</th>
<th>*11</th>
<th>*12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toal CFU in 4 days</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

CFU = colony forming units

There appear to be no differences in air contamination in the rooms where the samples were collected. The daily colony counts ranged from zero to two in both settings.

LESSONS LEARNED: As there are no standards for air colony counts available, the colony counts in the rooms were compared for significant differences in the laminar flow rooms versus non-laminar flow. There appear to be no gross differences in air contamination in the rooms where the samples were collected. Since the above number of samples is small; statistical comparison is not possible. More extensive studies are needed including colony counts performed during surgery. Literature search reveals no recent conclusive studies on laminar flow’s effect on surgical site infection rates. Studies, primarily in Europe, have been performed to correlate laminar flow and body exhaust with reduction of airborne contaminants. These studies have also come up with inconsistent conclusions. The CDC in it’s 2003 Guidelines for Environmental Infection Control in Healthcare Facilities determined laminar flow an “unresolved issue” and does not specify using it; although, the 1999 Guidelines did so. In a recent article in Infection Control and Hospital epidemiology, a survey was performed in hospitals of four states to find the level of usage of laminar flow, body exhaust and UV light. In the study it was found that in spite of lack of evidence in the literature and no government organization recommendation 30 % of hospitals responding did use laminar flow air in operating rooms where total knee arthroplasty was performed.
Sternal Wound Infection: At the Heart of the Matter Pre-Op Antibiotic Timing and Dosage Make the Difference

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J Marzouk, MD, CIC

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ISSUE: Timing of the first dose of antibiotics plays a crucial role in the risk of SSI. The variable on how antibiotics are administered affects the time of delivery. Vancomycin is given by IV piggyback (IVPB) and Cephalosporins are either by IV push (IVP) or by IVPB. Antibiotic re-dosing after more than 4 hours is not done consistently and an inadequate dose is often given to patients weighing > 80 kg.

PROJECT: A retrospective study was conducted on pre-op antibiotic administration from January to March 2006 on all CABG procedures (n = 199) performed at an urban acute care hospital. While looking at pre-op antibiotic timing and route of administration we found administration by IVPB or by IVP, however documentation was inconsistent in the patient record. Dosing was also investigated with relation to patient weight, as all patients with sternal infection weighed greater than 80 kilograms. Results were presented to Anesthesia and Surgical Services.

RESULTS: All 8 identified Sternal infections were given antibiotics at appropriate time except for 1 case of Vancomycin. The weight range of these 8 patients with sternal infections was between 88.6 kg to 132.3 kg. Five of the 8 patients with sternal wound infections had surgeries lasting longer than 4 hours without evidence of re-dosing at 4 hours.

LESSONS LEARNED: There is mounting evidence that a pre-op antibiotics given prior to incision help reduce the microbial burden of intraoperative contamination. To ensure adequate tissue levels, initiation recommendations are Cephalosporins 30 to 60 minutes prior to incision or Vancomycin 60 to 120 minutes prior to incision. However, adequate antibiotic concentrations must be maintained throughout the surgical procedure. Recommendations stemming from this investigation included establishing a standard administration route and timing for pre-op antibiotics. For Vancomycin this would be IVPB 60–120 minutes prior to incision. With Cephalosporins 30–60 minutes prior to incision for IVPB or 5–30 minutes if by IV push. Documentation in the Anesthesia Record should include antibiotic, time, dosage, and route specified by IVPB or IV push. Other recommendations included pre-op antibiotic administration be incorporated in the “Time-Out” process, that cases lasting longer than 4 hours have a re-dosing of Cephalosporins and that a dose of 2 gm Cefazolin be given to patient’s weighing > than 80 kilograms.

Reduction of SSI Sternal Wound in Cardiovascular Patient Population in a 350 Bed Metro-Suburban Midwest Community Hospital

SJ Rivera, MSN, RN

ISSUE: Infection Prevention & Control Practitioner identified through ongoing surveillance techniques, an increase in the volume of sternal wound infections following CV surgery during a 4 month time period. Rates were calculated for CV SSI using Statistical Process Control Run Charts, which confirmed the spike in the volume of infections.

PROJECT: Epidemiology performed a “focus review” and compiled data for the following: surgical procedure, surgical date/time, infection date, organism, pre-op antibiotic selection and timing, surgical prep used, length of time in surgery, antibiotics before infection, diabetic protocol used during surgery, glucose level before surgery and readmission for treatment. Also investigated were airflow configuration and functionality in the OR, OR
environment, clinical practice changes in the OR within the last year, OR traffic flow, OR surgical prep routines for CABG patients, OR cleaning between cases, and the perceptions of the staff as related to clinical issues. For post-op issues, patient locations were evaluated using Gant chart, transmission possibilities based on patient location and date of positive culture; and literature search. Observations were noted during this data compilation process to identify actionable tasks that could prevent SSI in the CV patient population. After thorough review, several recommendations were made including: Standardization of the surgical prep for CV surgery; develop and implement processes the ensure best clinical practice with IC techniques, i.e. hand hygiene, gloving, etc.; Physician education; Implement best clinical practice r/t post-operative management of sternal wounds including wound care and dressings; and implement use of antimicrobial body was by the patient pre-operatively.

RESULTS: After sharing this information with the CV surgeons, a decision was made to focus on wound care, antibiotic delivery, appropriate changes to the pre-printed order, AND surgical skin preparation of the patient. The Surgical Skin Preparation recommendations were a alcohol-zinc based body wash performed by the patient the night before the surgical procedure followed by a 10 minute scrub of the surgical site with the same product, then the surgical prep product. The surgical site was cared for post-operatively with a CHG skin product. These recommendations was implemented.

LESSONS LEARNED: The SSI Sternal Wound rate decreased from 6.7 per 100 CV surgical procedures to 1.6 within the following 6 months of implementation of the recommendations. The primary focus was the surgical skin prep process and wound care practices. The lessons learned were attention to detail by nursing and physician staff, adherence to SSI reduction strategies such as surgical skin wash followed by surgical skin prep, application and use of scientifically tested products such as the alcohol-zinc based patient body wash, and assessment of compliance with recommendations will work to reduce SSI of sternal wound in the CV patient population.

Publication Number 5-56

**Reduction in Urinary Tract Infection (UTI) Rate on an Acute Rehabilitation Hospital Unit with the Use of a Touch-Less Urethral Catheter Kit for Intermittent Catheterization Procedure**

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**BACKGROUND/OBJECTIVES:** An increase was noted in the UTI rate on a 90 bed acute rehabilitation hospital unit that cares for patients who can medically tolerate participation in at least 3 hours of therapy every day but still need the ongoing daily assessment and observation by RN and physician. The majority of patients on this unit experienced stroke, spinal cord or brain injury and are at risk for UTI related to the need for urinary catheter devices and help with perineal care. Many patients need to utilize an intermittent catheter. This unit was utilizing a separate catheter and catheter insertion tray for the intermittent catheter procedure. A touch-less, pre-lubricated urethral catheter was introduced as an intervention to try to lower the UTI rate on this unit.

**METHODS:** UTI rates are routinely monitored on this unit using the Centers of Disease Control and Prevention (CDC) definition for nosocomial UTI. A retrospective review was completed of all UTI that occurred during the baseline period of July-December 2005. Because the touch-less catheter requires a slightly different procedure for inserting the catheter, nursing staff was trained to use the touch-less catheter. The equipment used for the touch-less catheter procedure is less awkward than the traditional intermittent catheter procedure and in addition the touch-less catheter is protected from external contamination. A trial period for the touch-less catheter was set for January –August 2006. Concurrent review was completed on all UTI that occurred during the trial period.

**RESULTS:** The acute rehabilitation unit’s decision to use the touch-less catheter for intermittent catheter procedures resulted in a 30.2% reduction in UTI rate on that unit. During the baseline period the UTI rate was 5.37 UTI/1000 patient days. During the trial period the UTI rate was 3.75 UTI/1000 patient days.

**CONCLUSIONS:** The UTI rate was significantly decreased during the trial period when the touch-less urethral catheter was used for intermittent catheter procedures. The touch-less catheter required the nursing staff to learn a
different procedure for inserting an intermittent catheter; this resulted in training time for nursing staff and most expressed satisfaction with the new procedure. The reduction in the UTI rate significantly improved patient outcome and outweighed the cost of training the nursing staff.

Publication Number 5-57

**Journey to 150 Days Central Line Associated Bloodstream (CLAB) Infection Free in a Level III B Neonatal Intensive Care Unit (NICU)**

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**ISSUE:** CLABs contribute to morbidity and mortality in the NICU. The goal: Decrease CLAB infections by increasing days between CLABs to 150 days.

**PROJECT:** A multi-disciplinary team consisting of a Neonatologist, a Neonatal APN, two Neonatal Nurses, an Infection Control Practitioner (ICP) and the Manager of the Infusion Center (IC) was formed. Review of 2005 CLAB infections directed the focus to the care and maintenance of central lines. Policies and procedure review and direct observation of practices were performed by the ICP, the IC manager and a consultant in needle less systems. Inconsistencies in the handling of lines and hubs were identified. Tri-leads were manipulated in order to change hubs. Betadine pledgitts were no longer available. Practice variables among staff were further identified thru an anonymous survey which included a diagram of a line set-up with intermittent medication delivery and questions. Line care supplies were reviewed. The purchasing department secured betadine pledgitts. The vendor developed a tri-lead which had appropriate hubs pre-attached. The new tri-lead decreases the potential for contamination, uses less fill volume and costs less. The original tri-lead cost $11.75 per unit, the new tri-lead costs $3.69 per unit, realizing an annual cost savings of $14,310.00. Line supplies are now stocked in individual infant care carts at the bedside. Nurses, physicians and respiratory therapists were educated concerning infections in the NICU, the vision for infection reduction, infection graphs (updated monthly), data collection methods and the networks the NICU is benchmarked against. A CLAB days free poster is updated weekly. A hub care procedure based on resource guides for the prevention of hospital acquired infections in the neonatal population was developed. The procedure was tested and implemented. The “Bug-Off” Scrub the Hub campaign started on 5/2/06 and included a poster stressing the role of hub care in infection prevention, the definition of a hub and the procedure to be followed for hub care. All nurses and physicians completed education by 6/30/06. Monitoring is done and a hub care competency has been added to the yearly requirements.

**RESULTS:** The NICU realized 156 days without a CLAB infection as of 9/8/06. Achieving this goal more than doubled average days between infections from 29 days in 6/05 to 65 days as of 9/06. We celebrated with an Ice Cream Social for all 3 shifts with banners and giveaways.

**LESSONS LEARNED:** The lesson learned was that changes in products and purchasing practices have wide reaching effects. Practice variation occurs when appropriate supplies are not available. When the hospital switched to a chlohexidine and alcohol solution, which is not approved for use in infants less than 2 months old, betadine pledgitts were no longer kept in inventory. The tri-lead was obtained as a direct NICU order so when the hospital switched hub manufacturers it was not included in the hospitals product changes. Only by observation of practice can issues be identified and remediated.

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ISSUE: Catheter-associated urinary tract infections (CAUTI) are the most common hospital acquired infection in intensive care unit (ICU) patients. Recently, the Institute for Healthcare Improvement (IHI) developed the concept of “bundles.” Bundles are groups of interventions that, when implemented together, achieve significantly improved outcomes than when performed individually. Bundles were developed for treatment of complicated medical conditions, such as sepsis, and for the prevention of infections, such as central line-associated bacteremias and ventilator-associated pneumonia. To our knowledge, no bundle has been published for the prevention of CAUTI. We set forth to create a urinary catheter bundle as a method to reduce CAUTI in our healthcare system.

PROJECT: A urinary catheter bundle was developed and implemented at our healthcare system, which consists of three acute care facilities with five ICUs. The bundle elements were selected based on available scientific evidence of their effectiveness in preventing CAUTI. These include: 1) daily assessment for removal of the urinary catheter; 2) maintaining the urine drainage bag below the bladder; 3) sustaining a closed system; 4) using a securing device to prevent movement of the catheter. A mandatory on-line educational program was created for nursing staff and in-person workshops were held to kick-off the event. Infection control practitioners (ICPs) participated in daily interdisciplinary patient care rounds to enhance provider knowledge and to assess compliance with the bundle elements. In addition, collaborative discussions were conducted for a number of the CAUTI that occurred, with participation of nurses, physicians and ICPs. These discussions focused on identifying opportunities to prevent future CAUTI by recognizing gaps in the implementation process and compliance with bundle elements.

RESULTS: The urinary catheter bundle was successfully developed and implemented. This led to increased staff awareness about prevention of CAUTI and an enhanced partnership between ICPs and patient care providers. The collaborative discussions conducted identified several gaps in the implementation process. These include the need for additional training for other patient caregivers and the incompatibility of certain bundle elements with specific patient populations, such as burn patients.

LESSONS LEARNED: The partnership between ICPs and the patient care providers was an important factor in the success of the implementation of the bundle. Furthermore, the concept of the collaborative discussion proved to be of value in identifying methods to improve bundle implementation. Although the original training program was exclusive to ICU nursing staff, the collaborative discussions identified the need to expand it to include other patient caregivers. Furthermore, these discussions were instrumental in identifying solutions to be implemented to ensure that the needs of these special patient populations are met.
ISSUE: It is a well documented and known fact that the most common healthcare acquired (HA) infection is a urinary tract infection (UTI). Most authorities put the occurrence at 35-40% of all HA infections. Estimates suggest that these catheter-associated urinary tract infections (CAUTI) “directly cause almost 1,000 deaths (about 1 death per 1,000 episodes of catheter associated bactiuria and contribute to an additional 6,500 deaths annually in the U.S.” Despite these staggering statistics there has been little impact on this problem since the introduction of the “closed” catheter system in the 1950s. A search of the professional literature indicates that attempts to prevent bactiuria with the use of silver technology applied to the use of a catheter product have been inconclusive. A novel silver technology has become available (2003) and as the problems of bactiuria and symptomatic CAUTI have remained primary problems in hospitals, Southern Maryland Hospital Center decided to evaluate this new technology with the use of quality processes.

PROJECT: Following a product change from an all latex Foley catheter to a silicone with a novel silver technology Foley, matched surveillance was conducted for baseline and for trial periods (each lasting three months) during which symptomatic bactiuria (CAUTI) was considered. Using CDC definitions, charts were reviewed for both periods for all urine cultures documenting microbe CFUs $10^5$. Rates were calculated using symptomatic CAUTIs as the numerator, and discharge days as the denominator. Although it is recognized that catheter device days would provide a clearer assessment of the problem at our institution and the intervention being considered, this statistic was not available. Our patient population remained consistent during the two time periods. The rates for the two surveillance periods were calculated and compared.

RESULTS: During the baseline period nine CAUTI were identified. The trial period resulted in two CAUTI being identified. Attack rates were calculated as 0.49 and 0.11 per 1000 discharge-days in the baseline and trial periods respectively. The comparison of these rates resulted in a calculation of a 77% reduction in the CAUTI rate between the two periods.

LESSONS LEARNED: ●The primary interventions in preventing CAUTI are cautious use of indwelling catheters which are removed at the earliest possible times and maintaining a closed catheter system. ●In this quality process improvement project, silver appears to have a positive impact on the CAUTI rate at Southern Maryland Hospital Center. ●The impact of changing from latex to a silicone base in addition to adding a Foley with a silver coating may have confounded the results significantly and this impact needs further investigation. ●The reduction in rate, if continued, can result in a savings to the hospital of approximately $21,000 annually. ●Removing latex from the hospital environment is a significant improvement in patient safety and quality patient care. ●The use of silver Foley catheters may further improve patient safety and warrants further evaluation.
PROJECT: An interdisciplinary team, comprised of Critical Care Manager, IPCP, staff nurses, respiratory therapy, and Materials Management staff, was formed to design and implement the IHI VAP Bundle components and the addition of an oral care product for the ventilated patient.

The IHI ventilator bundle had four key components: 1. Elevation of the head of the bed to between 30 and 45 degrees; 2. Daily “sedative interruption” and daily assessment of readiness to extubated; 3. Peptic ulcer disease (PUD) prophylaxis; and 4. Deep venous thrombosis (DVT) prophylaxis (unless contraindicated). The hospital VAP team also added every two hour oral care with antiseptic oral product to prevent bacterial colonization of the oropharyngeal area as a bundle component due to literature review. Appropriate products were reviewed and trialed, including the oral care product. Physician standing orders were reviewed, revised and implemented to include the VAP Bundle components. The VAP reduction team met for 3 months during 2005.

RESULTS: The bundle components were implemented August 2005. The oral care product was also implemented, as part of the bundle, in August 2005. The oral care reduction strategy was use of a commercially packaged oral toothette/suction system with an alcohol-free antiseptic oral rinse every 2 hours for patients with oral endotracheal tube placement. Surveillance continued by the IPCP for VAP using the CDC definitions for hospital-acquired pneumonia. VAP rates continued to be calculated, published, and analyzed using Statistical Process Control Charts.

The VAP cases from August through December 2005 totaled 2. And from January through December 2006 there were zero cases of VAP. The estimated hospital cost of VAP during fiscal year (May 2004 - April 2005) 2005 was $481,536.00 and during fiscal year (May 2005 – April 2006) 2006 $160,512.00. The hospital system has seen cost avoidance during fiscal year 2007 of these dollar sums with zero cases to date. This data does not reflect patient safety and patient satisfaction issues.

LESSONS LEARNED: The hospital system has learned that zero tolerance for HAI’s is a target that is possible to achieve. By using known strategies to reduce VAP, published in bundle components, and implementing appropriate products and methods, zero VAP rates can be reached and sustained. Commitment by the hospital staff and leadership demonstrate that commitment to excellence by reducing HAI’s is cost effective. Continued surveillance for the presence of VAP will be required. Continued observation for compliance with the VAP bundle components will also be required to ensure continued VAP rates of zero. However, it is now recognized that zero tolerance is practical, feasible and realistic.

Publication Number 5-61

Catheter Associated Urinary Tract Infections in an Academic Medical Center: Assessing the Need for Silver Alloy Catheters

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BACKGROUND/OBJECTIVES: Catheter associated urinary tract infection (CA-UTI) is one of the most common hospital-acquired infections. CA-UTI increases length of stay, hospital costs, morbidity and mortality. Silver alloy impregnated catheters have been shown in the literature to reduce the incidence of CA-UTI by as much as 47% for patients requiring an indwelling urinary catheter over short periods of time (3-5 days). Our 722 bed urban academic institution currently uses silicone/latex indwelling catheters. The objective of this study was to evaluate baseline rates of CA-UTI and assess the need for a change to silver alloy urinary catheters.

METHODS: Patients in the medical oncology and genitourinary/gynecology surgical units were surveyed from 3/1/2006 - 9/30/2006 for CA-UTI using the Centers for Disease Control-National Healthcare Safety Network methodology. Patient census was collected from the hospital’s administrative database and catheter utilization data were collected by nursing staff on each unit. This study included 2,155 patients who accounted for 11,310 patient days. Electronic microbiology records were used to identify patients with positive urine cultures. Charts
were reviewed to assess whether criteria for symptomatic CA-UTI were met. Average duration of catheterization for infected patients was compared to a random sample of 21 uninfected catheterized patients on each unit (42 total) during the study period using Student’s T-test.

RESULTS: Indwelling urinary catheters were used for 33% of patient days on the gynecologic surgical unit. Eight patients on this unit met the criteria for symptomatic CA-UTI for a rate of 4.9/1,000 catheter days. The average duration of catheterization prior to infection was 8.5 days compared with 2.8 days total for uninfected patients (p = 0.0019). 57% of uninfected patients in this sample had catheters for ≥ 3 days. In the medical oncology unit, indwelling urinary catheters were used in 11% of patient days. Seven patients on this unit met the criteria for symptomatic CA-UTI for a rate of 10.6/1,000 catheter days. The average duration of catheterization prior to infection was 25.8 days compared with 8.9 days total for uninfected patients (p = 0.0168).

CONCLUSIONS: Catheter utilization was lower in the oncology patients than the surgical patients, however, the average duration of catheterization was longer in this population. Two-thirds of infected oncology patients had catheters for > 20 days prior to infection. The efficacy of silver alloy catheters has not been demonstrated with prolonged use. Other strategies, such as aseptic catheter care in the hospital or consideration of supra-pubic catheters may benefit this population. Our surgical population’s duration of catheterization was generally short, but there may be an opportunity to further decrease post-operative catheter use. However, patients undergoing selected procedures in which catheters must remain in place for ≥3 days may benefit from silver alloy catheters. A trial of silver alloy catheters is being planned for selected surgical patients.

Preventing Ventilator-Associated Pneumonias

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ISSUE: Ventilator-associated pneumonias (VAPs) cause significant morbidity and mortality and are associated with increased length of stay and excess costs up to $40,000/episode. Our rates of VAPs increased during 2005 and we instituted a program to prevent them.

PROJECT: A 13-bed Veterans Affairs medical/surgical intensive care unit. A multidisciplinary team including representatives from Infection Control, Nursing, Respiratory Therapy, and Pulmonary Medicine instituted an intervention which included 1) educating all involved nursing and respiratory therapy staff about our program to reduce VAPs including distributing informational flyers to new resident housestaff, 2) elevating the head of the bed to at least 30 degrees on all ICU patients on ventilators as clinically tolerated, 3) providing prophylaxis for deep vein thrombosis and peptic ulcer disease on all patients on ventilators, 4) developing oral hygiene procedure that included brushing patients’ teeth and oral cavity every 12 hours and routine oral care with swabs at least every 4 hours, 5) implementing a sedation scale to help avoid over-sedation of ventilated patients (the Richmond Agitation-Sedation Scale (RASS) was used), 6) implementing a daily awakening program for sedated patients, and 7) monitoring all aspects of the program and reported compliance data as well as infection rates to the ICU, Critical Care Committee, and Respiratory Therapy staff.

RESULTS: The VAP rate (number of infections/1,000 ventilator days) decreased significantly during the intervention period (2006).

LESSONS LEARNED: A multidisciplinary intervention can dramatically decrease the VAP rate in the acute care setting. We estimate this program saved the hospital $1,280,000.
Table 1. Impact of program

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<th>Device days</th>
<th>VAPs</th>
<th>Rate*</th>
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<td>834</td>
<td>5</td>
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</tr>
</tbody>
</table>

* # infections/1,000 device-days, †P < .0001

Publication Number 5-63

**Oral Care during Mechanical Ventilation Significantly Reduces the Incidence of Ventilator-Associated Pneumonia**

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### ISSUE:
Ventilator-associated pneumonia (VAP) is the second most common nosocomial infection in pediatric intensive care unit (PICU) patients and has a nearly 50% mortality rate. Even when it does not result in death, VAP prolongs time on the ventilator as well as ICU and hospital stay, and adds an estimated $40,000 to the cost of each patient admission.

### PROJECT:
Two pediatric hospitals (Hospital A, a teaching facility, and Hospital B, a private practice facility) implemented the ventilator bundle recommended by the Institute for Healthcare Improvement into their protocol for mechanically ventilated patients; this bundle includes elevation of the head of the bed by 30 to 45 degrees, daily sedation “vacations” and assessment of readiness for extubation, peptic ulcer disease prophylaxis, and deep venous thrombosis prophylaxis. In addition, Hospital B implemented a regimen of oral care using the Toothette® oral care system (Sage Products, Cary, IL). This regimen included assessment of the oral cavity, swabbing of the oral mucosa with a cleaning solution, and suctioning of oropharyngeal secretions every 4 hours, combined with tooth brushing twice daily.

### RESULTS:
Hospital A implemented the ventilator bundle in June 2005, with Hospital B following in February 2006. Between June 2005 and August 2006 a total of 7543 ventilated pediatric patients (age, neonates to 21 years) were treated at both hospitals (A, 3439; B, 4104). The addition of the oral care regimen to the ventilator bundle resulted in a significant reduction in VAP: 16 patients at A experienced VAP, compared with only 1 at B. Among patients who did not receive oral care, the mean incidence of VAP (3.75 per 1000 ventilator days) actually increased 61% over baseline. By comparison, among those who did receive oral care, the mean incidence (0.5 per 1000 ventilator days) decreased 69% from baseline, even though average monthly ventilator days and average monthly patient days were higher for these patients. The decreased incidence in VAP observed at B was not related to staff compliance with the ventilator bundle regimen, as staff compliance at B was actually lower than at A, and occurred even though staff compliance with the oral care regimen averaged only 74.9%.

### LESSONS LEARNED:
Implementation of a comprehensive oral hygiene program, in addition to the IHI-recommended ventilator bundle, resulted in a significant decrease in the incidence of VAP in ventilated pediatric patients. Challenges involved in implementing such a program include acquainting staff with the oral care policy and equipment, maintaining staff compliance over time, educating staff on the importance of elevating the head of the bed, and evaluating specific patient populations for risk factors that could be addressed in the regimen.

Publication Number 5-64

**Effectiveness of Switching from Open to Closed Infusion System for Reducing Central VascularAssociated Bloodstream Infections in an Italian Hospital**

*F Franzetti, MD*
BACKGROUND/OBJECTIVES: To determine the effect of switching from an open to a closed infusion system (Viaflo®) on the rate and time to onset of central venous catheter-associated bloodstream infection (CVC-BSI) in four intensive care units (ICUs) of Milan, Italy.

METHODS: An open label, prospective cohort, active healthcare associated infection surveillance, sequential study was conducted. The study was undertaken in adult patients admitted to four tertiary-care ICUs who had a CVC in place for at least 24 hours. The rate of CVC-BSI during the open infusion system period was compared to the rate during a closed infusion system period. CDC National Nosocomial Infections Surveillance Systems (NNIS) program definitions were used to define central vascular catheter associated bloodstream infections (CVC-BSI) catheter associated urinary tract infection (CAUTI) and ventilator associated pneumonia (VAP).

RESULTS: From March 2004 to February 2006, 1173 adult ICU patients with CVC in place for >24 hours were enrolled. Compliance with CVC site care (≥95%) and hand hygiene (≥70%) was achieved during both periods. The incidence of CVC-BSI during the open infusion system period was significantly higher than during the closed infusion system period (8.2 versus 3.5 BSI per 1000 CVC days, RR = 0.43, 95% CI = 0.22-0.84, P = 0.01). The probability of developing a CVC-BSI was assessed over time comparing the open and closed system. In the closed period, it remained relatively constant (0.8% at Days 1-3 to 1.4% at Days 7-9) whereas during the open period it increased (2% at Day 1-3 to 5.8% at Days 7-9). Overall, the chance of a patient acquiring a CVC-BSI was significantly decreased by 61% in the closed period (Cox proportional hazard ratio 0.39, P = 0.0043). There was no statistically significant difference between periods in CAUTI (3.3 versus 1.9 CAUTI per 1000 Foley catheter days; RR = 0.57, 95% CI = 0.17-1.95, P = 0.36). There was also no statistically significant difference between periods for VAP (3.8 versus 7.0 VAP per 1000 mechanical ventilator days; RR = 1.82, 95% CI = 0.53-6.20, P = 0.33). There was no statistically significant difference between periods with respect to mortality.

CONCLUSIONS: Changing to a closed infusion system resulted in significant reductions in the rate and cumulative probability of developing a CVC-BSI. There was no statistically significant difference between periods with respect to mortality; the power to detect meaningful differences in mortality was small as the length of follow-up was limited and the number of BSI deaths was small.

F Franzetti, MD, Baxter Healthcare, Grants for conducting the study; VD Rosenthal, MD, Baxter Healthcare, Grants for conducting the study; F Raimondi, MD, Baxter Healthcare, Grants for conducting the study.

Catheter-Associated Blood Stream Infection Rates, Extra Length of Stay and Mortality in 69 Adult ICUs of 37 Cities of 11 Developing Countries. Findings of the INICC

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BACKGROUND/OBJECTIVES: Our goal was to determine the rate, extra length of stay (ELOS) and extra mortality of central vascular catheter-associated blood stream infection (CVC-BSI) in 69 intensive care units (ICUs) of hospital members of the INICC in Argentina, Brazil, Colombia, Croatia, India, Macedonia, Morocco, Mexico, Peru, Philippines and Turkey.

METHODS: An open label, prospective cohort, active healthcare associated infection (HAI) surveillance study was conducted. On adult patients admitted to 69 tertiary-care ICUs of 37 cities in 11 countries. The protocol, forms, and methodology implemented were developed by INICC. The data collection was performed at the participating ICU. Data uploading and data analysis were conducted at INICC headquarters on proprietary software. Rates of HAI were recorded through applying the definitions provided by the Centers for Disease Control and Prevention (CDC) National Nosocomial Infection Surveillance (NNIS) system. We analyzed the HAI rate, extra LOS and mortality of patients with CVC-BSI. Adult patients with CVC-BSI were considered cases, while those without HAI were considered controls. We calculated ELOS subtracting average length of stay (ALOS) of patients with and without CVC-BSI.

RESULTS: From 2002 to 2006, we enrolled 34,080 patients, representing 214,658 bed days. The overall HAI rate was 12.8 (4,357/34,080) per 100 patients, and 20.3 (4,357/214,658) per 1000 bed days. The CVC-BSI rate was 11.4 (1,423/125,319) per 1000 CVC days. Overall 10.6% of all CVC-BSI were caused by Pseudomonas sp. infections—48.1% of which were resistant to ciprofloxacin, 42.2% were resistant to ceftazidime, 39.6% were resistant to imipenem, and 38.3% were resistant to piperacillin tazobactam; 14.0% were caused by Acinetobacter sp.; 23.0% were caused by Staphylococcus aureus infections—85.4% of which were resistant to methicillin; 24.6% were caused by Enterobacteriaceae—53.0% of which were resistant to ceftriaxone, 51.9% were resistant to ceftazidime, and 31.9% were resistant to piperacillin tazobactam; 4.8% were caused by Candida sp.; 2.9% were caused by Enterococcus sp.—4.3% of which were resistant to vancomycin; 1.0% were caused by Stenotrophomonas sp.; 16.4% by Coagulase-negative-staphylococci; 0.1% by Aeromonas sp., 0.5% by Alcaligenes sp.; 0.3% by Corynebacter sp.—1.0% by Haemophilus sp., 0.1% by Citrobacter sp., and finally 0.9% by Streptococcus sp. The LOS of patients without HAI was 4.7 days; the LOS of patients with CVC-BSI was 14.5 days (RR, 3.08) representing 9.8 ELOS. A total of 4,615 out of 29,774 (15.5%) patients without HAI died; 254 out of 833 patients (30.5%) with CVC-BSI died, the extra mortality for CVC-BSI was 15.0% (RR, 1.97; 95% CI, 1.73-2.23; P, 0.00001).

CONCLUSIONS: This study has identified that the CVC-BSI rate was high and increased 9.8 days the length of stay of patients in ICUs. CVC-BSI was significantly associated with higher mortality, which was increased 2 times.

Publication Number 5-66

Assessment of the Accuracy of Surgical Procedure Classification at an Orthopaedic Specialty Hospital

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BACKGROUND/OBJECTIVES: Surgical site infection (SSI) surveillance is an important part of infection prevention. Risk stratification is used to assure that comparison of SSI rates is made among patients at similar risk for this complication. The National Healthcare Safety Network risk stratification components are: duration of surgery, Anesthesia Society of America (ASA) score and wound classification. Standardized definitions are used for these components. The purpose of this study was to assess the scope and impact of surgical risk factor misclassifications at an orthopaedic specialty hospital.

METHODS: Electronic perioperative records from 1,089 hip and knee arthroplasties performed from 1/1/2006 – 10/31/2006 were reviewed for accuracy in documentation of wound class, and presence of surgery time. Validity of
documented surgical procedure times was not confirmed. A sample of 25 charts reflecting 29 procedures from this population was reviewed to assess ASA scores because they are not included in the electronic record, and to validate the classification of surgical wounds. Charts of patients with surgical wounds classified as infected were reviewed to confirm this documentation.

RESULTS: Surgical procedure time and wound class were available for all cases. 82% were clean cases (n = 895) and were assumed to be correct. Clean-contaminated cases (n = 6) were documented <1% of the time. It is not possible for hip or knee arthroplasty to meet the criteria for this category, thus these cases were all considered misclassified. 17% of cases were classified as contaminated (n = 180), due to systematic use of this classification for re-operations. In our chart review all (n = 9) cases documented as clean-contaminated or contaminated were misclassified, hence we considered all contaminated procedures to be misclassified in the larger population. 2 of 3 cases documented as being infected were confirmed through chart review. In the sample of 29 procedures for which chart review was conducted, 14 procedures were classified as ASA 1 or 2. 14 procedures were classified as ASA 3 and 1 was classified as ASA 4.

CONCLUSIONS: Surgical procedure time and wound class documentation was present for all cases. However, systematic errors in assigning wound class overestimated patients' risk in an estimated 17% of procedures. Because ASA score is not available electronically, our institution forgoes the ASA risk point for all cases. If our sample of 29 procedures is representative, ASA risk is underestimated in over half of our procedures. Systems are needed to assure the accuracy of surgical risk stratification. We plan to embed risk stratification algorithms into our new electronic documentation system for perioperative services. An electronic system will help guide clinicians toward accurate classification and assure the timeliness and availability of all needed risk stratification documentation in one electronic record.

Publicaton Number 5-67

**Standardized Data Collection and Reporting of Tissue Expander (TE) Procedure Surgical Site Infections (SSIs) Via a Web Based Format by Infection Control Professionals (ICPs) in a 22 Pediatric Hospital System**

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*JW Beckstead, PhD*, **Infection Control Work Group**

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BACKGROUND/OBJECTIVES: A new system that promoted procedure specific reporting of selected SSIs was initiated in a 22 hospital system in 2004. One of the procedures selected to monitor was SSI associated with insertion of tissue expander for reconstruction of burn scar as this is a high risk procedure within the system for which there are no appropriate comparative data available. Several factors place tissue expanders at relatively high risk for infection. Any foreign body increases risk of infection, and tissue expanders are left in place for prolonged periods. They are relatively superficial, increasing chances for contamination by skin flora. Repeated port injections increase the risk of introduction of microorganisms. Tissue expander infection may require expander removal prior to optimal expansion, thus resulting in less favorable reconstruction. Infection may also result in additional scarring.

METHODS: All patients undergoing tissue expander procedures between January 2004 – September 2005 were entered into the database from the existing coding system. Data entered from the coding system also included patient name, medical record number, age, sex, admission and discharge dates, ICD9 diagnosis and procedure codes, and date of procedure. ICPs were provided with an on-line process manual to ensure consistency in definitions and to support personnel. ICPs then entered specific data for each procedure including length of
operation, location of expander, number of expanders inserted, ASA score, date expander(s) removed and presence of SSI with date of occurrence. Data were analyzed by the Infection Control Work Group and individual hospital data along with systemwide comparative data were provided to each ICP for review.

RESULTS: A total of 199 surgical procedures were entered into the database with 19 SSIs (9.5%) identified systemwide. Stratifying cases by the NNIS SSI risk classification scheme revealed SSI rates of 8.7% for procedures with no risk factors and 12.2% for procedures with 1 risk factor. There were no procedures with greater than 1 risk factor. These differences were not statistically significant. Numbers of cases done by individual hospitals varied from a low of 1 to a high of 68 procedures with 7 hospitals not performing any TE procedures. SSI rates varied from 0% to 50% for all hospitals. Excluding hospitals with fewer than 5 procedures performed rates of SSI were 0% - 20%.

CONCLUSIONS: Pediatric patients had rates of SSI after TE procedures of 9.7% which compares favorably to rates reported in the literature of 4-18%. NNIS risk classification did not correlate with SSI rates. This is the only documented SSI rate data stratified by NNIS risk classification specifically for TE procedures to our knowledge.

Publication Number 5-68

**Effectiveness of Outcome and Process Surveillance for Reducing Ventilator-Associated Pneumonia in a Hospital of Turkey. Findings of the INICC**

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BACKGROUND/OBJECTIVES: To determine the effect of outcome and process surveillance (intervention) on the rate of ventilator associated pneumonia (VAP) in one intensive care unit (ICU) of Trabzon, Turkey.

METHODS: An open label, prospective cohort, active healthcare-associated infection (HAI) surveillance, sequential study was conducted on adult patients admitted to one tertiary-care ICU. The protocol, forms, and methodology implemented were developed by INICC. The data collection was performed in the participating ICU. Data uploading and data analysis were conducted at INICC headquarters on proprietary software. Rates of VAP were recorded through applying the definitions provided by the Centers for Disease Control and Prevention (CDC) National Nosocomial Infection Surveillance (NNIS) system. The rate of VAP during baseline was compared to the rate during an intervention period.

RESULTS: From January 2004 to June 2006, 435 adult ICU patients were enrolled. We divided the study period in the two following phases; phase 1, from January 2004 to November 2004 (11 months); and phase 2, from December 2004 to June 2006 (19 months). A total of 148 patients were incorporated during first phase, and 287 during the second phase. Patient’s demographic characteristics and underlying diseases were similar over the two periods (Patient gender, RR = 0.94, 95% CI = 0.74 - 1.20, P = 0.6411; Cardiac Surgery, RR = 0.26, 95% CI = 0.05 - 1.41, P = 0.0914; COPD, RR = 1.02, 95% CI = 0.66 - 1.55, P = 0.9444 and Abdominal Surgery, RR = 0.68, 95% CI = 0.42 - 1.11, P = 0.1233) Through process surveillance, we found that the presence of mucus on circuit was reduced significantly during phase two, 84.0% vs. 97.4% (RR = 1.16, 95% CI = 1.08 1.25, P-value = < 0.001). On the other hand, hand hygiene (HH) compliance was compared during the following two periods: from September 2004 to November 2004 (baseline HH period), matching with first phase; and December 2004 to June 2005 (intervention HH Period), matching with second phase. During baseline HH period, the HH was 36.9% and during intervention HH period it was 47.0%, showing significant HH compliance improvement (RR = 1.27, 95% CI = 1.00 1.62, P-value = 0.0464).
The incidence of VAP rate during the second phase (December 2004 to June 2006) was significantly lower than during the first phase (January 2004 to November 2004), 19.6 (26 VAP and 1329 mechanical ventilator days] versus 8.0 [13 VAP and 1624 mechanical ventilator days] VAP per 1000 MV days, RR = 0.41, 95% CI = 0.21 - 0.80, P = 0.0065). The percentage of patients with VAP during the second phase was significantly lower than during the first phase (17.6% [26/148] versus 4.5% [13/287]; RR = 0.26, 95% CI = 0.13 - 0.50, P = < 0.001).

CONCLUSIONS: Outcome and process surveillance resulted in a significant reduction of VAP rate, which was reduced 74%.

Publication Number 5-69

The Impact of Oral Care in Reducing Ventilator Associated Pneumonia in a Neuro Critical Care Unit

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BACKGROUND/OBJECTIVES: A multidisciplinary team has worked diligently to implement evidence based practice that would improve the outcomes for ventilated patients, including the prevention of ventilator associated pneumonia (VAP). This group has led the efforts to decrease VAP and all appropriate evidence-based interventions have been implemented. In 2004, we also began participation in the VHA’s Transforming the Intensive Care Unit initiative and implemented the ventilator bundle. The VAP rate in all of our ICUs decreased dramatically, we had documented an avoidance of 20 VAP cases in the first six months after initiating interventions. For the next several years, we continued to note a decreased rate of VAP in all ICU’s having mostly eradicated VAP. Although our Neuro Critical Care (NCC) also saw a dramatic decrease overall we continued to battle the rates in this unit consistently having one to two patients with VAP each month on an average. Guidelines and recommended care practices outlined by CDC, IHI and VHA had all be instituted with greater than 90% compliance rate.

METHODS: In an effort to decrease the incidence of VAP in this population, other interventions were investigated. Discussions included the possibility of using continuous subglottic suctioning, use of kinetic therapy, and the possibility of using Chlorhexidine oral rinses. As we investigated we found an oral care kit available with cetylpyridium antiseptic rinse agent. This antiseptic agent was currently being used in our suction toothbrushes, so we decided it may be worth the effort to evaluate this agent in the oral care kits on the prevention of VAP. In December 2005, we began an evaluation to institute a more aggressive oral care approach. The new approach utilized oral care kits with cetylpyridium antiseptic rinse agent along with use of deep oral-pharyngeal suction catheters, brushing the teeth every twelve hours, swabbing every four hours and deep suction above the cuff every twelve hours and before traveling to procedures off the unit.

RESULTS: The result of the new standard of care was impressive. After implementation of the strategies, NCC went thirteen weeks without a VAP and a total of twenty weeks with only one VAP. The longest period of time we had between VAP in 2003 was 48 days, 2004 was 50 days, 2005 was 57 days, and with the introduction of the oral care kit in December 2005 we did not have our first VAP for 88 days after. In 2003 our VAP rate was 9.05, 2004 was 6.97, 2005 was 4.10, and the rate thus far (June) for 2006 is 2.15.

CONCLUSIONS: This effort demonstrates the importance of instituting evidence-based practice and also supports the use of aggressive oral care measures to further prevent the accumulation and build-up of debris-containing bacteria and subglottic suctioning to prevent aspiration of these contents. This also demonstrates that when evidence is lacking, you must think outside the box to develop better solutions for our patients in order to provide optimal outcomes. We have since implemented the oral care kit in all patients admitted to neuro and adult critical care units.
A Team Approach To Reduce Surgical Site Infections in Pediatric Cardiac Surgery Patients

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ISSUE: Surgical site infections (SSI) are known to significantly increase morbidity, mortality and cost of care. Health care providers at our facility became concerned when the SSI rate in our cardiac surgery population increased in late 2004 and early 2005. The rate was especially high in delayed closure cases. Communication, planning and interventions were needed in an effort to reduce these infections.

PROJECT: A planning meeting was held between Infection Control and Cardiac Surgery to review data. These groups called a meeting of stakeholders involved in the care of cardiac surgery patients from admission through surgery and ICU stay. Areas represented included inpatient and outpatient nursing services, cardiac intensive care, cardiac surgery, cardiac imaging, perfusion, anesthesia, and infection control. SSI rates were reviewed and each provider described their involvement in the patient's care. Current research was reviewed with discussion of possible interventions to reduce surgical site infections. Several interventions were implemented including: changes in pre-op bathing, nasal mupuricin application prior to surgery, change in surgical skin prep, scheduled pre-operative and perioperative antibiotic administration, antibiotic dosing in the bypass priming volume, changes in management of delayed closure sites, as well as more stringent infection control practices in post-op cardiac sonography. Two measures were used to monitor performance: SSI rates, and compliance with recommended antibiotic administration. Periodic updates were provided to team members. Follow-up meetings were held to discuss results, any difficulties with planned implementation of changes and other feedback.

RESULTS: Cardiac surgical site infection rates decreased from 5.98 in the last half of 2005 to 1.75 in the first half of 2006. This improvement was sustained with no infections from April through September of 2006. The rate for 2005 was 7.3 infections per 100 procedures. The rate for 2006 was 1.7 for the calendar year. Compliance with antibiotic administration during surgery increased steadily during this time.

LESSONS LEARNED: It is important to have an influential leader to call together a meeting of essential members. There should be discussion and consensus about how to proceed, what interventions make sense based on available research as well as resources required to make changes. Monitoring compliance in key areas and providing feedback on compliance can optimize the benefit of interventions. Providing periodic updates to the group to communicate progress is critical to keep people interested and engaged. Everyone should share the
Reducing Surgical Site Infections in Breast Reduction Patients: Multiple Interventions, Significant Results

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BACKGROUND/OBJECTIVES: In August, 2004, an unusual number of surgical site infections (SSIs) in breast reduction cases was noted. A rate of 10.92 (13/119) was generated for breast reduction cases. The National Nosocomial Infections Surveillance rate for mastectomy is 1.74/100 surgeries. Breast reductions are included in the NNIS definition for mastectomy.

METHODS: An unmatched case-control study was initiated. The study time period was January –October 2004. Two cases for each control were chosen using a random number table. A data sheet was made incorporating known risk factors and possible risk factors gleaned from literature review. Data was analyzed using t-test for equality of means, chi-squares, and logistic regression. Additionally, observation in the OR provided valuable information.

RESULTS: Twenty-six risk factors were evaluated, and four were of statistical significance; smoking (p = 0.03-0.07 with regression), implant (p = 0.044 with regression), number of people involved in OR case (p = 0.026 with regression), and duration of case (p = 0.039 with regression). Skin organisms were noted in 9 of 11 positive cultures (57% of infections did not have cultures). Operative review noted hand scrub errors, and high traffic in and out of room. Pre-operatively, patients were not routinely asked to shower at home prior to their surgery. Surgeons made a decision to not perform elective surgery on smokers and to decrease traffic and number of staff in and out of OR room when possible. Only 43% of cases had wounds cultured. Surgeons were asked to increase culturing of wounds, as identification of organism can provide valuable information. To decrease skin flora, recommendations were made to have patients shower X 2; the night before and morning of OR, with an antibacterial soap. Errors were noted with all personnel in the use of the brushless, waterless, surgical hand scrub. The recommendation was made to follow manufacturer’s instructions and have the company re-educate operating room staff. Some surgeons returned to a surgical wet hand prep. Interventions were instituted in 2005. The 2005 rate was 7.2 and the January-October 2006 rate was 2.7/100 breast reductions.
CONCLUSIONS: Surgical site infections are impacted by both host factors and those risks that the patient is exposed to in the operating room. This study identified risks through the case-control study as well as opportunities to improve practice through observation. Addressing those identified risks has significantly decreased the risk of infection for the patient undergoing breast reduction.

A Study of the Effects on Bacteremia and Sharps Injury Rates after Introduction of an Advanced Luer Activated Device (LAD) for Intravascular Access in a Large Hospital Setting

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BACKGROUND/OBJECTIVES: Over the last several years, reports from several healthcare institutions have been published indicating increased rates of bloodstream infections (BSI) associated with the use of a variety of different LADs. Factors attributed as potential causes of device-related infections include adherence to procedure, aseptic device management, and product design. In order to address incidents of sharps injuries, the Infection Control, Products Evaluation & Standardization, and Safety Committees undertook a detailed review of an advanced positive displacement device that incorporated several risk reducing design features: smooth, flat luer surface which minimizes bacterial accumulating points; no interstitial space which reduces risk of bacterial growth; dual seal design; positive fluid pulse which assists in reducing occlusion; high-flow rates. A study was designed to determine the effect of this new device on rates of bacteremia and sharps injuries when used with peripheral IVs (PIV) and central lines (CL).

METHODS: Subjects in the study included all adult patients who had a peripheral intravascular extension set or central line placed at the institution after admission for a period of >1 day. Group I (Pre-intervention; 6/1/06-8/31/06) patients had split septum devices (SSD) in place (Interlink, Baxter Healthcare, Round Lake, IL). An extensive education program for nurses, physicians, anesthesiologists, and ancillary technicians was conducted focusing on safety, proper maintenance procedures, and antiseptic procedure for wiping luer surface. Group II (Intervention; 9/1/06-11/30/06) patients had a positive displacement LAD placed (Flolink, Baxter Healthcare, Round Lake, IL). PIVs continued to be flushed with saline. Flush procedures for CLs were changed from heparin to saline during this period. No other revisions in dressing types, skin antisepsis, dressing time changes, antiseptic wiping with 70% alcohol, IV administration set and LAD replacement (q4 days), flush times (q8 h for dormant lines; flush at medication administration for intermittent lines) or other components in peripheral or central line devices were made during the two study periods.

RESULTS: Observation sessions (n = 105) to verify compliance with antiseptic protocol were conducted over the two study periods. Compliance was calculated to be 98.1% (103/105). BSI rates for patients with peripheral lines were 0.17 per 1000 catheter days (CD) with SSDs and 0.14 per 1000 CD in patients with LADs. For patients with central lines, the rates were 1.16 in the SSD group and 1.15 in the LAD group. No statistical differences in infection rates were found between the two groups for either type of line. Sharps injuries related to IV port access were reduced from four during the Group I study period, to zero during the Group II period.

CONCLUSIONS: The results of this study suggest that the use of an advanced design LAD device, in coordination with adherence to proper infection control practice, does not contribute to increases in either BSI rates or sharps injuries.

Investigation of Breast Tissue Expander Infections Involving Toxic Shock Syndrome Due to Staphylococcus aureus

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ISSUE: Sporadic episodes of Toxic Shock Syndrome (TSS) associated with infection of implantable breast tissue expanders placed after mastectomy have been infrequently described. Over a seven month period, we identified a cluster of three infections following breast tissue expansion that were associated with ICU admission and probable TSS caused by Staphylococcus aureus (SA).

PROJECT: An outbreak investigation was conducted after a third case of SA breast tissue expander (TE) infection requiring ICU admission was identified. Each patient had undergone mastectomy with immediate placement of TE. In each case, infection developed approximately two days after an outpatient procedure for installation of saline into the TE. Surgical and clinic staff were notified and met with Infection Control to collect information, review practices, and discuss plans. Anterior nares cultures for SA were obtained from all clinic staff and surgeons. All tissue expansion procedures were halted temporarily. Patient isolates were only available from the third patient. Changes to practice after the second case, included pre-op showering with CHG, use of CHG with 70% alcohol prep, and ceasing of batch pre-filling of saline syringes used with the TE’s. Later changes included: Use of the manufacturer’s recommended closed fill system for filling the TE’s, Use of sterile gloves, a surgical drape and a mask during the filling procedure, Hand hygiene prior to stocking all supplies used during the procedure, Regular cleaning of a stocking tote, and Discontinuation of drains prior to filling TE’s in the clinic. Passive surveillance for infections after breast tissue expansion was changed to active surveillance. Anterior nares cultures were obtained from all clinic staff and surgeons. All TE procedures were halted until results from these cultures were available. DNA (PFGE) testing was performed on one staff isolate that matched the patient isolate in species and susceptibility pattern. The patient isolate was sent for TSS toxin testing.

RESULTS: No trends were seen in surgical or clinic staff involved in the three possible TSS infections. All patient isolates had different antibiotic susceptibility patterns. Two staff had positive cultures for SA. One staff isolate matched the third patient in susceptibility pattern but was not identical by DNA (PFGE) testing. TSS Toxin 1 was recovered from the patient SA isolate. All three patients recovered from the episodes of possible TSS.

LESSONS LEARNED: Due to the serious nature of the infections seen after tissue expansion, we recommended a modified “sterile” procedure with a closed system be implemented. Due to passive surveillance and a higher threshold for action, we did not save patient isolates associated with the first two cases of possible TSS. This may have prevented us from identifying a point source for the toxin-producing SA. However, infections may have resulted from the patients’ endogenous flora. Thus, we are considering recommending surveillance and decolonization of SA culture positive patients undergoing breast TE procedures.

Staff Training/Competency/Compliance

Publication Number 6-74

Enhancing Infection Control Education through Collaborative University Partnerships

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ISSUE: The public health workforce is projected to decrease by 25% - 40% by the year 2010. This shortage of trained workers comes in an era when public health threats including emerging infectious diseases, natural disasters, pandemic influenza, and bioterrorism are greater than ever. With such a drastic workforce shortage on the horizon, it is imperative that new public health personnel are adequately trained not only through traditional educational methods but also through practical real-world experiences found only in the field. This need is exemplified in the infection control arena.

PROJECT: A unique infection control training initiative has been established at the authors’ institutions. These facilities afford students from a local university in the Masters of Public Health (MPH) program, the experience of working in several different infection control settings as part of their course curriculum. Specifically, the student’s field experience, special project requirements, or both, are incorporated into these infection control settings under the mentorship of an infection control professional. The training settings include hospital infection control departments, alternative infection control programs, and research laboratories. The research labs are set-up with advanced equipment and measurement tools needed to perform experiments in the field of infection control and occupational safety.

RESULTS: Since this initiative began in 2002, over 30 field experiences and special projects from MPH students have been completed. These students have majored in various fields including medicine, public health, epidemiology, nursing, communicable diseases, and global health. Projects have ranged from literature searches on current global infectious diseases to internships in infection control departments to designing and conducting infection control and occupational health-related experiments with experts in the field. These experts come from the fields of public health, medicine, nursing, engineering and ergonomics. Students also contribute to the development, writing and presentation of scientific abstracts and articles. Over 15 abstracts, posters, oral presentations and peer-reviewed scientific journal papers have been produced with these students as contributing authors.

LESSONS LEARNED: This initiative has resulted in a mutually beneficial partnership for students and infection control professionals. Students gain invaluable knowledge by assisting with the design and implementation of infection control-related projects and experiments. In turn, infection control professionals receive assistance in day-day tasks, contributions to longer-term projects, and are able to help “shape” these interns for potential future infection control careers. It is important to obtain feedback from the students in order to enhance future projects. The implications of this initiative are to reverse the effects of a public health worker shortage by providing such programs to not only better prepare the workforce but also to instill a stimulating interest in the field of infection control and global health.

Publication Number 6-75

National Tuberculosis Curriculum Consortium (NTCC): Active-Learning Teaching Tools for Your Staff

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ISSUE: In 2003 the National Institutes of Health perceived a need to strengthen teaching about tuberculosis (TB) to health professions students. The National Tuberculosis Curriculum Consortium (NTCC) was funded to meet this need.

PROJECT: The National Tuberculosis Curriculum Consortium (NTCC) was funded for 5 years (2003-2008) by the NIH/NHLBI to improve knowledge, attitudes, and confidence in caring for patients with LTBI/TB in students in health
professions schools throughout the United States. Information about the NTCC is on the website at http://ntcc.ucsd.edu. The headquarters for the NTCC are at the University of California San Diego School of Medicine. Over 35 Consortium members representing eight disciplines (medicine, undergraduate nursing, advanced practice nursing, respiratory therapy, physician assisting, clinical laboratory sciences, pharmacy, and public health) are faculty in 25 universities representing 45 academic programs.

RESULTS: A survey in 2004 of NTCC faculty and a survey in 2005 of 1480 students in NTCC schools confirmed the need for additional TB-related education among health professions students. The NTCC has developed competencies and learning objectives for each discipline and a variety of products using active-learning strategies. These products include computerized cases, resource banks (multimedia, clinical case descriptions, and questions/answers/teaching points), standardized patient cases, games, and lectures. In order to reach the 3-4 million students and practicing health professionals in the U.S, the NTCC is also working with many professional organizations that accredit academic programs, certify and/or license health professionals for entry into practice, and provide lifelong learning, to insure that adequate attention is paid to the topic of tuberculosis.

LESSONS LEARNED: Although the NTCC is funded for five years, it has become clear that this is a very short time in which to achieve our goals. Our work with professional organizations is going well but the wheels turn very slowly. We are actively seeking additional funding for the project (after the NIH Contract ends) to insure that the website remains active and current and that dissemination efforts continue in a focused way to inform academic faculty and practicing professionals of the availability and usefulness of these active-learning tools.

Publication Number 6-76

Annual Infection Control Education: Create an Attitude of Fun and Engage the Customer!

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ISSUE: It is imperative to provide a venue for learning that instills in the customer, both clinical and nonclinical health care workers, the desire to learn that infection prevention and control is integrated in every job function!

PROJECT: A team of Infection Control Professionals (ICPs) set out to plan, design and host an Infection Control booth that would maintain the customer’s interest in learning science-based infection control. Three year of experience will be shared. Selection of a theme that is appealing to the customer is the first step in creating interest to attend. The ICPs then developed an educational plan based on prioritized key infection prevention messages. Design of the educational booth is developed integrating infection prevention into theme-based, fun, interactive activities or games. A theme-based computerized educational program is also developed to provide the same messages to those unable to attend or opt a self-directed learning venue. Creative visuals enhance teaching participants with limited educational backgrounds or the hearing-impaired. Handouts were provided to reinforce the educational objectives. A key question to assess competency is included in the “proof of attendance” that is marked at each educational booth, this also serves as a chance for attendance prizes. In lieu of give-aways, theme-based food & drink was provided. Feedback from the customer was solicited using an evaluation from obtained at the registration table.
RESULTS: Attendance consistently increased the past three years. Recommendation from the customers were integrated into the plans and development of subsequent fair. The participants overall responded favorably to themed-based learning, participated in the game or activity and was comfortable asking questions, clarifying information or presented their perception of infection control issues.

LESSONS LEARNED: Themed-based education provides a setting that increases interest to learn. Participants in a group setting learn from each other. The venue provides increases interchange of Infection Control issue and resolutions. Retention of information is questionable; further evaluation is being considered. Some participant may be too focus on the food, drink & prizes incentive rather than learning.

Publication Number 6-77  
**Effectiveness of a Hand Hygiene Campaign**

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**ISSUE:** Hand hygiene is a simple but most effective measure in preventing the spread of infection. This is a common concept among medical staffs, however, actual practice in clinical setting is difficult to achieve. In this study we held a hand hygiene campaign as an educational tool to raise awareness about hand hygiene at Juntendo University hospital in 2003.

**PROJECT:** All medical staffs of Juntendo university hospital. We conducted four interventions, posters on the walls in nurses’ office, distribution of leaflets, exercise of hand washing procedure, and measuring consumption of the amount of soap and alcohol gel (before and after campaign). Furthermore, we executed hand hygiene audit and questionnaire after campaign.

**RESULTS:** Among all medical staffs, 550 staffs (including nurses, assistant nurses, doctors, pharmacists) participated in both the hand washing exercise and the questionnaire. The consumption of soap and alcohol gel increased after the campaign (soap:2%, alcohol gel:14%). Hand hygiene audit showed that the practice rates was 68% with all the staffs. The practice rates of nurses (75%) was higher that of doctors (54%). In addition, many positive comments were given “I’ll refrain from wearing a wrist watch” “I’ll carry an alcohol gel with me” and “I’m more interested in infection control now” were written in the questionnaires.

**LESSONS LEARNED:** The Campaign improved the skill of hand washing and raised the awareness of hand hygiene importance among participants.

Publication Number 6-78  
**Use of Gown Counts To Assess and Improve Compliance with Contact Isolation**

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ISSUE: The MRSA (methicillin-resistant *Staphylococcus aureus*) Prevention Initiative is a program to prevent healthcare-acquired MRSA transmission by identifying potential MRSA reservoirs. It includes active surveillance nares cultures on all admissions, discharges, and transfers, contact isolation for all MRSA-positive patients, and aggressive hand hygiene. When it was rolled out to a 60-bed long-term care ward, the number of patients in isolation immediately increased. A staff member observed lack of compliance with gowns in isolation which was attributed to staff apathy to the project. An informal covert gown count in February 2006 revealed that only 0.5 gowns per patient were used in 48 hours (9 gowns used, 18 isolation patients), implying that only 0.5 visits per patient occurred in 48 hours. Staff were advised of these findings, gown supplies were increased to accommodate use, and more convenient location of gown supplies was made. Formal covert gown counts were undertaken in August 2006 and again in January 2007 to reassess compliance and to heighten staff awareness.

PROJECT: The number of patients in isolation and the total number gowns were counted at start of each study period and each day for 2 days. Study was blinded to the staff.

RESULTS: In August there were 21 patients in isolation, and a total of 76 gowns were used (18 on Day 1, 58 on Day 2), or 3.6 per patient for that 48-hour study period. In January there were 10 patients in isolation, and a total of 35 gowns were used (17 on Day 1, 18 on Day 2), or 3.5 per patient for 48 hours.

LESSONS LEARNED: After the initial count in February, staff were advised of the poor result. Subsequent gown counts were higher and remained stable indicating a certain consistency of staff usage. Gown counts might be considered as surrogate markers for patient contacts but may belie the true quantity of contacts with each patient. We believe some direct care was delivered without proper isolation attire. After February observations were fed back to staff, there was an increase in gown usage indicating a growing compliance to isolation protocol. Limitations of the study include consideration that some of the gowns may have been used for tasks other than isolation, i.e., transporting dirty linen, or that additional gowns may have been added by other personnel not included in the count. Heightened awareness of the MRSA problem via ongoing briefings, greater ease and supply of gowns, and other infection control activities on the unit are cofounders to these results. Some staff had learned the gown count was underway in August which may account for the increase in gown use from Day 1 to Day 2 (Hawthorne effect). Implications for practice include ongoing assessment of barriers to obtaining isolation supplies, continued education and briefing of staff on the importance of isolation practices for MRSA, periodic gown counts, and encouraging all staff to share their personal practices that overcome barriers to 100% observation of gowning.

Publication Number 6-79

**Development of a Standard Infection Prevention and Control Preceptor Program**

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BACKGROUND/OBJECTIVES: Kaiser Permanente (KP) is an Integrated Healthcare system consisting of approximately 5000 inpatient beds in 37 medical centers in 8 states and the District of Columbia. In 2003 the Kaiser IC (infection prevention and control) leadership team in California identified that the IC vacancy rate ranged from 12-28%. Compounding this vacancy rate was the need for additional FTEs (full-time equivalents) at each medical center in response to the continually expanding role of IC across the continuum of care including both inpatient and ambulatory care settings. Further impacting the situation was the limited pool of experienced IC staff in the community. As a result of this limited pool, many of our new ICPs (infection control professionals) are staff nurses with no prior IC experience. These observations prompted the identification of a critical need for development of an
internal training program for this specialized discipline. The team agreed that the program would need to provide a comprehensive and standardized guide for the training of current and future applicants for Kaiser IC positions throughout California.

METHODS: A work group was convened which met monthly by phone conference during 2003 to develop the Kaiser IC Preceptor Program Manual. The work group was comprised of seven IC managers, the regional directors of IC for Kaiser in Northern and Southern California, representation from Infectious Disease physician Chiefs and the departments of Work Force Planning, Recruitment and Educational Services. Kaiser Permanente senior leadership support for the project was provided by Regional Patient Care Services (Nursing). The APIC (Association for Professionals in Infection Control) Text, Chapter 28 was used as a guide when developing the Program content and training schedule. In 2004 this Preceptor Program Manual was finalized and distributed widely throughout the California Kaiser medical centers.

RESULTS: Since 2004 the Kaiser IC Preceptor Program has been utilized for the training of: 18 ICPs in Northern California, and 8 ICPs in Southern California. The vacancy rate has decreased from 12-28% to 7% in California. Reports from Preceptors and trainees indicate satisfaction with the program. In addition the overall retention rate to date is 20/26 IC staff (77%) since implementation of the preceptor program.

CONCLUSIONS: Based on the reduced vacancy rate, reports from Preceptors and trainees in addition to documented retention rate since inception of the program, even prior to completion of a formal evaluation, the program appears to have provided a positive impact. Next steps will include a formal evaluation the program and development of a process for ongoing review and updating of the Program Manual and content.

Publication Number 6-80

Infection Control Education: Practice to Reality

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ISSUE: Compliance with basic infection prevention practices, including hand hygiene is the cornerstone of reducing the risk of healthcare associated infections. Further more, the Centers for Disease Control and Prevention (CDC) and Joint Commission on Accreditation of Healthcare Organizations (JCAHO) endorse compliance with basic infection control practices, including hand hygiene. Unfortunately, these basics are not always practiced at optimum levels. In 2004, Infection Control began monitoring hand hygiene compliance, conformity ranging between 60% and 75% with a goal of 90% compliance. Standard education programs, including orientation, and mandated annual education had not improved compliance. Infection Control recognized learner activities needed to encourage healthcare worker ownership to help improve compliance with basic infection control practices, including hand hygiene.

PROJECT: Education programs were updated using learning tools with a positive impact throughout the healthcare spectrum, with a primary focus on the reduction of healthcare associated infections. Learning effectiveness was measured by pre tests, post test and compliance by direct observation. Increased emphasis was placed on providing education that is conducive to positive behavior, delivered in a non threaten manner with the outcome of empowering staff to improve compliance with infection control practices including hand hygiene compliance. Education was provided at multi-disciplinary unit Skills Days, Facility wide Safety Fairs, emphasizing hands on practice and resolving misconceptions. Interactive games were developed to incorporate problem solving in applying infection control concepts for everyday patient care situations. Learning methods included increased Infection Control Rounds to reinforce infection control practices, monitoring hand hygiene and isolation compliance.