Multicenter Study of Hand Carriage of Potential Pathogens by Neonatal ICU Healthcare Personnel

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A multicenter surveillance study was performed to determine the rates of hand carriage of potential pathogens among healthcare personnel in four neonatal intensive care units. Staphylococcus aureus, enterococci, and gram-negative bacilli were recovered from 8%, 3%, and 2% of 1000 hand culture samples, respectively.

Key words. gram-negative bacilli; hand hygiene; methicillin-resistant Staphylococcus aureus (MRSA); nurses; physicians.

INTRODUCTION

Infants hospitalized in neonatal intensive care units (NICUs) become colonized with potentially pathogenic flora, some of which may be acquired from the hands of healthcare personnel (HCP). Hand carriage of pathogens by HCP in the NICU has also been associated with infant infections and outbreaks [1]. To assess hand carriage during nonoutbreak periods, surveillance cultures of HCP hands were obtained to characterize hand flora and hand carriage rates over 2 years.

METHODS

Study Design and Study Sites

This prospective surveillance study of HCP hand carriage was part of a larger multicenter study that examined interdisciplinary interventions to improve antibiotic stewardship. Study sites included 4 NICUs in the United States with a mean of 1055 (range: 730–1176) annual discharges, 64 (range: 50–83) beds, and 165 (range: 102–252) nursing staff members per site. The study was approved by the institutional review boards of each study site with a waiver of written consent. HCP were provided an information sheet describing the study purpose and hand cultures.

Surveillance Efforts and Eligible Subjects

Surveillance cultures were collected every 6 months between April 2010 and May 2012 (5 surveillance efforts per site). During each effort, the first 50 eligible HCP to volunteer at each site were cultured. Eligible subjects were HCP with direct patient contact in the NICU, including nurses, physicians, neonatal nurse practitioners (NNPs), and other healthcare professionals (e.g., respiratory and physical therapists, and physician assistants). No identifying information was collected; subjects were asked to report their profession, when they last performed hand hygiene, and if alcohol hand sanitizer or soap and water was used. Individual HCP could be cultured during multiple surveillance efforts.

Surveillance Culture Methods

At an initial site visit, research personnel were trained to collect hand cultures using a modified glove-juice method [2]. Additionally, prior to each surveillance effort, research personnel reviewed a video demonstrating the appropriate collection method. Briefly, the dominant hand was massaged for 1 minute through a polyethylene bag containing 50 mL sampling solution of 0.07 M phosphate-buffered saline (Sigma-Aldrich, St. Louis, MO) with 1% Tween 80 (EMD Chemicals, Gibbstown, NJ). Hand cultures were
refrigerated, shipped within 24 hours to the core microbiology laboratory at Columbia University Medical Center, and processed by plating 50 µL on CNA blood agar and on MacConkey agar (Becton Dickinson, Franklin Lakes, NJ) to isolate Gram-positive cocci and Gram-negative bacilli (GNB), respectively. If applicable, 2 GNB morphologies were identified.

Species identification and susceptibility tests were performed according to the manufacturers’ recommendations for Staphaurex (Remel Inc., Lenexa, KS), PYR Identicult AE (PML Microbiologicals, Wilsonville, OR), MicroScan WalkAway (Siemens Healthcare Diagnostics Inc., Tarrytown, NY), Vitek 2 (bioMérieux Inc., Durham, NC), Etest (bioMérieux Inc.), and Kirby-Bauer discs (Becton Dickinson). Microscan was used to identify methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant enterococci (VRE). Nonsusceptible GNB were those with minimum inhibitory concentrations or zone diameters classified as intermediate or resistant according to the 2012 Clinical and Laboratory Standards Institute breakpoints for gentamicin, 3rd/4th-generation cephalosporin agents, and carbapenem agents [3].

Statistical Analysis
Student’s t test, χ², and Fisher’s exact test, when applicable, were performed in SAS 9.2 for Windows (SAS Institute Inc., Cary, NC) to assess differences in the rates of hand carriage at different study sites, over time, by different HCP characteristics, and by most recent episode of hand hygiene.

RESULTS

Samples Obtained
During the study period, 1000 hand cultures were obtained. Most samples were from women (94%) and nurses (78%). The proportion of samples obtained from nurses and physicians was similar at each site (mean: 78% [range: 73%–81%], P = .12 and mean 9% [range: 7%–11%], P = .55, respectively). However, the proportion of samples obtained from NNPs (mean 6% [range: 3%–11%], P = .002) or from men (mean 6% [range: 2%–8%], P = .002) differed among the sites.

Microorganisms Detected
Overall, 97% of hand cultures grew normal skin flora, defined as coagulase-negative staphylococci (CoNS) and/or diphtheroids (Table 1). Recovery of normal flora was similar among sites and surveillance efforts. Micrococcus and streptococcal spp. were also frequently isolated (21% and 26%, respectively), but recovery of streptococcal spp. differed among the sites (range: 18%–33%, P < .01).

Twelve percent of samples had ≥1 potential pathogens isolated including S aureus (8%), enterococci (3%), and/or GNB (2%) (Table 1). Within each NICU, the carriage rates of potential pathogens were similar over time, but carriage rates for S aureus varied among the sites (range: 2%–14%, P < .01). MRSA and VRE were isolated from 6 and 1 cultures, respectively. Only 2 MRSA isolates were detected from HCP from the same NICU during the same surveillance effort. Nineteen GNB isolates were recovered in 15 samples; Klebsiella spp. were most common. No GNB were nonsusceptible to gentamicin or carbapenem agents, and only 1 GNB (Acinetobacter lwoffii) was nonsusceptible to 3rd/4th-generation cephalosporin agents.

Factors Affecting Hand Carriage Rates

HCP Characteristics. Potential pathogens were more likely to be recovered from samples obtained from males than females (23% vs. 12%, respectively, P = .01). When comparing the proportion of samples with S aureus

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>NICU 1</th>
<th>NICU 2</th>
<th>NICU 3</th>
<th>NICU 4</th>
<th>Total</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>No growth</td>
<td>12 (5%)</td>
<td>4 (2%)</td>
<td>8 (3%)</td>
<td>5 (2%)</td>
<td>29 (3%)</td>
<td>0.16</td>
</tr>
<tr>
<td>Normal flora</td>
<td>235 (94%)</td>
<td>244 (98%)</td>
<td>242 (97%)</td>
<td>244 (98%)</td>
<td>965 (97%)</td>
<td>0.09</td>
</tr>
<tr>
<td>Micrococcus spp.</td>
<td>46 (18%)</td>
<td>43 (17%)</td>
<td>61 (24%)</td>
<td>59 (24%)</td>
<td>209 (21%)</td>
<td>0.11</td>
</tr>
<tr>
<td>Streptococcal spp.</td>
<td>82 (33%)</td>
<td>81 (32%)</td>
<td>46 (18%)</td>
<td>50 (20%)</td>
<td>259 (26%)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Data are column %. 2 × 4 χ² or Fisher’s exact test (if numbers were <5) were used to compare healthcare personnel characteristics and proportions of microorganisms at the different NICUs.

Abbreviations: NICU, neonatal intensive care unit; MRSA, methicillin-resistant Staphylococcus aureus; MSSA, methicillin-susceptible Staphylococcus aureus.

*More than one microorganism could be detected from a single hand culture.

*Included coagulase-negative staphylococci and/or diphtheroids.

* Included Klebsiella (n = 7), Enterobacter (n = 3), Pantoea (n = 4), Serratia (n = 2), Acinetobacter (n = 2), and Pseudomonas (n = 1) spp.
versus the proportion of samples with no potential pathogens, *S. aureus* was more likely to be recovered from samples obtained from males than females (20% vs. 8%, respectively, *P* = 0.002).

Overall recovery of potential pathogens from samples obtained from nurses vs. non-nurses was similar (13% vs. 10%, respectively, *P* = 0.22). However, when comparing the proportion of samples with enterococci vs. those with no potential pathogens, enterococci were more likely to be recovered from samples obtained from nurses than non-nurse HCPs (5% vs. 0.5%, respectively, *P* = 0.004).

**Hand Hygiene.** Among the 996 (99.6%) subjects reporting the time since they last performed hand hygiene, 900 (90%) reported performing hand hygiene ≤30 minutes prior to hand cultures (mean: 14 minutes, median: 5 minutes, range: 1 minute–5 hours). The mean time was similar between sites (*P* = 0.19). The carriage rate of potential pathogens was similar among those who performed hand hygiene ≤5 versus >5 minutes prior to hand cultures or ≤15 versus >15 minutes prior to hand cultures (data not shown). Women reported their last performed hand hygiene more recently than men (mean: 13 [SD = 25] minutes vs. 30 [SD = 59] minutes prior to culture, respectively, *P* < 0.01).

Overall, 59% of subjects used alcohol hand sanitizer prior to obtaining cultures, but this varied by site (range: 41%–76%, *P* < 0.01). The recovery rate of potential pathogens was similar from samples obtained following use of alcohol hand sanitizer versus soap and water (13% vs. 12%, respectively, *P* = 0.97).

**Seasonality.** No differences in the detection of potential pathogens were observed for samples obtained during spring (n = 600 samples) versus fall (n = 400 samples) months (12% vs. 13%, *P* = 0.78).

**DISCUSSION**

To our knowledge, this is the largest recent multicenter study to assess hand carriage of potential pathogens by HCP in the NICU over time. While only 12% of subjects carried potentially pathogenic flora, few of which were antimicrobial resistant, the majority were colonized with CoNS, which is considered normal skin flora. We performed a previous study in which *S. aureus*, enterococci, and GNB were similarly recovered from 3%, 2%, and 7% of samples from NICU nurses, respectively [4]. In addition, several studies of HCP hand carriage have been performed during outbreaks in efforts to detect a potential point source.

Outbreaks of *Pseudomonas aeruginosa* [5, 6], extended spectrum β-lactamase-producing *Klebsiella pneumoniae* [7], and *Serratia marcescens* [8] have been linked to artificial nails worn by HCP, and molecular epidemiology has confirmed transmission to infants. However, all 4 sites in this current study banned HCP from wearing artificial nails.

The current study was performed in an era of intense focus on performing hand hygiene and glove use [1]. We speculate that recent hand hygiene performed by 90% of subjects had removed most transient skin flora. We found that recovery of potential pathogens was similar from HCP who used alcohol sanitizer versus soap and water, which is generally inconsistent with the findings of others as alcohol-based hand hygiene has been found to be more effective than antiseptic or plain soap [1]. Previous studies have shown reduced hand hygiene compliance among physicians compared to nurses and among men compared to women [9, 10]. In this study, men were more likely to have hand carriage of potential pathogens, and we speculate that this finding reflected that more time had elapsed since their last episode of hand hygiene when compared to women.

This study had some limitations. As hand surveillance efforts were anonymous, we were unable to examine hand carriage of individuals over time or analyze the contribution of persistent hand carriage by an individual HCP. More samples were collected during day shifts despite efforts to culture during both day and night shifts. We did not collect other subject demographics that could have affected hand carriage (i.e., age, race, or years of job experience). Finally, the type of product used and timing of the most recent hand hygiene episode were self-reported.

In conclusion, hand carriage of potential pathogens by NICU HCP appears to be relatively low, which is likely a result of their frequent hand hygiene and glove use. Nevertheless, because contaminated HCP hands represent a potential risk to patients, efforts should continue to implement effective strategies to improve hand hygiene compliance, including the appropriate technique, quantity, and duration of product use.

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**References**


