National Epidemiology of Mycoses Survey (NEMIS): Variations in Rates of Bloodstream Infections Due to Candida Species in Seven Surgical Intensive Care Units and Six Neonatal Intensive Care Units

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Candida species are the fourth most frequent cause of nosocomial bloodstream infections, and 25%–50% occur in critical care units. During an 18-month prospective study period, all patients admitted for ≥72 hours to the surgical (SICUs) or neonatal intensive care units (NICUs) at each of the participating institutions were followed daily. Among 4,276 patients admitted to the seven SICUs in six centers, there were 42 nosocomial bloodstream infections due to Candida species (9.8/1,000 admissions; 0.99/1,000 patient-days). Of 2,847 babies admitted to the six NICUs, 35 acquired a nosocomial bloodstream infection due to Candida species (12.3/1,000 admissions; 0.64/1,000 patient-days). The following were the most commonly isolated Candida species causing bloodstream infections in the SICU: Candida albicans, 48%; Candida glabrata, 24%; Candida tropicalis, 19%; Candida parapsilosis, 7%; Candida species not otherwise specified, 2%. In the NICU the distribution was as follows: C. albicans, 63%; C. glabrata, 6%; C. parapsilosis, 29%; other, 3%. Of the patients, 30%–50% developed incidental stool colonization, 23% of SICU patients developed incidental urine colonization, and one-third of SICU health care workers’ hands were positive for Candida species.

Candida infections are important in the hospital setting for a number of reasons. They currently rank as the fourth most common cause of nosocomial bloodstream infections [1–3]. The associated crude mortality is high (38%–75%) [4], despite appropriate treatment with amphotericin B or one of the new triazoles. Importantly, infections that invade the bloodstream carry a high direct or attributable mortality. Specifically, in a carefully performed historical cohort study of nosocomial bloodstream infections due to Candida species, the crude mortality for cases and controls at a large tertiary care institution was reported to be 57% and 19%, respectively. Thus, the point estimate for the attributable mortality due to the infection alone was 38% [5].

Infections increase the length of hospital stay and the cost over those expected for the underlying diseases alone [5]. There has also been a consistent increase in the number and rate of Candida infections nationally [6], possibly because of the rapidly changing practice of medicine. Additionally, an increased number of hospitals have identified clusters and outbreaks of bloodstream infections due to Candida species, mainly in high-risk areas such as neonatal and surgical intensive care units (NICUs, SICUs, respectively) [7–9].

Bloodstream infections due to Candida species in critical care patients arise frequently from autoinfection after previous colonization of the gastrointestinal tract [10]. Clustering of Candida strains in time and space may result from person-to-person transmission may occur with a high efficiency.
[12]. With the high mortality and costs of treating Candida infections, epidemiological studies are warranted to establish better estimates of infection rates in high-risk critical care units. Such studies would supply useful information about risk factors for acquisition of Candida species and for mortality. Furthermore, microbiological investigations could provide estimates of the degree of clustering of similar strains of Candida in SICUs and NICUs and the frequency of hand carriage of Candida strains by hospital personnel. The National Epidemiology of Mycosis Survey (NEMIS) was designed to examine interinstitutional variation in rates of bloodstream infections with Candida species in both SICUs and NICUs. Patient data, surveillance cultures of samples from patients and health care workers, and outcome information were collected. Herein, we describe the NEMIS surveillance system and report the variation in rates across participant institutions in the United States.

Methods

An 18-month prospective study was performed in each of the following study centers: Columbia University Hospital, New York City; Harbor UCLA Medical Center, Los Angeles; Emory University (Grady Memorial Hospital), Atlanta; University of Iowa Hospitals and Clinics, Iowa City; University of Oregon Health Sciences Center, Portland; and the University of Texas at San Antonio Medical Center. In each of the centers, SICUs and NICUs were surveyed. At the University of Texas, data were collected from both the university-based SICU and the Department of Veterans Affairs Medical Center SICU.

Case finding. At all centers we performed a prospective cohort study in both SICUs and NICUs. The study period extended from October 1993 to November 1995, with some centers beginning data collection slightly later than others. All patients admitted for ≥72 hours were followed daily for 28 days or until discharge if it occurred before 28 days. Surveillance was done by two nurses in each of the centers. Before the study, all nurses were trained at the University of Iowa to follow standardized definitions and surveillance methods.

For all enrolled patients, a computerized case report form was completed every day by use of a hand-held computer. The data collected included the following patient information: name; hospital number; date of admission; hospital ward; presence of an endotracheal tube, nasogastric intubation, peripheral or central catheters, Foley catheter, rectal tube, or hemodialysis; specific antibiotic use; and other useful information for evaluating risk factors.

Severity of illness was calculated for all patients at enrollment. Three severity of illness scores were recorded: the American Society of Anesthesia score [13], the Acute Physiology and Chronic Health Evaluation (APACHE) II score for adults [14] or the SNAP score for neonates [15], and the McCabe and Jackson score [16].

Screening cultures. Samples for screening cultures for colonization with Candida species were obtained on admission to the NICU or SICU and once a week thereafter until discharge or until a maximum of 28 days after admission. All patients had prospective stool or perianal samples obtained for culture; in the SICU, urine was also obtained. For a patient to be considered as being colonized, they needed to have a positive result of culture of stool or urine after having had a previously negative result for that species. Thus, only those patients with two or more culture samples taken are included in the results. In patients with signs of infection, cultures of blood, sputum, or sterile fluids from biopsies were made whenever clinically appropriate.

Patients who acquired Candida species in stool or urine during hospitalization were considered colonized, and the specific site of acquisition was recorded. Candida infections were detected by a daily review of the microbiology laboratory results and confirmed by nurse practitioners by use of standard definitions [17]. The isolation of any Candida species from the bloodstream was considered clinically significant.

Cultures from hands. Estimates of the prevalence of carriage of Candida species on hands of health care personnel were sought with monthly cultures of a random sample of all personnel on both units (all personnel present during a randomly selected 2-hour period) on all nursing shifts. Culture samples were obtained by the bag-broth method [18].

Environmental cultures. Swabs for culture from intensive care unit sinks and bedside equipment were obtained concurrently with hand samples for culture to estimate possible environmental contamination with Candida species and relationships between patient colonization or infection and environmental contamination. Environmental culture data will be presented separately.

Microbiological testing. All cultures were obtained and incubated according to standard methods and identified by use of either an API 20C (bioMérieux Vitek, Hazelwood, MO) or Vitek (bioMérieux Vitek) yeast identification system. All fungal isolates were stored in sterile water slants at room temperature. These cultures were sent at monthly intervals to the special microbiology laboratory at the University of Iowa and to the medical mycology laboratory directed by one of the authors (M.R.) at the University of Texas, San Antonio. All isolates were tested to determine susceptibility to fluconazole, amphotericin B, and 5-fluorocytosine by use of National Committee for Clinical Laboratory Standards methods (standard M27-A).

Bloodstream infections. If a bloodstream infection was detected, stool samples for culture were obtained from the index patient and from the entire hospitalized cohort (patients on the same ward at the time of the collection of the blood sample). Cultures were repeated 7 days later. Hand samples were also obtained from patients from individual units if a bloodstream infection with Candida species was detected from a patient on that unit. The purpose of this aspect of the study was to compare strain clustering in an individual unit at a time when there was an active bloodstream infection vs. clustering at times when there were no bloodstream infections due to Candida species.
Reliability of data collection. Seventy data items from 10 cases entered at each hospital (5 SICU and 5 NICU) were compared with data collected by a reference standard quality assurance team. Each item was scored correct if it matched this reference standard. For each item, the percentage of correct entries was calculated, as well as the mean percentage correct for all items at each hospital. We compared differences in adherence to the reference standard between items. A perfect score would be 100%. Differences among hospitals were compared by one-way analysis of variance and confirmed by use of the nonparametric Kruskal-Wallis test.

The average percentage correct for NICU data was 90.3% (95% CI, 88.6%–92.0%), and the average percentage correct for SICU data was 89.2% (95% CI, 86.9%–91.5%). In the NICU, three items were correct 75% of the time: the SNAP score and the start and stop dates for the first procedure. In the SICU, two items were correct 75% of the time: the APACHE score and the start date of the second medication. Additional educational efforts were spent on the latter items, but no further validation was done.

Statistical analysis. Data were electronically sent from all centers to the University of Iowa’s Department of Preventive Medicine, Division of Biostatistics, where they were reviewed to determined completeness and accuracy. Rates of infection and colonization with *Candida* species were calculated with two denominators, 1,000 admissions and 1,000 patient-days. The log rank test was used to compare rates across the study institutions.

### Table 1. *Candida* isolates from bloodstream infections—NEMIS data from surgical and neonatal intensive care units.

<table>
<thead>
<tr>
<th>Parameter or isolate</th>
<th>SICUs (n = 42)</th>
<th>NICUs (n = 35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td>4,276</td>
<td>2,847</td>
</tr>
<tr>
<td>Infected</td>
<td>42</td>
<td>35</td>
</tr>
<tr>
<td>Infections/1,000 admissions</td>
<td>9.82</td>
<td>12.29</td>
</tr>
<tr>
<td>Infections/1,000 patient-days</td>
<td>0.99</td>
<td>0.64</td>
</tr>
<tr>
<td><em>Candida albicans</em></td>
<td>20 (48)</td>
<td>22 (63)</td>
</tr>
<tr>
<td><em>Candida glabrata</em></td>
<td>10 (24)</td>
<td>2 (6)</td>
</tr>
<tr>
<td><em>Candida tropicalis</em></td>
<td>8 (19)</td>
<td>—</td>
</tr>
<tr>
<td><em>Candida parapsilosis</em></td>
<td>3 (7)</td>
<td>10 (29)</td>
</tr>
<tr>
<td>Other <em>Candida</em> species</td>
<td>1 (2)</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

NOTE. Data are no. (%). NICU = neonatal intensive care unit; SICU = surgical intensive care unit.

### Table 2. Frequency of bloodstream infection due to *Candida* species in seven surgical intensive care units.

<table>
<thead>
<tr>
<th>Center</th>
<th>No. of admissions</th>
<th>Species</th>
<th>No. of isolates</th>
<th>Rate (per 1,000 admissions)</th>
<th>Rate (per 1,000 patient-days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>749</td>
<td><em>Candida glabrata</em></td>
<td>1</td>
<td>4.01</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Candida tropicalis</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>345</td>
<td><em>Candida albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>4</td>
<td>11.59</td>
<td>1.75</td>
</tr>
<tr>
<td>3</td>
<td>1,029</td>
<td><em>C. albicans</em></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Candida parapsilosis</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. tropicalis</em></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other <em>Candida</em> species</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>16</td>
<td>15.55</td>
<td>1.43</td>
</tr>
<tr>
<td>4</td>
<td>1,006</td>
<td><em>C. albicans</em></td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. tropicalis</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>11</td>
<td>10.93</td>
<td>1.13</td>
</tr>
<tr>
<td>5</td>
<td>687</td>
<td><em>C. albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td>15.79</td>
<td>1.34</td>
</tr>
<tr>
<td>6</td>
<td>190</td>
<td><em>C. albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td>11.11</td>
<td>0.79</td>
</tr>
<tr>
<td>7</td>
<td>270</td>
<td><em>C. albicans</em></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td>9.82</td>
<td>0.99</td>
</tr>
<tr>
<td>Total</td>
<td>4,276</td>
<td><em>C. albicans</em></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. tropicalis</em></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other <em>Candida</em> species</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Frequency of bloodstream infection due to *Candida* species in six neonatal intensive care units.

<table>
<thead>
<tr>
<th>Center</th>
<th>No. of admissions</th>
<th>Species</th>
<th>No. of isolates</th>
<th>Rate (per 1,000 admissions)</th>
<th>Rate (per 1,000 patient-days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>291</td>
<td><em>Candida albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>2</td>
<td>6.87</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>700</td>
<td><em>C. albicans</em></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Candida parapsilosis</em></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>5</td>
<td>7.14</td>
<td>0.39</td>
</tr>
<tr>
<td>3</td>
<td>528</td>
<td><em>C. albicans</em></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Candida glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other <em>Candida</em> species</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>15</td>
<td>28.41</td>
<td>1.31</td>
</tr>
<tr>
<td>4</td>
<td>335</td>
<td><em>C. albicans</em></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td>8.96</td>
<td>0.51</td>
</tr>
<tr>
<td>5</td>
<td>628</td>
<td><em>C. albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>7</td>
<td>11.15</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>365</td>
<td><em>C. albicans</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>3</td>
<td>8.22</td>
<td>0.38</td>
</tr>
<tr>
<td>7</td>
<td>2,847</td>
<td><em>C. albicans</em></td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. glabrata</em></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>C. parapsilosis</em></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other <em>Candida</em> species</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>35</td>
<td>12.29</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Table 4. Incidence of colonization by *Candida* species as determined by culture of stool from initially culture-negative patients in surgical and neonatal intensive care units.

<table>
<thead>
<tr>
<th>SICU (n = 910)</th>
<th>NICU (n = 1,050)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. colonized</td>
</tr>
<tr>
<td><em>Candida albicans</em></td>
<td>183</td>
</tr>
<tr>
<td><em>Candida krusei</em></td>
<td>14</td>
</tr>
<tr>
<td><em>Candida lusitaniae</em></td>
<td>7</td>
</tr>
<tr>
<td><em>Candida parapsilosis</em></td>
<td>37</td>
</tr>
<tr>
<td><em>Candida tropicalis</em></td>
<td>38</td>
</tr>
<tr>
<td><em>Candida glabrata</em></td>
<td>63</td>
</tr>
<tr>
<td><em>Candida saitoana</em></td>
<td>8</td>
</tr>
<tr>
<td>Other <em>Candida</em> species</td>
<td>7</td>
</tr>
<tr>
<td>Any <em>Candida</em> species</td>
<td>312</td>
</tr>
</tbody>
</table>

NOTE. NICU = neonatal intensive care unit; SICU = surgical intensive care unit. Data are for patients with at least two samples taken for culture. Colonization is defined as having a species-specific negative culture result before having a positive culture result.

Results

Among the 4,276 patients admitted to seven SICUs, there were 42 *Candida* nosocomial bloodstream infections (9.8/1,000 admissions; 0.99/1,000 patient-days) (table 1). Of 2,847 babies admitted to six NICUs, 35 acquired a nosocomial bloodstream infection due to *Candida* species (12.3/1,000 admissions; 0.64/1,000 patient-days).

In the SICU, the *Candida* species most frequently isolated from blood (table 1) were *Candida albicans* in 20 cases (48%), *Candida glabrata* in 10 (24%), *Candida tropicalis* in 8 (19%), *Candida parapsilosis* in 3 (7%), and *Candida* species not otherwise specified in 1. In the NICU, 22 episodes (63%) were due to *C. albicans*, 10 (29%) to *C. parapsilosis*, 2 (6%) to *C. glabrata*, and 1 (3%) to *Candida* species not otherwise specified. Overall, the most common *Candida* species causing bloodstream infections were *C. albicans* (55%), *C. glabrata* (16%), *C. parapsilosis* (17%), and *C. tropicalis* (10%).

Variations in rates of bloodstream infections in SICUs and
Table 5. Incidence of colonization by *Candida* species as determined by culture of urine from initially culture-negative patients in surgical intensive care units.

<table>
<thead>
<tr>
<th></th>
<th>No. colonized</th>
<th>No. at risk for colonization</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Candida albicans</em></td>
<td>141</td>
<td>1,017</td>
<td>13.9</td>
</tr>
<tr>
<td><em>Candida krusei</em></td>
<td>5</td>
<td>1,068</td>
<td>0.5</td>
</tr>
<tr>
<td><em>Candida lusitaniae</em></td>
<td>1</td>
<td>1,073</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Candida parapsilosis</em></td>
<td>14</td>
<td>1,066</td>
<td>1.3</td>
</tr>
<tr>
<td><em>Candida tropicalis</em></td>
<td>31</td>
<td>1,064</td>
<td>2.9</td>
</tr>
<tr>
<td><em>Candida glabrata</em></td>
<td>58</td>
<td>1,039</td>
<td>5.6</td>
</tr>
<tr>
<td><em>Candida saitoana</em></td>
<td>4</td>
<td>1,072</td>
<td>0.4</td>
</tr>
<tr>
<td>Other <em>Candida</em> species</td>
<td>2</td>
<td>1,071</td>
<td>0.2</td>
</tr>
<tr>
<td>Any <em>Candida</em> species</td>
<td>228</td>
<td>979</td>
<td>23.3</td>
</tr>
</tbody>
</table>

NOTE. Data are for patients with at least two samples taken for culture. Colonization is defined as having a species-specific negative culture result before having a positive culture result.

NICUs are shown in tables 2 and 3, respectively. Rates in SICUs varied from 2.9/1,000 admissions (0.28/1,000 patient-days) to 15.8/1,000 admissions (1.34/1,000 patient-days). In the NICUs, rates varied from 6.9/1,000 admissions (0.34/1,000 patient-days) to 28.4/1,000 admissions (1.31/1,000 patient-days). There is statistical support for the statement that variations in rates exist: on the basis of bloodstream infection due to *Candida* species per admissions, the *P* value for the SICUs was .06 and for the NICUs was .04. On the basis of rates per 1,000 patient-days, the *P* value for the SICUs was .12 and for the NICUs was .02.

Incident colonization of stool with *Candida* species occurred in almost 50% of 910 SICU patients and 30% of 1,050 NICU patients (table 4). *C. albicans* was found in samples from 26.5% of SICU patients and 16.3% of NICU patients, representing the most commonly isolated species in stool. Of interest, *C. glabrata* was found in samples from 7.7% of SICU patients but only 1.5% of NICU patients, whereas *C. parapsilosis* was found in samples from 4.2% of SICU patients and 10.3% of NICU patients. In the SICU, 23.3% of patients had evidence of colonization with *Candida* species in urine, almost 14% of them with *C. albicans*, the most frequently isolated species (table 5).

Medical personnel had positive results of culture of samples from their hands ~30% of the time: among 1,796 SICU personnel, 33.1%, and among 856 NICU personnel, 28.6% (table 6). Variations across institutions were 17.2%–58.3% for SICUs and 7.8%–62% for NICUs.

Discussion

Rates of bloodstream infection due to *Candida* species have increased steadily. NNIS data show that *Candida* species were the fifth leading cause of bloodstream infection hospitalwide and the fourth in the intensive care units [1–3]. Current data from the SCOPE (Surveillance and Control of Pathogens of Epidemiologic Importance) surveillance system confirm that *Candida* species were the fourth leading cause of bloodstream infection [19], as do data from The Surveillance Network–USA, which reflects information from >100 laboratories across the country [20].

The downward trend in hospital bed size combined with a proportional increase in the number of beds in intensive care units has increased the complexity of patients who are hospitalized. These patients are more severely compromised. Such patients tend to require more invasive diagnostic and therapeutic interventions [21]. These interventions have been associated with an increased risk for developing *Candida* infections [22, 23], and the current trend is not likely to slow. *Candida* species will almost certainly continue to be a major cause of morbidity and mortality in these units.

Half of the patients in SICUs and 30% of those in NICUs developed incident colonization apparent on culture of stool samples. Furthermore, 28% of SICU patients developed incident colonization as determined by culture of urine. Surely such data reflect antibiotic selection and subsequent risk for candidemia [22, 23].

Approximately one-third of health care personnel were found to have hand carriage of *Candida* species, yet there was wide variation across institutions. However, rates in SICUs paralleled rates in NICUs for individual institutions. With increasing reports of clusters of bloodstream infections due to *Candida* species, we plan to analyze the species among patients and health care workers and, in subsequent reports, estimate the proportion of infections that are potentially related to cross-infections.

The NEMIS surveillance system defines for the first time remarkable interinstitutional variation in rates of bloodstream infections due to *Candida* species. Furthermore, we now have the ability to analyze data from different institutions that may yield clues to risk factors for candidemia. Further analyses, currently under way, may show differences in patient populations, infection control practices, and specific medical management of SICU and NICU patients.

Recently, we have examined the antifungal susceptibility of *Candida* species obtained from the NEMIS study [24]. Regarding amphotericin B, the MIC₉₀ was 1.0 μg/mL at all study centers. In contrast, the fluconazole MIC₉₀ varied from 8 μg/mL at one institution to 64 μg/mL at another, and the itraconazole MIC₉₀ varied from 0.5 μg/mL to 2 μg/mL across institutions. Similar studies of bloodstream isolates of *C. albicans* from the SCOPE program showed that 90% of isolates were susceptible to fluconazole and itraconazole and 92% were susceptible to 5-fluorocytosine [25]. In that study, isolates of *C. albicans* from the Northwest and Southeast were more frequently resistant to fluconazole (13%–16%) and itraconazole (17%–20%) than were those from the Northeast and Southwest.

The NEMIS system in future analyses will attempt to correlate secular trends in drug use, specifically the use of azole therapy, with changes in the *Candida* species recovered. Increases in the rates of *Candida* isolates other than *C. albicans* may be explained with such an approach. In this study,
C. albicans constituted only half of the clinical bloodstream isolates in SICU and NICU patients. Although the reasons for the variations in infection rates and the emergence of species other than C. albicans are unclear, further analyses of the NEMIS data may shed light on probable causes.

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**References**


**Table 6.** Crude findings from culture of hand samples from health care personnel in surgical and neonatal intensive care units.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>SICU</th>
<th>NICU</th>
</tr>
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<tbody>
<tr>
<td>No. of positive hand culture results</td>
<td>No. of hand samples taken</td>
<td>Proportion (%)</td>
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<tr>
<td>1</td>
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<tr>
<td>Total</td>
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<td>5427</td>
</tr>
</tbody>
</table>

NOTE. NICU = neonatal intensive care unit; SICU = surgical intensive care unit.