that this approach could be utilized in routine screening for Mycobacterium avium recoveries relative to other sample types and the inability to NTM disease when it is clinically suspected given the lower However, this approach should not be utilized to rule out whom there are currently no effective screening methods.

implemented within regular microbiology work relative ease with which the RGM culture method can be

grow mycobacteria from the complex and do not

apply to the slower-growing pathogens from the M. abscessus complex. Mycobacterium avium complex bacteria cannot be recovered by the RGM culture method, nor have we observed M. avium from AFB cultures of deep pharyngeal swabs. While a limitation, M. abscessus and related pathogens appear to be more closely linked to negative clinical outcomes, and recent studies suggest that these pathogens are increasing in frequency in CF. Recovery of NTM from DP samples was generally lower than in sputum, although differences did not reach statistical significance.

why the 45% recovery rate of M. abscessus was less in this subset of patients relative to the 65%–75% sensitivity for the RGM method estimated for the group as a whole. Notably, the results from this study are specific for rapidly growing mycobacteria from the M. abscessus complex and do not apply to the slower-growing pathogens from the M. avium complex. Mycobacterium avium complex bacteria cannot be recovered by the RGM culture method, nor have we observed M. avium from AFB cultures of deep pharyngeal swabs. While a limitation, M. abscessus and related pathogens appear to be more closely linked to negative clinical outcomes, and recent studies suggest that these pathogens are increasing in frequency in CF.

These findings suggest a role for deep pharyngeal swabs in the management of M. abscessus respiratory disease in CF, particularly in conjunction with the RGM culture method. The relative ease with which the RGM culture method can be implemented within regular microbiology work flows suggests that this approach could be utilized in routine screening for M. abscessus in children too young to produce sputum, for whom there are currently no effective screening methods. However, this approach should not be utilized to rule out NTM disease when it is clinically suspected given the lower sensitivity relative to other sample types and the inability to recover Mycobacterium avium complex pathogens.

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**References**


**High Counts of Carbapenemase-Producing Enterobacteriaceae in Hospital Sewage**

*To the Editor*—Carbapenemase-producing Enterobacteriaceae (CPE) are an increasing problem worldwide. Because they are
TABLE 1. Characteristics of Carbapenemase-Producing Enterobacteriaceae (CPE) in Sewage and Clinical Samples

<table>
<thead>
<tr>
<th>Institution</th>
<th>CPEs in Sewage</th>
<th>CFU/mL</th>
<th>No. of Isolates of CPE</th>
<th>Predominant CPEs in Clinical Isolates</th>
<th>No. of Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital A</td>
<td>Enterobacter cloacae bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>80,000</td>
<td>34</td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;KPC&lt;/sub&gt;</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Citrobacter freundii bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>10,000</td>
<td></td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;OXA-48 type&lt;/sub&gt;</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Aeromonas caviae bla&lt;sub&gt;IMI&lt;/sub&gt;</td>
<td>1,000</td>
<td></td>
<td>Escherichia coli bla&lt;sub&gt;KPC&lt;/sub&gt;</td>
<td>4</td>
</tr>
<tr>
<td>Hospital B</td>
<td>Enterobacter cloacae bla&lt;sub&gt;KPC&lt;/sub&gt;</td>
<td>80,000</td>
<td>14</td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>7</td>
</tr>
<tr>
<td>Site 1</td>
<td>Aeromonas caviae bla&lt;sub&gt;OXA-48-type&lt;/sub&gt;</td>
<td>30,000</td>
<td></td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;OXA-48 type&lt;/sub&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Site 2</td>
<td>Escherichia coli bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>1,000</td>
<td>9</td>
<td>Escherichia coli bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Hospital C</td>
<td>Enterobacter asburiae bla&lt;sub&gt;KPC&lt;/sub&gt;</td>
<td>70,000</td>
<td>1</td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;IMI&lt;/sub&gt;</td>
<td>2</td>
</tr>
<tr>
<td>Hospital D</td>
<td>Enterobacter kobei bla&lt;sub&gt;KPC&lt;/sub&gt;</td>
<td>10,000</td>
<td></td>
<td>Escherichia coli bla&lt;sub&gt;OXA-48 type&lt;/sub&gt;</td>
<td>1</td>
</tr>
<tr>
<td>Hospital E</td>
<td>0</td>
<td></td>
<td>2</td>
<td>Serratia marcescens bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>1</td>
</tr>
<tr>
<td>Site 1</td>
<td>0</td>
<td></td>
<td></td>
<td>Klebsiella pneumoniae bla&lt;sub&gt;NDM&lt;/sub&gt;</td>
<td>1</td>
</tr>
<tr>
<td>Site 2</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community</td>
<td>0</td>
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</tr>
</tbody>
</table>


often resistant to almost all available antibiotics, treating infections caused by these bacteria is extremely difficult. Recently, concern has also been raised about hospital sewage as a potential source of CPE in the environment. To investigate this possibility locally, we recently sampled sewage from 6 hospitals and a community institution (used as control) in Singapore.

Unconcentrated sewage was streaked out using 1 µL and 10 µL loops onto ChromID CARBA plates (bioMérieux, Marcy l’Etoile, France). After incubation for up to 48 hours at 35°C in air, 3 predominant colony morphotypes resembling Enterobacteriaceae per sample were chosen for further investigation. Carbapenemase activity was determined by the Carba NP test and the modified Hodge test. Identification of bacteria was done by MALDI-TOF (Bruker Daltonics Pte. Ltd., Singapore). The presence of carbapenemase genes was confirmed by multiplex polymerase chain reaction (PCR). The results of our survey are shown in Table 1 together with the number of CPEs isolated from clinical specimens (not stool surveillance cultures) taken from patients in each hospital.

CPEs were found in the sewage of 4 hospitals. The numbers of isolates of CPE in sewage generally corresponded with the frequency of isolation of clinical isolates in the hospitals. However, there was no direct correlation between sewage and clinical isolates with regard to bacterial species and carbapenemase genes. Clinical isolates were commonly Klebsiella pneumoniae and Escherichia coli, whereas Enterobacter and Aeromonas species were more common in sewage. We are uncertain of the reasons for this discrepancy between sewage and clinical isolates; it could be a chance finding resulting from limited sampling. However, this finding does seem to be quite consistent across different hospitals. Another possibility is that it may reflect a difference between the species of CPE that cause disease (clinical isolates) and those that merely colonize the gut (found in sewage) without resulting in infection. This explanation is only partial. During the same period (January 1, 2014–May 31, 2014) in Hospital A, which has the most comprehensive surveillance program for CPE, K. pneumoniae (83 isolates) and E. coli (47 isolates) remained the most common species isolated from patient stools, with Enterobacter cloacae a distant third (27 isolates). No Aeromonas species were isolated from stool surveillance cultures. Finally, these results may be the result of an ecological dynamic occurring in the sewage system. Aeromonas species are able to survive and proliferate in water distribution systems and may acquire plasmids containing carbapenemase genes from the clinical isolates entering into the system.

This study has several limitations. Data collection was performed at only 1 time point per sampling site, and the methods used for quantifying colony counts were very simple. Nevertheless, we were surprised at the ease with which large numbers of CPEs could be isolated from the unconcentrated sewage of some hospitals. All 6 hospitals that took part in this study already have a stool screening program for CPE in place, but the extent of the screening varies. Most hospitals screen patients who have been hospitalized in the past year. The hospitals with the largest clinical burden of CPE (hospitals A and B) additionally screen patients on-at-risk wards like Hematology and Intensive Care. Finally, we did not exclude the possibility that the CPE came from staff because personnel are not routinely screened for CPE carriage.

The results of this study suggest that large numbers of CPEs in hospital sewage may strengthen the case for a screening program if none exists. The microbial ecology of resistant bacteria in the sewage system, the risk of environmental contamination, and the role of Enterobacter species and Aeromonas.
species in the dissemination of carbapenemase genes in the environment remain to be studied.

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