Multihospital
Outbreak of
Clostridium difficile
Infection, Cleveland, Ohio, USA

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To determine whether a multihospital Clostridium difficile outbreak was associated with epidemic strains and whether use of particular fluoroquinolones was associated with increased infection rates, we cultured feces from C. difficile–infected patients. Use of fluoroquinolones with enhanced antianaerobic activity was not associated with increased infection rates.

Recent outbreaks of Clostridium difficile infection have been attributed to the emergence of an epidemic strain characterized as North American pulsed-field gel electrophoresis type 1 (NAP1) or restriction endonuclease assay group BI (1,2). Fluoroquinolone resistance is a hallmark of epidemic C. difficile isolates (1), and fluoroquinolone use has been associated with C. difficile infection (2–9). Because the C-8 methoxy fluoroquinolones gatifloxacin and moxifloxacin have enhanced antianaerobic activity, they might promote C. difficile infection to a greater degree than ciprofloxacin and levofloxacin (10). In 3 studies, substitution of gatifloxacin or moxifloxacin for levofloxacin was associated with an increase in C. difficile infection (6,8,9); in 2 of the 3 studies, a formulary change back to levofloxacin was associated with reduced C. difficile infection (6,9). However, ciprofloxacin and levofloxacin also have been associated with C. difficile infection (2–5,7).

Beginning in 2002, outbreaks of C. difficile infection occurred in several hospitals in the Cleveland, Ohio, USA, area. In response, the Ohio Department of Health (ODH) made C. difficile infection a reportable disease in 2006. One objective of the current study was to examine the magnitude of the outbreaks in Cuyahoga County, which comprises Cleveland and the surrounding area, and to determine whether the outbreaks were associated with epidemic BI/NAP1 strains. A second objective was to examine whether use of gatifloxacin and/or moxifloxacin was associated with increased rates of C. difficile infection in healthcare facilities and to assess whether outbreaks correlated with formulary changes in fluoroquinolones.

The Study

We used the ODH website (www.odh.state.oh.us) to obtain rates (cases/10,000 patient-days) of initial C. difficile infections during January–December 2006 for the 22 hospitals in Cuyahoga County. All healthcare facilities in Ohio were required to submit C. difficile infection rates by using a standardized method of reporting. An initial case was defined as a first positive laboratory diagnostic test for C. difficile, pseudomembranes on endoscopy, or confirmatory histologic features from surgical or autopsy specimen. An infection that occurred >6 months after a previous infection was classified as an initial infection.

For a subset of 5 hospitals, up to 20 consecutive stool samples from individual patients with C. difficile infection were cultured for C. difficile (11). C. difficile isolates were tested for in vitro cytotoxin production and moxifloxacin susceptibility and analyzed for binary toxin gene cdtB and partial deletions of the tcdC gene (11–13). Molecular typing was performed by using PCR ribotyping (11). The 5 hospitals were 1 community hospital, 3 tertiary care facilities, and 1 Veterans Affairs hospital. Three of the hospitals had experienced large outbreaks of C. difficile infection in 2002–2003 (i.e., their C. difficile incidence doubled and their peak incidence was >20 cases per 1,000 discharges); the other 2 reported an increase in the proportion of cases that were fulminant. The infection control departments of each institution provided information about C. difficile infection rates, fluoroquinolones on formulary, and infection control measures for C. difficile during January 2000–December 2006.

Rates of C. difficile infection for 2006 were compared among hospitals with moxifloxacin or gatifloxacin versus those with levofloxacin on formulary as primarily fluoroquinolones used to treat respiratory infections. In addition, for 2 hospitals in the molecular typing analysis that had a formulary change from 1 respiratory fluoroquinolone to another, we used Poisson analysis to compare rates of C. difficile infection during the 12 months before and after the formulary change, with a lag of 1 month after the change. We analyzed data using SPSS statistical software version 10.0 (SPSS Inc., Chicago, IL, USA) and STATA 9.1 (StataCorp, College Station, TX, USA).
For the 18 adult acute-care hospitals and 4 long-term acute-care (LTAC) facilities in Cuyahoga County, the median \textit{C. difficile} infection rate in 2006 was 7.3 (range 4.2–63.1 cases/10,000 patient-days). The highest rates were observed in 2 LTAC facilities. Six facilities (3 acute-care hospitals and 3 LTACs) had higher \textit{C. difficile} infection rates than did each of the 5 hospitals in the molecular typing analysis.

A total of 64 toxigenic \textit{C. difficile} isolates were cultured from feces samples obtained from 5 hospitals. Features of 42 (66%) isolates were consistent with epidemic BI/NAP1 strains (range 55%–83% for each facility), including amplification of the binary toxin gene \textit{cdtB} and partial deletions in \textit{tcdC} and resistance to moxifloxacin (MICs >32 \(\mu\)g/mL). By PCR ribotyping, we observed a characteristic banding pattern for isolates with features of the epidemic strain; 6 isolates with this banding pattern were confirmed as BI strains in the laboratory of D.G.

Of the 22 facilities, 8 used moxifloxacin as the primary respiratory fluoroquinolone, 13 used levofloxacin, and 1 did not have a respiratory fluoroquinolone on formulary. The \textit{C. difficile} infection rate did not differ between facilities with levofloxacin (8.5 cases/10,000 patient-days, 95% confidence interval [CI] 7.8–9.3) and moxifloxacin (8.5 cases/10,000 patient-days, 95% CI 7.8–9.2) on formulary (\(p = 1\)) (Table). The facility that did not have a respiratory fluoroquinolone on formulary had a lower rate of \textit{C. difficile} infection than the median rates for facilities that used levofloxacin or moxifloxacin. However, 8 facilities had lower \textit{C. difficile} infection rates than did this institution.

Two of the 5 hospitals in the molecular typing analysis changed their formulary fluoroquinolones during the study period (Figure). Both hospitals made formulary changes from levofloxacin to gatifloxacin; however, the increase in \textit{C. difficile} infection rates preceded the formulary change in each hospital. \textit{C. difficile} infection rates did not differ significantly in the 12 months before and after the change from levofloxacin to gatifloxacin (relative risk [RR] 1.0, 95% CI 0.97–0.86; \(p = 0.973\)). For hospital 2 (Figure, panel B), a subsequent formulary change from gatifloxacin to levofloxacin was associated with a reduction in \textit{C. difficile} infection (RR 0.59, 95% CI 0.51–0.70; \(p<0.001\)); an intervention to improve environmental cleaning with a 10% bleach solution occurred at the time of the formulary change.

### Conclusions

Our findings provide further evidence that emergence of epidemic NAP1/BI strains in a geographic region may be associated with large multihospital outbreaks of \textit{C. difficile} infection. Before the ODH decision to require mandatory reporting, many area hospitals were either not collecting surveillance data about \textit{C. difficile} infection or were reluctant to share their rates. Therefore, we believe that mandatory public reporting of \textit{C. difficile} infection rates provided a valuable tool to examine the full magnitude of the outbreaks and an incentive for hospitals with high rates to increase efforts to control infection. One area hospital recently reported that the ODH database underestimated the incidence of \textit{C. difficile} infection (14), but this observation does not affect our conclusions because all facilities used the same surveillance definitions. Our findings do not support the hypothesis that use of moxifloxacin or gatifloxacin is associated with higher rates of \textit{C. difficile} infection than is use of levofloxacin or ciprofloxacin.

Our analysis of formulary fluoroquinolones and \textit{C. difficile} infection has several limitations. First, data on the amount of the fluoroquinolones used in the hospitals were not available. Second, analysis of hospital formularies does not account for the effects of fluoroquinolones used in long-term care facilities and among outpatients. Third, we did not assess confounding factors, such as use of other classes

### Table. \textit{Clostridium difficile} infection rates and healthcare facility characteristics according to respiratory fluoroquinolone on formulary, Cleveland, Ohio, USA, 2006

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Levo</th>
<th>Moxi</th>
<th>Neither</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. hospitals</td>
<td>13</td>
<td>8</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>No. beds, median (IQR)</td>
<td>232 (108–371)</td>
<td>361 (217–565)</td>
<td>1,008</td>
<td>316 (125–424)</td>
</tr>
<tr>
<td>Type of facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary care</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Acute care</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Long-term acute care</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Hospital system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System 1</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>System 2</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Neither</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>No. cases of \textit{C. difficile} infection</td>
<td>494</td>
<td>569</td>
<td>206</td>
<td>1,269</td>
</tr>
<tr>
<td>Patient-days</td>
<td>580,893</td>
<td>666,719</td>
<td>293,833</td>
<td>1,541,445</td>
</tr>
<tr>
<td>Rate of \textit{C. difficile} infection/10,000 patient-days, median (IQR)</td>
<td>8.5 (7.8–9.3)</td>
<td>8.5 (7.8–9.2)</td>
<td>7.0 (6.1–8.0)</td>
<td>8.2 (7.8–8.7)</td>
</tr>
</tbody>
</table>

*†Ciprofloxacin on formulary but no respiratory fluoroquinolone on formulary.
of antimicrobial drugs and differing patient populations. Finally, studies that evaluate group-level effects may not reflect the biological effects at the individual-patient level. Additional studies are needed to evaluate the risk for *C. difficile* infection associated with different fluoroquinolones.

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References


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