Antimicrobial resistance in *Escherichia coli* and *Pseudomonas aeruginosa* before and after the coronavirus disease 2019 (COVID-19) pandemic in the Dominican Republic

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Abstract

Objective: To describe antimicrobial resistance before and after the COVID-19 pandemic in the Dominican Republic.

Design: Retrospective study.

Setting: The study included 49 outpatient laboratory sites located in 13 cities nationwide.

Participants: Patients seeking ambulatory microbiology testing for urine and bodily fluids

Methods: We reviewed antimicrobial susceptibility reports for *Escherichia coli* isolates from urine and *Pseudomonas aeruginosa* (PSAR) from bodily fluids between January 1, 2018, to December 31, 2021, from deidentified susceptibility data extracted from final culture results.

Results: In total, 27,718 urine cultures with *E. coli* and 2,111 bodily fluid cultures with PSAR were included in the analysis. On average, resistance to ceftriaxone was present in 25.19% of *E. coli* isolated from urine each year. The carbapenem resistance rates were 0.15% for *E. coli* and 3.08% for PSAR annually. The average rates of *E. coli* with phenotypic resistance consistent with possible extended-spectrum β-lactamase (ESBL) in urine were 25.63% and 24.75%, respectively, before and after the COVID-19 pandemic. The carbapenem resistance rates in urine were 0.11% and 0.20%, respectively, a 200% increase. The average rates of PSAR with carbapenem resistance in bodily fluid were 2.33% and 3.84% before and after the COVID-19 pandemic, respectively, a 130% percent increase.

Conclusions: Resistance to carbapenems in PSAR and *E. coli* after the COVID-19 pandemic is rising. These resistance patterns suggest that ESBL is common in the Dominican Republic. Carbapenem resistance was uncommon but increased after the COVID-19 pandemic.

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period. The University of Illinois at Chicago Institutional Review Board approved this study.

Study site
Amadita Laboratories is a private commercial laboratory company that provides outpatient services nationwide in the Dominican Republic. There are 49 outpatient laboratory sites across the Dominican Republic, representing 13 urban areas and all geographic regions of the country (Fig. 1).

Laboratory workflow and microbiology testing
Samples are collected at the outpatient laboratory sites and are processed centrally in the city of Santo Domingo. The central laboratory is equipped with the VITEK MS, VITEK 2 XL, VITEK 2 Compact (bioMérieux, Marcy-l’Étoile, France) and advanced expert systems (AESs) for initial analysis. The VITEK 2 XL and VITEK 2 Compact are used for the initial testing. VITEK 2 XL uses the AST-GN67, AST XN05, and AST XN08 susceptibility cards, and VITEK 2 Compat uses the AST-GN67, AST XN05, and AST XN08 cards. VITEK MS is used for matrix-assisted laser desorption/ionization time-of-flight mass spectroscopy (MALDI-TOF MS) analysis of organisms. AES software versions 8.0 and 9.2 were used for analysis and interpretation of the antibiogram. Additional confirmatory testing was performed using the Kirby-Bauer method via the MASTDISCS Combi AMP-C, ESBL ID MAST GROUP, and MASTDISCS Combi CARBA PLUS discs (Mast Group, Bootle, UK). Sensitivity discs for individual carbapenems and the E-test for meropenem were used to confirm resistance.

For *E. coli*, a minimum inhibitory concentration (MIC) of $\geq 4 \mu g/mL$ to ceftriaxone was considered resistant and possible extended-spectrum β-lactamase (ESBL) whereas an MIC of $\geq 8 \mu g/mL$ to meropenem was considered resistant (carbapenem-resistant Enterobacteriales or CRE). For PSAR, an MIC of $\geq 32 \mu g/mL$ to ceftazidime was considered resistant and possible ESBL while an MIC of $\geq 8 \mu g/mL$ for meropenem was considered resistant (carbapenem-resistant *Pseudomonas aeruginosa* or CR-PSAR). Thresholds for resistance were based on Clinical and Laboratory Standards Institute (CLSI) M100.

Results
In total, 27,718 urine cultures with *E. coli* were reviewed from 2018 to 2021. On average, 6929.5 urine cultures were performed per year. For *E. coli*, the resistance rates to ceftriaxone were 25.21% in 2018, 26.05% in 2019, 24.84% in 2020 and 24.65% in 2021 (Table 1). The resistance rates to meropenem were 0.08% in 2018, 0.13% in 2019, 0.10% in 2020, and 0.30% in 2021 (Table 1). The average *E. coli* with ceftriaxone resistance rates were 25.63% and 24.75% before and after the COVID-19 pandemic, respectively (Fig. 2). The average rates of *E. coli* with CRE were 0.11% and 0.20% before and after the COVID-19 pandemic, respectively (Fig. 3). Between 2020 and 2021, a 200% increase in carbapenem-resistant *E. coli* occurred.

In total, 2,111 bodily fluid cultures with PSAR were reviewed from 2018 to 2021. On average, 527.75 cultures were performed per year. For PSAR, the resistance rates to ceftazidime were 11.79% in 2018, 13.48% in 2019, 15.19% in 2020 and 15.13% in 2021 (Table 2). The resistance rates to meropenem were 2.12% in 2018, 2.53% in 2019, 2.33% in 2020, and 5.35% in 2021 (Table 2). The average rates of PSAR with ceftazidime resistance...
in bodily fluid were 12.64% and 15.16% before and after the COVID-19 pandemic, respectively (Fig. 2). The average rates of PSAR with carbapenem resistance were 2.33% and 3.84% before and after the COVID-19 pandemic, respectively (Fig. 3). Between 2020 and 2021, a 130% increase in CR-PSAR occurred.

In conclusion, we detected high levels of resistance in *E. coli* isolated from urine samples and rising resistance to carbapenems in PSAR from bodily fluids. On average, resistance to ceftriaxone was present in 25.19% of *E. coli* isolates from urine each year. These resistance patterns suggest that ESBL is common in the Dominican Republic, at levels comparable to other countries in Latin America.12–14 Carbapenem resistance was rare in both *E. coli* and PSAR, averaging 0.15% and 3.08% each year, respectively. However, an increase was seen after the COVID-19 pandemic, particularly in PSAR from bodily fluids. With bodily fluids as a source, this increase may be in more complex patients than those from urine samples and raises the concern of a similar effect in hospitalized patients.

In Latin America, the use of azithromycin for COVID-19 was widespread.10,15 Antibiotic use increased in hospitalized and ambulatory patients alike, despite efforts from professional societies to discourage their use.8–10 Reports showing an increase in AMR in Latin America after the pandemic are emerging.16 This finding mirrors a rise of AMR in the United States, where nosocomial infections by ESBL increased by 32%, CRE increased by 35% and AMR PSAR increased by 132% in the first year of the pandemic.11

Excess antibiotic use is a significant problem in LMICs.4,5 In the Dominican Republic, antimicrobials can be purchased without prescriptions and are available in pharmacies and stores.6 Aminopenicillins are commonly used and may contribute to high rates of ESBL. Studies have reported ceftriaxone resistance in >24% of *E. coli* at a pediatric hospital and 46% in hospitalized adults.17,18 Circulating ESBL genotypes in the Dominican Republic include *blaCTX* and *blaTEM*.19 Future ASP interventions must focus on both ambulatory and hospital settings. Treatment guidelines reflecting local susceptibilities reported herein can be an important patient safety and stewardship tool.

A strength of our study was the large number of samples and wide geographic representation of samples in the Dominican

### Table 1. Ceftriaxone Resistance (Possible ESBL) and Meropenem Resistance (CRE) in E. coli Isolates from Urine

<table>
<thead>
<tr>
<th>Year</th>
<th>Total E. coli Isolates in Urine</th>
<th>Total E. coli With Ceftriaxone Resistance (possible ESBL)</th>
<th>E. coli Percentage With Ceftriaxone Resistance (possible ESBL), %</th>
<th>Total E. coli With Carbapenem Resistance</th>
<th>E. coli Percentage With Carbapenem Resistance, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>5,949</td>
<td>1,500</td>
<td>25.21</td>
<td>5</td>
<td>0.08</td>
</tr>
<tr>
<td>2019</td>
<td>5,778</td>
<td>1,505</td>
<td>26.05</td>
<td>8</td>
<td>0.13</td>
</tr>
<tr>
<td>2020</td>
<td>6,869</td>
<td>1,706</td>
<td>24.84</td>
<td>7</td>
<td>0.10</td>
</tr>
<tr>
<td>2021</td>
<td>9,122</td>
<td>2,249</td>
<td>24.65</td>
<td>28</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Note. ESBL, extended-spectrum β-lactamase; CRE, carbapenem-resistant Enterobacteriales.

**Fig. 2.** *Escherichia coli* from urine with ceftriaxone resistance and *Pseudomonas aeruginosa* (PSAR) from bodily fluids with ceftazidime resistance (possible extended-spectrum β-lactamase or ESBL) before and after the COVID-19 pandemic.
Republic. These samples may provide a valuable portrait of susceptibilities in these communities. The study also had several limitations. All cultures performed during the study period were included; thus, patients with recurrent infections may be overrepresented. The large number of isolates in the study may balance this weakness. Inferring resistance based on phenotypic resistance patterns rather than genotypes is the main limitation of our study. Ceftriaxone nonsusceptibility without ESBL genes can occur. MIC accuracy can be affected by bacterial inoculum, antimicrobial dilutions, and differing enzyme expression.20 High inoculum can occur in severe infections and may have an impact on MICs. Ceftazidime resistance may indicate ESBL in PSAR. However, genes other than ESBL may also contribute to ceftazidime nonsusceptibility in PSAR. The lack of patient specific information, such as comorbidities or prior antibiotic use, is another weakness in our study. Despite these weaknesses, we have reported susceptibilities using the same methodology used in routine clinical practice and may provide valuable information for empiric antimicrobial selection and the development of local treatment guidelines.

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

References

Table 2. Phenotypic Resistance Consistent With ESBL (Ceftazidime Resistance) and CR-PSAR (Meropenem Resistance) in PSAR Isolates From Bodily Fluids

<table>
<thead>
<tr>
<th>Year</th>
<th>Total PSAR Isolates in Bodily Fluid</th>
<th>Total PSAR With Ceftazidime Resistance (possible ESBL)</th>
<th>PSAR Percentage With Ceftazidime Resistance (possible ESBL), %</th>
<th>Total PSAR With Carbapenem Resistance</th>
<th>PSAR Percentage With Carbapenem Resistance, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>424</td>
<td>50</td>
<td>11.79</td>
<td>9</td>
<td>2.12</td>
</tr>
<tr>
<td>2019</td>
<td>512</td>
<td>69</td>
<td>13.48</td>
<td>13</td>
<td>2.53</td>
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<tr>
<td>2020</td>
<td>428</td>
<td>65</td>
<td>15.19</td>
<td>10</td>
<td>2.33</td>
</tr>
<tr>
<td>2021</td>
<td>747</td>
<td>113</td>
<td>15.13</td>
<td>40</td>
<td>5.35</td>
</tr>
</tbody>
</table>

Note. ESBL, extended-spectrum β-lactamase; PSAR, Pseudomonas aeruginosa; CR-PSAR carbapenem-resistant PSAR.

Fig. 3. Escherichia coli from urine and Pseudomonas aeruginosa (PSAR) from bodily fluids with carbapenem resistance before and after the COVID-19 pandemic.


