Resistance profile of urine isolate enterobacterial strains at Donka University teaching hospital in Conakry, Guinea

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Received 24 February, 2024; Accepted 9 April, 2024

The objective of this study was to describe the resistance profile of enterobacterial strains isolated from urine samples at the laboratory of Donka National Hospital. Urine samples were collected from both outpatients and hospitalized patients. Cultures were performed using standard techniques, strains were identified using the API 20E kit, and antibiotic susceptibility testing was carried out using the ATB™ UR EU (08) kit. The results were interpreted according to the recommendations of the Antibiogram Committee of the French Society of Microbiology (CASFM v1 2023). Out of a total of 520 urine samples analyzed, 111 were positive for enterobacterial strains. Among them, 75 (67.57%) were of community origin. Escherichia coli was the most represented species (n=61, 55%), followed by Klebsiella pneumoniae (n=24, 22%). The resistance of E. coli strains to third generation cephalosporins (TGC) varied from 5.41% (n=6) to 25.23% (n=28) in the community and from 13 to 38% in the hospital. The profile for carbapenems was categorized as "susceptible to high dosage (SHP)," accounting for 16.22% (n=18). This study provided insight into the resistance profile to antibiotics used in urinary tract infections. The increasing resistance to carbapenems poses a threat to the management of strains producing extended-spectrum beta-lactamases (ESBL). It would be important to strengthen resistance surveillance in this context.

Key words: Enterobacterial, urinary tract infection, resistance, community, hospital, Guinea.

INTRODUCTION

Enterobacterials constitute a group of Gram-negative bacteria divided into seven groups (groups 0 to 6). They constitute most of the commensal flora in the intestine (Jenkins et al., 2017; Machado et al., 2013). They have
natural resistance to certain antibiotics based on their group membership due to the presence of β-lactamase enzymes capable of hydrolyzing penicillins, carboxypenicillins, and first-generation cephalosporins (FGC) (Carattoli, 2009; Paterson, 2006; Philippon and Arlet, 2006). Secondary resistances can occur and spread within the groups through genetic supports (plasmids, integrons) (Carattoli, 2009; Machado et al., 2013). This phenomenon can lead to a therapeutic deadlock due to the acquisition of multidrug resistance, making enterobacterials redoubtable among the causative agents of urinary tract infections (Carattoli, 2009; Paterson, 2006; Philippon and Arlet, 2006). Among uropathogenic enterobacterials, *Escherichia coli* is the most frequent, followed by *Klebsiella* species (Matalka et al., 2021; Moges et al., 2021).

Multidrug resistance poses a challenge to the selection of antibiotics, impacting all prescribed classes of antibiotics. Various studies conducted in different locations highlight the extent of this phenomenon (Lee et al., 2018; Pasom et al., 2013; Sbiti et al., 2017) and its consequences, both at the individual and public health levels.

Thus, high proportions of multidrug resistance have been reported in various studies conducted in Africa, and these proportions vary from one region to another (Djim-Adjim-Ngana et al., 2023; Moges et al., 2021). The prevalence of multidrug-resistant bacteria can reach up to 85% (Moges et al., 2021). A review on the emergence and spread of resistance in West Africa described a particularly concerning situation regarding the production of extended-spectrum β-lactamases (ESBLs) among Enterobacteriales. The same trend has been observed for carbapenem resistance (Ouedraogo et al., 2017).

Guinea is not spared from the phenomenon of resistance. The prevalence of urinary tract infections accounts for between 16 and 60.2% of healthcare-associated infections, according to studies (Diallo et al., 2022; Keita et al., 2016). *E. coli* and *Klebsiella pneumoniae* are the most isolated pathogens. Resistance in Enterobacterial is characterized by high-level cephalosporinas (56%), extended-spectrum β-lactamases (20%), and carbapenems (12%). Resistance to quinolones is reported at 36%, and 20% for aminoglycosides (Diallo et al., 2022). However, antibiotic susceptibility data are not always accessible, and treatments are often empirical. This study aimed to describe the resistance profile of Enterobacteriales isolated from urine samples at the National Hospital of Donka laboratory.

### MATERIALS AND METHODS

#### Study design, sites and samples collection

This is a cross-sectional study conducted at Laboratoire de Biologie médicale du Centre Hospitalier Universitaire de Donka (CHU Donka) over a period of 15 months (September 2022-December 2023). It is one of the level I hospital structures that reopened its doors after a renovation period. The laboratory service of the CHU consists of 7 technical units (Immunology, Biochemistry, Bacteriology, Parasitology, Haematology, Blood Transfusion, and the emergency laboratory) and a sample collection room. The assays were performed in the bacteriology unit.

Urine samples were collected from both outpatients and hospitalized patients at the University Teaching Hospital of Donka (Emergency Department and other services). Urine samples were collected in sterile containers and transported to the laboratory within 2 h of collection.

#### Isolation and identification

Upon receiving the samples, the conformity of the container was checked. The samples were macroscopically assessed for color and turbidity upon receipt. Microscopy using a Malassez cell allowed for the evaluation of the presence of leukocytes, red blood cells, crystals, and other elements. Culture media, Uriselect, and CLED (cystine lactose electrolyte deficient) were inoculated and incubated for 24 to 48 h at 37°C in aerobic conditions. Enumeration was performed with a threshold of 10^8 CFU/mL for *E. coli* and 10^6 CFU/mL for other Enterobacterial strains. Identification was conducted using the 23 biochemical tests (O-nitrophenyl-β-D-galactosidase, arginine dihydrolase, lysine and ornithine decarboxylase, citrate utilization, hydrogen sulfide, urease, tryptophan deaminase, indole, Voges–Proskauer, gelatin liquefaction, fermentation of glucose, mannitol, inositol, sorbitol, rhamnose, sucrose, melibiose, amygdalin and arabinose, nitrate reduction, and nitrogen gas production, and catalase production) available on the API 20E gallery (BioMérieux SA, Marcy-l'Étoile, France).

#### Antibiotics susceptibility test and detection of extended spectrum beta-lactamase producers

The antibiotic susceptibility testing was conducted using ATB™ UR EU (08) (BioMérieux SA, Marcy-l’Étoile, France) following the manufacturer’s recommendations (Lustiner - Galerie ATB™ UR EU [Antibiogramme/Norme NCCLS] Biomerieux®, n.d.). The ATB™ UR EU (08) gallery is a standardized qualitative technique for determining the sensitivity of urinary Enterobacteriales to antibiotics in a semi-solid medium under conditions very close to reference dilution techniques in agar or microdilution. It consists of 16 pairs of wells. The first pair, without antibiotics, serves as a positive growth control. The next 15 pairs contain antibiotics at one or two concentrations (c and C). The bacteria to be tested are suspended and then transferred to the culture medium, inoculated into the gallery. After incubation, the growth in the wells is visually assessed. The obtained result categorizes the strain as Susceptible, Intermediate or Resistant.
Table 1. Characteristics of patients.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall, N = 520(^1)</th>
<th>Negative culture, n = 409(^1)</th>
<th>Positive culture, n = 111(^2)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>43 (28, 60)</td>
<td>42 (27, 58)</td>
<td>44 (28, 63)</td>
<td>0.3</td>
</tr>
<tr>
<td>Age range (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5</td>
<td>5 (1.0)</td>
<td>5 (1.2)</td>
<td>0 (0)</td>
<td>0.7</td>
</tr>
<tr>
<td>5-15</td>
<td>26 (5.0)</td>
<td>22 (5.4)</td>
<td>4 (3.6)</td>
<td></td>
</tr>
<tr>
<td>16-25</td>
<td>76 (15)</td>
<td>61 (15)</td>
<td>15 (14)</td>
<td></td>
</tr>
<tr>
<td>26-45</td>
<td>180 (35)</td>
<td>140 (34)</td>
<td>40 (36)</td>
<td></td>
</tr>
<tr>
<td>46-60</td>
<td>104 (20)</td>
<td>85 (21)</td>
<td>19 (17)</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td>129 (25)</td>
<td>96 (23)</td>
<td>33 (30)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Feminine</td>
<td>269 (52)</td>
<td>188 (46)</td>
<td>81 (73)</td>
<td></td>
</tr>
<tr>
<td>Masculine</td>
<td>251 (48)</td>
<td>221 (54)</td>
<td>30 (27)</td>
<td></td>
</tr>
<tr>
<td>Origin of strains</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Community</td>
<td>465 (89)</td>
<td>390 (95)</td>
<td>75 (68)</td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>55 (11)</td>
<td>19 (4.6)</td>
<td>36 (32)</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Median (IQR); n (%) \(^2\)Wilcoxon rank sum test; Fisher's exact test; Pearson's Chi-squared test.

Intermediate, or Resistant. Since 2020, the EUCAST committee introduced the concept of "Susceptible at standard dosage" for the Susceptible category and "Susceptible at high dosage" for the Intermediate category. The “Resistant” category remains unchanged.

The most commonly used antibiotics were tested: Beta-lactams (Penicillins: ampicillin, ticarcillin, piperacillin, amoxicillin+clavulanic acid, piperacillin-tazobactam, Cephalosporins: Cephalexin, Cefoxitin, Cefuroxime, Cefixime, Cefotaxime, Cefazidime, Cefepime, Carbapenems: imipenem, ertapenem, meropenem μg), Aminoglycosides (amikacin, gentamicin, tobramycin), Quinolones (nalidixic acid, ciprofloxacin, ofloxacin, norfloxacin, levofloxacin), Tetracyclines (tigecycline, tetracycline), and other antibiotics (nitrofurantoin, trimethoprim-sulfamethoxazole, fosfomycin). The results obtained were interpreted according to the recommendations of Comité de l'Antibiogramme de la Société Française de Microbiologie (CA-SFM 2023).

Statistical analysis

The data was extracted from the information system of CHU Donka, sent to Excel, and analysed using the R software. Chi-square test and Fisher's exact test were used for comparing proportions or estimating the association between variables when the conditions for use were met. Quantitative variables were compared using the Student's t-test.

Ethical consideration

The protocol was approved by the Research Committee of the University Gamal Abdel Nasser (Conakry, Guinea) and performed following the Declaration of Helsinki.

RESULTS

Table 1 describes the socio-demographic characteristics of the patients. Out of a total of 520 urine samples received and analyzed in the laboratory over a period of 15 months (September 2022 to December 2023), 111 were positive for Enterobacterial after culture on ordinary media. The median age of the patients was 42 (IQR: 28-63). The female gender was predominant with a ratio of 0.4.

Among the isolated Enterobacterial strains, 75 (67.57%) were of community origin, and 36 (32.43%) were of hospital origin (Table 1). The species *E. coli* was the most represented, whether of community origin (n=40) or hospital origin (n=21), followed by the species *K. pneumoniae*, with n=14 (58%) community strains and n=10 (42%) hospital strains.

Among the antibiotics tested on the 111 strains of Enterobacterial (Table 2), resistance to penicillin varied between 15.31% (n=17) and 81.08% (n=90). The resistance by antibiotic was distributed as follows: 72.97% (n=81) were resistant to ampicillin, 81.08% (n=90) were resistant to ticarcillin, 49.55% (n=55) were resistant to piperacillin, 39.64% (n=44) were resistant to amoxicillin/clavulanic acid, and 15.32% (n=17) were resistant to the piperacillin/tazobactam combination. The resistance for *E. coli* strains was (n=44), distributed in the community setting (n=23) and the hospital setting (n=21) (Table 2). For *K. pneumoniae* strains (n=17), seven were in the community setting and ten were in the hospital setting, and for *Klebsiella oxytoca* strains (n=5), all were in the community setting. Resistance to amoxicillin/clavulanic acid varied between 4.5 and 52%, with a predominance in *E. coli* strains (52%, n=23), which were community-acquired. Resistance to carboxypenicillins was predominantly found in *E. coli*, with n=53 for ticarcillin and n=32 for piperacillin. Resistance to piperacillin/tazobactam ranged from 6.30 to 63.00%, and
this resistance was mostly encountered in hospital-acquired strains (14.41%, n=16).

Out of a total of 111 isolated Enterobacterial strains, resistance to cephalosporins (Table 3) varied between 7.21% (n=8) and 48.65% (n=54). Third generation cephalosporins (TGC) were affected, with proportions ranging from 36.94% (n=41) to 47.75% (n=53).

Resistance to quinolones varied from 9.91% (n=10) to 43.42% (n=48) for hospital-acquired strains and from 6.31% (n=4) to 36% (n=11) to 75% (n=36) for hospital-acquired strains. Resistance to aminoglycosides varied from 6.31% (n=4) to 36% (n=11) to 75% (n=36) for community-acquired strains and from 2.70% (n=3) to 22.52% (n=25) for hospital-acquired strains.

Resistance to quinolones varied from 9.91% (n=11) to 53.15% (n=59). This resistance varied from 36% (n=4) to 64% (n=18) for E. coli strains. Quinolone resistance according to the origin of the strain varied from 14.66% (n=11) to 37.33% (n=28) for community-acquired and from 72.22% (n=26) to 83% (n=30) for hospital-acquired strains.

Resistance to other tested antibiotics based on strains varied from 13 to 43% for nitrofurantoin, from 3.6 to 61% for trimethoprim-sulfamethoxazole, and from 13 to 75% for trimethoprim-sulfamethoxazole.

Table 2. Distribution of enterobacterial species by origin.

<table>
<thead>
<tr>
<th>Species</th>
<th>Overall (N=111)</th>
<th>Community strain, n=75</th>
<th>Hospital strain (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrobacter freundii</td>
<td>7 (6.3)</td>
<td>6 (86)</td>
<td>1 (14)</td>
</tr>
<tr>
<td>Klebsiella aerogenes</td>
<td>1 (0.9)</td>
<td>0 (0)</td>
<td>1 (100)</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>4 (3.6)</td>
<td>3 (75)</td>
<td>1 (25)</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>61 (55)</td>
<td>40 (66)</td>
<td>21 (34)</td>
</tr>
<tr>
<td>Klebsiella oxytoca</td>
<td>6 (5.4)</td>
<td>6 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Klebsiella pneumonia</td>
<td>24 (22)</td>
<td>14 (58)</td>
<td>10 (42)</td>
</tr>
<tr>
<td>Proteus mirabilis</td>
<td>4 (3.6)</td>
<td>4 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Proteus spp.</td>
<td>1 (0.9)</td>
<td>0 (0)</td>
<td>1 (100)</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>1 (0.9)</td>
<td>0 (0)</td>
<td>1 (100)</td>
</tr>
<tr>
<td>Serratia odorifera</td>
<td>2 (1.8)</td>
<td>2 (100)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Fisher’s exact test; p-value= 0.11.

Table 3. Resistance profile to Penicillin of enterobacterial strain according to their origin.

<table>
<thead>
<tr>
<th>Species</th>
<th>N=111</th>
<th>Ampicillin</th>
<th>Ticarcillin</th>
<th>AMC</th>
<th>PipTaz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Com, n=44</td>
<td>Hosp, n=36</td>
<td>Com n=55</td>
<td>Hosp, n=35</td>
<td>Com n=44</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>7</td>
<td>4 (8.9)</td>
<td>1 (2.8)</td>
<td>4 (7.3)</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td>Klebsiella aerogenes</td>
<td>1</td>
<td>-</td>
<td>1 (2.8)</td>
<td>0 (0)</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>4</td>
<td>2 (4.4)</td>
<td>1 (2.8)</td>
<td>2 (3.6)</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>61</td>
<td>23 (51)</td>
<td>21 (58)</td>
<td>31 (56)</td>
<td>21 (60)</td>
</tr>
<tr>
<td>Klebsiella oxytoca</td>
<td>6</td>
<td>5 (11)</td>
<td>-</td>
<td>4 (7.3)</td>
<td>-</td>
</tr>
<tr>
<td>Klebsiella pneumonia</td>
<td>24</td>
<td>7 (16)</td>
<td>10 (28)</td>
<td>10 (18)</td>
<td>10 (29)</td>
</tr>
<tr>
<td>Proteus mirabilis</td>
<td>4</td>
<td>2 (4.4)</td>
<td>0 (0)</td>
<td>3 (5.5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Proteus spp.</td>
<td>1</td>
<td>0 (0)</td>
<td>1 (2.8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>1</td>
<td>1 (2.8)</td>
<td>0 (0)</td>
<td>1 (2.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Serratia odorifera</td>
<td>2</td>
<td>2 (4.4)</td>
<td>-</td>
<td>1 (1.8)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Com= Community, Hosp=hospital, AMC=amoxicillin + clavulanic acid, PipTaz=piperacillin+tazobactam.
Table 4. Resistance profile to Cephalosporin of enterobacterial strain according to their origin.

<table>
<thead>
<tr>
<th>Species</th>
<th>N=111</th>
<th>1st generation</th>
<th></th>
<th>2nd generation</th>
<th></th>
<th>3rd generation</th>
<th></th>
<th>4th generation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cefalotin</td>
<td>Cefoxitin</td>
<td>Cefuroxim</td>
<td>Cefixim</td>
<td>Cefotaxim</td>
<td>Ceftazidim</td>
<td>Cefepim</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Com, n = 53</td>
<td>Hosp, n = 14</td>
<td>Com, n = 47</td>
<td>Com, n=53</td>
<td>Com, n=547</td>
<td>Hosp, n=4</td>
<td>Com, n=15</td>
<td>Hosp, n=26</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>4 (7.5)</td>
<td>1 (5.0)</td>
<td>1 (7.1)</td>
<td>3 (6.4)</td>
<td>3 (5.7)</td>
<td>3 (6.4)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (3.8)</td>
</tr>
<tr>
<td>Klebsiella aerogenes</td>
<td>-</td>
<td>0 (0)</td>
<td>1 (7.1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>3 (5.7)</td>
<td>0 (0)</td>
<td>1 (5.0)</td>
<td>0 (0)</td>
<td>3 (5.7)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (3.8)</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>27 (51)</td>
<td>1 (100)</td>
<td>6 (30)</td>
<td>8 (57)</td>
<td>23 (49)</td>
<td>28 (53)</td>
<td>23 (49)</td>
<td>3 (75)</td>
<td>6 (40)</td>
</tr>
<tr>
<td>Klebsiella oxytocca</td>
<td>5 (9.4)</td>
<td>0 (0)</td>
<td>3 (15)</td>
<td>0 (0)</td>
<td>5 (11)</td>
<td>5 (9.4)</td>
<td>5 (11)</td>
<td>0 (0)</td>
<td>2 (13)</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>8 (15)</td>
<td>0 (0)</td>
<td>5 (25)</td>
<td>3 (21)</td>
<td>10 (21)</td>
<td>8 (15)</td>
<td>11 (23)</td>
<td>1 (25)</td>
<td>5 (33)</td>
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<tr>
<td>Proteus mirabilis</td>
<td>4 (7.5)</td>
<td>0 (0)</td>
<td>2 (10)</td>
<td>0 (0)</td>
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<td>3 (6.4)</td>
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<td>Proteus ssp.</td>
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<td>Serratia marcescens</td>
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<td>0 (0)</td>
<td>1 (7.1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>0 (0)</td>
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<tr>
<td>Serratia odorifera</td>
<td>2 (3.8)</td>
<td>0 (0)</td>
<td>2 (10)</td>
<td>0 (0)</td>
<td>2 (4.3)</td>
<td>2 (3.8)</td>
<td>2 (4.3)</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
</tr>
</tbody>
</table>

Com= Community, Hosp=Hospital.

Table 5. Resistance profile to Carbapenem of enterobacterial strain according to their origin.

<table>
<thead>
<tr>
<th>Species</th>
<th>N=111</th>
<th>Imipenem</th>
<th></th>
<th>2nd generation</th>
<th></th>
<th>Erta penem</th>
<th></th>
<th>Meropenem</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Com S, n=53</td>
<td>Hosp, n=33</td>
<td>Com SFP, n=17</td>
<td>Hosp, SFP n=1</td>
<td>Com S, n=2</td>
<td>Hosp S, n=1</td>
<td>Com S, n=18</td>
<td></td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>2 (3.8)</td>
<td>1 (3.0)</td>
<td>3 (18)</td>
<td>0 (0)</td>
<td>1 (50)</td>
<td>1 (50)</td>
<td>0 (0)</td>
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<td>1 (3.0)</td>
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<td>20 (61)</td>
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<td>19 (61)</td>
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<td>5 (29)</td>
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<td>1 (50)</td>
<td>1 (50)</td>
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<tr>
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</table>

Com=Community, Hosp=Hospital, S=susceptible, SFP= susceptible to high posology. The strains categorized as SFP were 15.32% (n=17) at the community level and 0.90% (n=1) at the hospital level. Category R was 1.80% (n=2).

for fosfomycin.

Regarding the overall resistance profile (Figure 1), the most affected antibiotics were penicillins (aminopenicillin and carboxypenicillin), cephalosporins, and quinolones. Carbapenems retained their activity against the strains, while
A cross-sectional study was conducted over a period of 15 months (September 2022 to December 2023) with the aim of describing the resistance profile of Enterobacterales isolated from urine samples at the Laboratory of Medical Biology of CHU Donka. The limitation of this study was the duration and the size of the samples from the hospital setting. This could be attributed, firstly, to the fact that the laboratory initially started receiving samples from outpatient consultations, and secondly, hospitalizations at CHU began only after 3 months of the facility's opening. However, this does not allow for generalization to the entire population. Nevertheless, the results obtained provide an idea of the current level of resistance and should help clinician for management of patient with urinary tract infection (UTI) and also to encourage the surveillance of antimicrobial resistance in hospital and community setting.

Out of a total of 520 urine samples received and analysed in the laboratory, 111 tested positive for Enterobacterales. This allowed us to outline a comprehensive resistance profile of Enterobacterales to various antibiotic classes commonly used in urinary infections. The antibiotics most affected by resistance were penicillins (amino-penicillins and carboxy-penicillins), cephalosporins, and quinolones (fluoroquinolones), accounting for more than half. It is important to note that with Enterobacterales, there is a risk of spreading these resistances within the group. They possess resistance carriers (plasmids, integrons) that can be shared among them, facilitating the spread of resistance (Partridge et al., 2018; Rozwandowicz et al., 2018).

The strains of *E. coli* were the most isolated, followed by *K. pneumoniae*. These species are considered the most commonly isolated around the world, both in community and hospital settings. Some studies conducted in Germany, Espana, Peruvia, Ethiopia, Tanzania, and Ghana highlighted the same constatation (Abubaker and Anwar, 2023; Alzahrani et al., 2022; Donkor et al., 2019; Moges et al., 2021; Rondon et al., 2023; Schmider et al., 2022; Stoltidis-Claus et al., 2023). However, this pattern may vary in certain areas, as seen in a study conducted in Sierra Leone, where samples from the community showed a predominance of *Citrobacter freundii* strains (Leski et al., 2016) and another study among elderly patients living in the community and in the nursing home showed that *Proteus mirabilis* was the second strains isolated after *E. coli* (Pulcini et al., 2019).

The resistance profile to penicillins was dominated by high resistance to amino-penicillins and carboxy-penicillins. *E. coli* strains showed high resistance to these groups of penicillins, extending to the amoxicillin-clavulanic acid combination. This resistance profile has been described in other studies with high prevalence.
ranging from 51 to 97.2% for ampicillin and 20.5 to 77.3%
fur amoxicillin-clavulanic acid (Ahmed et al., 2019;
Bernabé et al., 2017; Matalka et al., 2021; Moges et al.,
2021; Schmider et al., 2022; Stoltidis-Claus et al., 2023).
However, their sensitivity was restored by the
combination of penicillin/beta-lactamase inhibitor
(tazobactam), as described in other studies with
sensitivity rates reaching between 94 and 96.12%
(Matalka et al., 2021; Nkont et al., 2023; Schmider et al.,
2022).

Resistance to penicillins was similar in both hospital
and community settings, with a predominance of E. coli
strains. This profile has been previously observed in
other studies with variable prevalence rates depending
on the regions (Nkont et al., 2023). Study conducted
among rural patients in Karnataka (India) showed the
high prevalence over than 45% (Mardourian et al., 2023).
However, study performed in two French centres
describe that Temocillin showed a high level of activity
against Enterobacterales strains from community
acquired urinary tract infection (UTI) (Alexandre et al.,
2018). An increase in resistance to the combination of
amoxicillin-clavulanic acid and ticarcillin was described
for E. coli strains. Nevertheless, this resistance can be
either natural or acquired for certain strains. It
corresponds to a group resistance for the wild-type
phenotype (Chagneau et al., 2024). The combination of
piperacillin-tazobactam could be an alternative for
managing infections caused by multidrug-resistant strains
(Bader et al., 2017; Long and Koyfman, 2018).

Resistance profile to cephalosporins was impacted with
high rates for TGC. E. coli strains showed high rates for
TGC, as reported in Benin with 100% resistance of E. coli
strains to cefixime and ceftriaxone (Assouma et al.,
2023). However, the resistance rate to TCF was about
12.6% for E. coli, K. pneumoniae, and P. mirabilis UTI
in Northern California (USA) (Mark et al., 2021) and 18.4%
for E. coli, 30.7% for Klebsiella spp. in a systematic
review conduction in some west African countries
(Nigeria, Senegal, Ghana, Benin, Burkina Faso, and Cote
d’Ivoire) (Bernabé et al., 2017). In addition, the activity of
FGC remains maintained for all Enterobacterales isolated
in our study. Nevertheless, low resistance proportions to
FGC, particularly for E. coli strains, were noted. This calls
for their rational use. Hospital strains showed high
resistances as described in other areas, with rates
ranging from 43.9 to 77% for E. coli and 49.2 to 72% for
K. pneumoniae being resistant to TGC (Abubaker and
Anwar, 2023; Rondon et al., 2023). A low level of
resistance to FGC for community strains, unlike other
studies that reported high rates around 50% (Abubaker
and Anwar, 2023). FGC could be an alternative for
managing multidrug-resistant strains in our context.

Carbapenems are antibiotics that are effective against
Enterobacterial secreting penicillinase and
cephalexinorinase (Nkont et al., 2023). Strains categorized
as "sensitive at high dosage (SHD)" or resistant to at
least one of the carbapenems can be considered
suspicuous of producing a carbapenemase. These strains
are producers of significant resistance mechanisms,
including carbapenemases (Comité de l’Antibiogramme de
la Société Française de Microbiologie, 2023). A low rate
of resistance was observed to carbapenems and an
increase in strains categorized as SHD. This profile has
been described in other studies with prevalence rates of
0.9% for E. coli and 3.2% for K. pneumoniae
tocarbapenem (García-Castillo et al., 2018; Rondon et al.,
2023). However, in a study on the confirmation of the
carbapenem profile of Enterobacterales, only 8.9% were
confirmed resistant (Steward et al., 2003). Another study
conducted in Benin reported resistance rates ranging
from 12.5 to 66.6% of Enterobacterales to imipenem
(Assouma et al., 2023). This low resistance rate to
carbapenems could make these antibiotics an option for
managing multidrug-resistant bacteria in our context and
Ceftazidime-avibactam could be used to manage UTI
caused by carbapenemase producing Enterobacterial
such as KPC and OXA-48 producers (García-Castillo et
al., 2018). Nevertheless, the increase in strains
categorized as SHD should alert and lead to the search
for carbapenemases. Another study conducted over the
20-year period showed that except carbapenems, all the
antibiotics tested showed increasing resistance rate
(Milano et al., 2022).

The resistance to aminoglycosides was high, affecting
a quarter of the strains. The main aminoglycosides
affected were gentamicin and tobramycin. Twenty-five
percent of hospital strains were affected by this
resistance. Higher rates have been described in other
studies. In Iran the resistance rate was 47.9% for
tobramycin, 39.3% for kanamycin, and 27.8% for
gentamicin (Yekani et al., 2018) and in India the rate was
31% for all aminoglycosides (Mardourian et al., 2023).
In Nigeria, the study conducted among pediatric population
found 96.9% of resistance to kanamycin (Oli et al., 2019).
These molecules, often used in the management of
urinary tract infections due to their good diffusion, could
be limited by the emergence of resistance.

Resistance to quinolones was high, with an overall
proportion of 53%. It involved nalidixic acid, which was
higher in hospital strains, and fluoroquinolones with the
same proportions in hospital and community strains. High
rates have been described, ranging from 32 to 63.2% of
E. coli strains resistant to fluoroquinolones (Lyonga et al.,
2015; Mardourian et al., 2023; Moirongo et al., 2020;
Rondon et al., 2023; Schmider et al., 2022). As described
in some studies, the resistance to quinolones is mediated
by plasmid and more examination should be conducted
in case of strains exhibiting reduced susceptibility and
intermediate phenotype (Pasom et al., 2013; Szabó et al.,
2018). This increase in resistance for this group raises
concerns about the rational use of these molecules, as
they are used in the management of multidrug-resistant
bacteria (MDR) (Bader et al., 2017).
All strains tested for tetracycline were categorized as sensitive to high dosage. A study conducted in four sub-Saharan African countries reported an overall prevalence of 17%, with rates varying from 7 to 23% depending on the countries (Moirongo et al., 2020). Concerning other antibiotics, resistance was high for fosfomycin and trimethoprim-sulfamethoxazole, with a predominance among K. pneumoniae strains in the community and E. coli strains in the hospital setting. In contrast to other authors who reported widespread sensitivity to fosfomycin and strong resistance to trimethoprim-sulfamethoxazole (Schmider et al., 2022), a study conducted in sub-Saharan Africa reported prevalence ranging from 42 to 100% (Moirongo et al., 2020).

**Conclusion**

This study provided insight into the resistance profile of enterobacterial to antibiotics used in urinary tract infections. The observed resistance is substantial in both hospital and community environments. Additionally, the increasing resistance to carbapenems presents a challenge to the management of strains producing extended-spectrum beta-lactamases (ESBL). It would be important to strengthen resistance surveillance in this context.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interest.

**ACKNOWLEDGEMENTS**

The authors thank the technical staff of Donka teaching hospital in Conakry. They also thank all the participants in this study.

**REFERENCES**


