

«Urinary tract infections caused by extended-spectrum beta-lactamase-producing Enterobacteriaceae in patients treated at Abass Ndao Hospital Center from April 2020 to December 2024"»

Abstract:

The aim of this study was to evaluate the prevalence of extended-spectrum β -lactamase (ESBL)-producing Enterobacteriaceae causing urinary tract infections (UTIs), as well as their antibiotic resistance profiles. This retrospective study was conducted at the bacteriology laboratory of Abass Ndao Hospital between April 2020 and December 2024. Out of 5,277 urine samples, 779 met the criteria for Enterobacteriaceae-associated UTI (15%), with 260 strains identified as ESBL producers (33%). The majority of cases involved hospitalized patients (78%) compared to outpatients (22%), with a sex ratio of 1.76. The predominant species were *Escherichia coli* (65%) and *Klebsiella pneumoniae* (22%). The mean patient age was 57.4 years. ESBL-producing strains exhibited high resistance to amoxicillin, the amoxicillin-clavulanic acid combination, ticarcillin, and third-generation cephalosporins (100%). Conversely, good susceptibility was observed for imipenem (92.42%), amikacin (89.16%), colistin (94.85%), and fosfomycin (72.22%). These results confirm the growing importance of ESBL-producing Enterobacteriaceae in UTIs and highlight the need for regular surveillance.

Keywords: Urinary tract infection, Enterobacteriaceae, ESBL, Antibiotics, CHAN

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections in both community and hospital settings. They are characterized by the proliferation of pathogenic bacteria within the urinary tract, triggering an inflammatory response and, most often, clinical symptoms. UTIs primarily affect women, children, the elderly, and immunocompromised or hospitalized patients (Foxman, 2010). Enterobacteriaceae, particularly *Escherichia coli*, are the primary causative agents of UTIs. This bacterium is isolated in approximately 70–80% of community-acquired UTI cases, followed by other species such as *Klebsiella pneumoniae* and *Proteus mirabilis* (Flores-Mireles et al., 2015). In recent decades, a concerning rise in multidrug-resistant bacterial strains has been observed, particularly among extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae. ESBLs, notably the CTX-M type, confer resistance to beta-lactam antibiotics, specifically third-generation cephalosporins, by hydrolyzing their structure. This situation significantly limits therapeutic options and complicates clinical management, thereby increasing the risk of complications and mortality (Paterson & Bonomo, 2005). In Senegal, several studies have highlighted a high prevalence of multidrug-resistant strains in healthcare facilities. A 2021 survey conducted at the Abass Ndao Hospital Center (CHAN) revealed a significant proportion of multidrug-resistant Enterobacteriaceae in urine samples, underscoring the urgent need for continuous surveillance. The rise of UTIs caused by ESBL-producing Enterobacteriaceae represents a major public health concern. The general objective of this study is to evaluate the susceptibility profile of

organisms isolated from urinary tract infections caused by ESBL-producing Enterobacteriaceae in patients seen at CHAN between April 2020 and December 2024. Specific objectives have thus been defined, notably:

- determine the prevalence of beta-lactamase-producing Enterobacteriaceae in urinary tract infections at CHAN during the study period.
- To describe the sociodemographic and clinical characteristics of patients with ESBL-producing Enterobacteriaceae urinary tract infections.
- To determine the antibiotic resistance profile of the isolated strains.

MATERIALS AND METHODS

Study setting

The study was conducted at the laboratory of the Abass Ndao Hospital Center (CHAN) in Dakar, Senegal. It is a public referral hospital featuring several clinical departments, such as internal medicine, urology, pediatrics, nephrology, and gynecology-obstetrics, as well as a well-equipped medical biology laboratory.

Study type and period

This is a retrospective descriptive study based on data collected at the laboratory over a four-year period, from April 2020 to December 2024.

Study population

The study included all patients treated at the Abass Ndao Hospital Center who underwent urine cytobacteriological analysis at the bacteriology laboratory that resulted in the isolation of ESBL-producing Enterobacteriaceae. The study population comprised patients of all ages and genders, whether hospitalized or seen as outpatients, for whom both microbiological and clinical data were available and usable.

Inclusion and exclusion criteria

Inclusion criteria

Patients with a urinary tract infection confirmed by urine culture (ECBU) were included in this study. The test had to allow for the isolation of an ESBL-producing Enterobacteriaceae strain with an available antibiogram interpreted according to current standards. Sociodemographic data (age, sex, origin) had to be complete.

Exclusion criteria

Patients were excluded from the study if their urine samples showed sterile cultures or uninterpretable polymicrobial contamination. Also excluded were patients whose urinary tract infections were caused by organisms other than Enterobacteriaceae, and patients with incomplete medical records or laboratory reports.

Data collected

Data were collected from bacteriology laboratory registers and patient medical records. A data collection form was designed to systematically extract relevant information, including

sociodemographic characteristics, urine culture results, antibiograms, and medical history (where available).

Materials used

Biological material

The biological material used in this study consisted of whole urine samples.

Non-biological material

This consisted of sampling and analysis equipment, including laboratory apparatus, reagents, culture media, and antibiotic disks required for bacterial isolation, identification, and antibiotic susceptibility testing.

Sampling material

The sampling material used consisted of: gloves, sterile containers, cotton swabs soaked in Dakin's solution, Petri dishes, platinum loops, forceps, and physiological saline. Analysis

Equipment

Various materials and pieces of equipment were used for the analysis, such as: optical microscopes, Bunsen burners, calibrated loops, Pasteur pipettes, transfer pipettes, incubators, centrifuges, vortex mixers, microscope slides, coverslips, racks, culture media (CLED, EMB, MH, etc.), antibiotic discs, forceps, and graduated rulers.

Urine collection method

It is recommended to collect the first morning urine or, failing that, urine collected after the bladder has not been emptied for at least 4 hours. The sample must be taken before starting antibiotic treatment to avoid interfering with bacterial growth during culture. The patient must wash their hands with soap and water or use an alcohol-based hand rub before collection.

For women

Separate the labia majora and clean the vulvar area from top to bottom (front to back) using mild soap or an antiseptic, followed by rinsing with sterile water.

For men

Expose the glans and clean the urinary meatus with mild soap or an antiseptic, followed by rinsing with sterile water.

For catheterized patients

The sample must be collected directly from the catheter using sterile equipment.

Use a sterile container provided by the laboratory or pharmacy. Do not touch the inside of the container or the lid to avoid contamination. After collection, seal the container tightly and label it with the patient's surname, first name(s), initials, and the date and time of collection.

Sample transport

116 Samples must be transported to the laboratory within a maximum of two hours after collection.
117 In the event of a delay, they should be kept at 37°C to prevent bacterial proliferation or
118 alteration of the flora. Upon arrival, samples are immediately registered, visually inspected,
119 and prepared for inoculation.

120 **Macroscopic and microscopic examination**

121 **Macroscopic examination**

122 Macroscopic examination of the urine involves a visual analysis of its characteristics. It
123 begins by homogenizing the urine by inverting the container and noting whether the
124 appearance is clear or cloudy, as well as the presence of any hematuria, as shown in Figure 1.

125 **Microscopic examination**

126 The microscopic examination was conducted in two parts: a cytological examination and a
127 bacteriological examination.

128 **Bacteriological examination**

129 The collected urine was centrifuged at 3,000 rpm for 5 minutes. A drop of the sediment was
130 placed between a microscope slide and a coverslip at the lower end, while a drop of whole
131 urine was placed at the upper end.

132 **Cytological examination**

133 Cytological analysis comprises two parts: a quantitative study involving the counting of
134 leukocytes and erythrocytes per microscopic field, and a qualitative study to assess the
135 presence of formed elements such as epithelial cells, mucus strands, yeast, crystals
136 (amorphous urates, ammonium magnesium phosphate), and parasites.

137 **Gram Staining**

138 This is a differential staining technique used to classify bacteria into two groups, Gram-
139 positive and Gram-negative, based on their cell wall structure (see Figure 2). A drop of
140 bacterial suspension is placed on a clean slide and spread into a thin smear. After air-drying,
141 the slide is heat-fixed by passing it through a flame.

142 **Urine Cytobacteriological Examination**

143 Various culture media were used during this study, depending on the specific objectives of
144 each step. These included CLED (Cystine-Lactose-Electrolyte-Deficient) medium for urine
145 culture; EMB (Eosin Methylene Blue) agar for the detection of Enterobacteriaceae (illustrated
146 in Figures 3 and 4); and MH (Mueller-Hinton) agar for performing antibiotic susceptibility
147 testing. Urine culture was carried out under strict aseptic conditions. First, the workbench was
148 thoroughly cleaned with soapy water and then disinfected with bleach. Next, a Bunsen burner
149 was lit to maintain a sterile atmosphere in the work area. A Petri dish containing CLED
150 medium was used for inoculation. Using a sterile syringe, 1 mL of physiological saline was
151 drawn up and transferred to a sterile hemolysis tube. A calibrated 10 µL loop was used to
152 collect a urine sample, which was added to the tube containing the saline and gently mixed.
153 Inoculation onto the CLED medium was performed using the streak plate method: tight
154 streaks were made initially, followed by progressively wider spacing until the inoculum was

exhausted, in order to obtain isolated colonies. The dishes were then incubated for 24 hours at 37°C in an incubator.

Reading and interpretation of cultures

Following incubation, cultures, inoculated onto appropriate media using a calibrated loop, were evaluated based on bacterial growth density:

- ✓ $\geq 10^5$ CFU/mL: urinary tract infection
- ✓ $< 10^3$ CFU/mL: absence of urinary tract infection
- ✓ Between 10^3 and 10^5 CFU/mL: interpretation based on clinical signs

Polymicrobial cultures were considered non-significant.

Microorganism identification

The mini-panel

Performing the biochemical panel allows for bacterial identification by examining biochemical and enzymatic characteristics. Three culture media are used.

Simmons Citrate (SC)

This is a culture medium that uses citrate as the sole carbon source. Bacteria capable of metabolizing citrate produce bicarbonate ions that alkalize the medium, causing the bromothymol blue indicator to turn blue. After flame-sterilizing a Pasteur pipette, the center of an isolated colony from a nutrient agar plate is carefully sampled using the pipette. The sample is inoculated directly onto the slanted surface of the tube by making longitudinal streaks from the bottom to the top. The SC test is positive if bacterial growth occurs, with or without a blue color change. It is negative if there is no growth or if the medium remains green, as shown in Figure 5.

Kliger-Hajna

This is a differential culture medium used for the preliminary identification of Enterobacteriaceae. It allows for the simultaneous assessment of several metabolic characteristics essential for differentiating genera and species. It detects:

- Glucose fermentation.
- Lactose utilization.
- Gas production during fermentation.
- Hydrogen sulfide (H₂S) production via the reduction of thiosulfate or iron salts.
- β -galactosidase activity, involved in the intracellular hydrolysis of lactose.
- And the presence of lactose permease, which regulates the entry of lactose into the bacterial cell.

The medium contains phenol red as a pH indicator, turning yellow in an acidic environment (fermentation) and red/orange in an alkaline environment (absence of fermentation), as shown in Figure 6. The ferrous sulfate present allows for the detection of H₂S, which precipitates as ferrous sulfide, causing blackening at the base of the tube. Using a Pasteur pipette that has been flame-sterilized beforehand, an isolated colony is carefully picked from a nutrient agar plate. The colony is then homogenized in a drop of sterile urea to facilitate handling and promote dispersion. Inoculation is performed using a combined technique: first, the agar slant

is inoculated by streaking upwards from the bottom; second, a central stab is made into the butt of the tube using the same Pasteur pipette.

Mannitol Motility

This is a semi-solid medium used to simultaneously study two bacterial characteristics: mannitol fermentation and motility. The medium contains mannitol as a carbon source and phenol red as a pH indicator. Bacterial fermentation of mannitol causes acidification of the medium, resulting in a color change of the indicator from red to yellow, as shown in Figure 7. Additionally, the low agar concentration allows for the assessment of bacterial motility: motile bacteria diffuse throughout the medium, whereas non-motile bacteria remain localized along the line of inoculation. A bacterial suspension is prepared from a pure colony and then inoculated via a central stab into the tube containing the medium.

Urea test

Figure 8 illustrates the detection of the enzyme urease, which is capable of hydrolyzing urea into ammonia and carbon dioxide. Ammonia raises the pH of the medium, causing a color change from reddish-orange to bright pink in the presence of phenol red. The urea test is considered positive if a pink color appears and negative if there is no color change.

Urea-indole medium

This is a biochemical medium used to identify Enterobacteriaceae by detecting two enzymatic activities: urease production and indole production. The test relies on the bacteria's ability to break down the tryptophan present in the indole medium through the action of the enzyme tryptophanase. After incubation, the addition of Kovacs' reagent reveals the presence of indole. The indole test is positive if a red ring forms on the surface of the medium; it is negative if no colored ring forms and the reagent remains yellow, as shown in Figure 9.

Oxidase test

This is an identification technique for Gram-negative bacteria. A disk impregnated with oxidase reagent is placed on a clean slide, followed by the addition of a drop of sterile physiological saline. Using a sterile loop, an isolated bacterial colony is then applied to the disk. A purple color appearing within 10 to 30 seconds indicates a positive reaction, signifying the presence of the enzyme cytochrome oxidase. If no color develops, the reaction is considered negative, as shown in Figure 10.

Antibiogram

Figure 11 illustrates the susceptibility profile of the strains to various antibiotics. Using a Pasteur pipette, 5 μ L of sterile physiological saline was introduced into a hemolysis tube. In a second tube, 1 μ L of physiological saline was added. Using a 20 μ L micropipette, a portion of the liquid from the tube containing 1 μ L was transferred to the tube containing 5 μ L to obtain a diluted suspension. Using a sterile swab, the resulting bacterial suspension was homogenized and then streaked onto an MH or CLED agar plate. Inoculation was performed uniformly by streaking the agar surface in four different directions to ensure an even distribution of the inoculum. Antibiotic disks were then placed on the surface of the inoculated agar using sterile forceps, maintaining sufficient distance between disks to prevent overlapping of the zones of inhibition. The plates were incubated at 37°C for 24 hours. After

incubation, the diameters of the zones of inhibition around the disks were measured using a millimeter ruler. The radius of each zone of inhibition was measured and doubled to obtain the diameter. The results were interpreted according to CA-SFM-EUCAST criteria, allowing the strain to be classified as susceptible (S), intermediate (I), or resistant (R) to each antibiotic tested.

Detection of ESBL-producing Enterobacteriaceae

Detection method

Testing for extended-spectrum beta-lactamase (ESBL) production was performed on all isolated Enterobacteriaceae strains. The method used relies on detecting synergy between clavulanic acid and certain third-generation cephalosporins (3GCs), specifically cefotaxime (CTX) and ceftazidime (CAZ), as illustrated in Figure 12.

Interpretation

The appearance of a distinct enlargement of the inhibition zone on the side facing the disk containing clavulanic acid indicates ESBL production by the tested strain.

Statistical analysis

Collected data were entered and processed using Microsoft Excel and analyzed with Stata (2016 version) and RStudio 4.3.5 software. The chi-square (χ^2) test was used to examine associations between qualitative variables. The significance threshold was set at $p < 0.05$. A descriptive analysis was conducted to characterize the resistance and susceptibility profiles of the ESBL-producing Enterobacteriaceae. Qualitative variables, such as susceptibility or resistance to various antibiotics, were expressed as percentages. Results were presented graphically to facilitate data interpretation.

RESULTS AND DISCUSSION

RESULTS

Prevalence of Urinary Tract Infections

A total of 5,277 urine culture and sensitivity tests (ECBU) were performed at the CHAN bacteriology laboratory between April 2020 and December 2024. Of these, 779 tested positive for a urinary tract infection caused by an Enterobacteriaceae species, representing a prevalence of 15% of all tests performed (779/5,277) (Figure 13). Among these isolated Enterobacteriaceae, 260 were extended-spectrum beta-lactamase (ESBL) producers. Thus, the prevalence of ESBL-producing strains among Enterobacteriaceae-related urinary tract infections is 33% (260/779) (Figure 14).

Distribution of ESBL-producing Enterobacteriaceae urinary tract infections by gender

Analysis of Table I shows the distribution of ESBL-producing Enterobacteriaceae urinary tract infections by gender. A male predominance was observed. Of the 260 recorded cases, 165 patients (63%) were male and 95 patients (37%) were female. The male-to-female ratio is 1.73.

Population distribution by age

Analysis of the patient distribution by age group shows a clear predominance of subjects aged 60 and older, representing 56% (146/260). The 45–59 and 15–29 age groups rank second and third, respectively, at 16% and 12%. The 30–44 and under-14 age groups are the least represented, with proportions of 11% and 5%, respectively (Fig. 15).

Distribution of ESBL-carrying patients by age and sex

Table II presents the distribution of ESBL-carrying patients by age and sex. Men constituted the majority, with 165 patients (63%), compared to 95 women (37%). The age group of 60 years and older was the most represented, with 146 patients (56.2%), comprising 109 men and 37 women. The 45–59, 15–29, 30–44, and under-14 age groups accounted for 42 (16.2%), 30 (11.2%), and 13 patients (5%), respectively.

Chi-square tests showed a significant association between patient age and sex ($\chi^2 = 18.8$; $df = 4$; $p < 0.001$). Men were predominantly represented in the 60-and-older age group (109/165; 66.1%).

Population distribution by hospital department

Data analysis reveals that the majority of patients came from CHAN internal departments, representing 78% of cases, compared to 22% for outpatients (Fig. 16).

Distribution by isolated organism

Analysis of Table III shows that *Escherichia coli* was the most frequently isolated ESBL-producing bacterial species, with 168 strains (65%), followed by *Klebsiella pneumoniae* with 56 strains (22%) and *Klebsiella oxytoca* with 18 strains (7%). Other species were less represented: *Proteus mirabilis* (3%), *Proteus vulgaris* (2%), and *Klebsiella ozaenae* (0.4%).

Distribution by gender

Table IV shows the distribution of organisms by gender. Of the 260 isolated strains, 165 (63%) were from men and 95 (37%) from women. *Escherichia coli* was the most frequently isolated organism in both genders, with 168 strains (68 from women and 100 from men). It was followed by *K. pneumoniae* with 56 strains (39 in men and 17 in women), then *K. oxytoca* with 18 strains (12 in men and 6 in women). Other species were less frequent: *P. mirabilis* (8 strains), *P. vulgaris* (5 strains), *Enterobacter* sp. (4 strains), and *K. ozaenae* (1 strain). The distribution shows a higher number of strains in men across all the bacterial species studied.

Distribution of organisms by hospital department

Analysis of Table V shows that ESBL-producing Enterobacteriaceae were isolated from hospitalized patients (202/260; 78%) compared to outpatients (58/260; 22%). *Escherichia coli* was the most frequently isolated species in both settings, with 128 strains from hospitalized patients and 40 from outpatients, followed by *K. pneumoniae* (45 and 11 strains, respectively). Other species were found in low numbers.

Antibiotic susceptibility and resistance profile

The overall antibiotic susceptibility and resistance profile of the isolated Enterobacteriaceae is presented in Figure 17 below. Percentages were calculated using RStudio software and then plotted on a graph to facilitate interpretation. The study revealed high resistance rates to penicillins, specifically ampicillin (100%), amoxicillin (100%), amoxicillin-clavulanic acid

(99%), and ticarcillin (100%). Moderately high resistance was observed for quinolones—specifically nalidixic acid (85%)—and for ceftazidime (100%).

Regarding aminoglycosides, moderate resistance was noted for gentamicin (44.31%) and tobramycin (52.50%), whereas resistance remained low for amikacin.

The fluoroquinolones ciprofloxacin (78.24%), levofloxacin (80.10%), and norfloxacin (77.31%) showed moderate resistance rates. In contrast, good susceptibility was observed for fosfomycin (77.22%), colistin (94.85%), and imipenem, indicating low resistance to these antibiotics.

DISCUSSION

This is a retrospective study of patients who underwent urine culture (ECBU) at CHAN between 2020 and 2024. A total of 5,277 urine cultures were performed. Of these, 779 tested positive for uropathogenic Enterobacteriaceae, representing a positivity rate of 15%. Among these 779 isolates, 260 were ESBL producers, corresponding to a prevalence of 33%. This prevalence is lower than that reported by Der and Niang (2024), who recorded a rate of 21% at the CHNU de Fann in Dakar. Conversely, it is higher than the rates observed in Algeria (11%) by Meriem and Meryem (2024) and in Morocco (12%) by Sbiti et al. (2017), as well as higher than the 7.2% prevalence previously reported at CHAN (Naomie, 2023). The variations in positive rates for bacterial urinary tract infections observed across these studies can be attributed to several factors. These include the size and nature of the study sample, the screening method employed, healthcare practices, and the uncontrolled use of antibiotics. Consequently, any change in one of these factors can lead to variations in the recorded rates. In our study, the prevalence of ESBL-producing Enterobacteriaceae among uropathogens was 33%. This rate is lower than the 38.7% prevalence reported by Sarr (2019) in Dakar, and also lower than the 59.1% rate found in another study conducted in Senegal (Ndir, 2015). In contrast, our result is higher than that observed in Togo, where a prevalence of 22.4% was reported. The frequency of ESBL production among Enterobacteriaceae strains varies unevenly across the globe. This geographical variation could be explained by the frequent use of empirical beta-lactam prescriptions, particularly in outpatient settings, while awaiting urine culture results. Furthermore, the emergence of resistance to third-generation cephalosporins is a major factor leading to the hospitalization of infected patients and limits therapeutic options against these bacteria (Assouma et al., 2023). Our results showed a male predominance of 63%, corresponding to a sex ratio of 1.76. In Senegal, Sene et al. (2024) reported a similar finding with a male predominance of 51.9%, as did Eddair et al. (2024), who observed a male predominance of 57%. However, this result contrasts with that reported by Der and Niang (2024), who found a female predominance of 51.3%. This female predominance is primarily attributable to anatomical and physiological factors. However, our results may also be explained by the hospital setting of the study; men are more heavily represented in the wards where patients with complicated urinary tract infections, particularly those with urinary catheters or chronic urological conditions, are treated. Analysis of our data revealed a mean age of 57.4 years. All age groups were represented, with a predominance of cases among subjects aged 60 and older (56%). Patients aged 45–59 (16%), 15–29 (12%), 30–44 (11%), and under 14 (5%) were represented at lower frequencies. These findings align with those reported by Der and Niang (2024) in Senegal, who found a mean age of 48.7 years, with a predominance in the 60–80 age group. Similarly, Rania and Rania (2017) in Algeria identified

an infection rate of 48% among subjects over the age of 60. The prevalence of urinary tract infections in elderly patients may be explained by several age-related risk factors, such as malnutrition, poorly controlled diabetes, urinary incontinence, constipation, vaginal atrophy in women, prostatic hyperplasia in men, prolonged hospitalization, and impaired mental status, which significantly increase this population's vulnerability (Wojszel and Toczyńska-Silkiewicz, 2018). In our study, ESBL-producing Enterobacteriaceae were predominantly isolated from hospitalized patients (78%), compared to 22% from outpatients. Our results align with those of Sbiti et al. (2017) in Morocco, who reported 54.8% of cases among hospitalized patients versus 5.2% among outpatients. This predominance in the hospital setting may be explained by the fact that hospitalized patients face an increased risk of developing this type of infection. This risk is linked to several factors, notably prolonged hospitalization, disease severity, the use of various invasive devices (urinary catheters, central venous catheters, mechanical ventilation, intubation), and multiple antibiotic treatments, particularly with broad-spectrum cephalosporins (Foulal, 2013). During our study, we isolated seven bacterial species. However, *Escherichia coli* was the most frequently isolated ESBL-producing organism (65%), followed by *Klebsiella pneumoniae* (22%) and *K. oxytoca* (7%). Other Enterobacteriaceae, such as *P. mirabilis* (3%), *P. vulgaris* (2%), and *Enterobacter* spp. (2%), were found at lower frequencies, while *K. ozaenae* was minimally represented, with only a single strain isolated. These results are consistent with the literature, which consistently reports the predominance of *E. coli* as the primary causative agent of urinary tract infections. In our study, *E. coli* was the predominant species (65%). This result is similar to that found in Mauritania by Soukeina and Mohamed (2025), who reported 64.4% *E. coli* followed by 24.1% *K. pneumoniae*. In Senegal, Camara et al. (2017) found 45.2% *E. coli* followed by 26.2% *K. pneumoniae*. Similarly, a study in Morocco reported a 52% prevalence of *E. coli* (Kettani Halabi et al., 2021). ESBL-producing *E. coli* and *Klebsiella* strains are increasingly reported worldwide, in both community and hospital settings, underscoring the need for continuous surveillance (Paterson and Bonomo, 2005). In a retrospective, descriptive study conducted at CHNU Fann regarding the profile of healthcare-associated infections and antimicrobial resistance in an infectious disease ward, *K. pneumoniae* was the predominant species (28%), followed by *E. coli* (25%) and *Enterobacter* spp. (24%) (Massaly et al., 2022). This predominance of *K. pneumoniae* could be attributed to the proportion of patients with pulmonary infections within the study population. Furthermore, *E. coli* remains the primary uropathogen in males, as reported by Reissier et al. (2025). However, a study conducted in France reported different results, showing a predominance of *E. coli* in women. This discrepancy may be explained by the high proportion of hospitalized men in our study, who often presented with risk factors such as urinary catheters and prostatic disorders. This distribution is explained by the pathophysiology of urinary tract infections (UTIs), which are most often ascending in origin. There is heavy colonization of the perineum by Enterobacteriaceae of digestive origin. Furthermore, specific virulence factors contribute to the predominance of these organisms (Larabi et al., 2003). For several years, Enterobacteriaceae have been exposed to the intensive and repeated use of antibiotics. Consequently, increasing resistance to the most commonly used agents has been observed. In our study, high resistance rates were observed against beta-lactams. Indeed, 100% resistance was noted for amoxicillin, the amoxicillin-clavulanic acid combination, and piperacillin. Very high rates were also found for aztreonam (99.50%), third-generation cephalosporins, specifically ceftriaxone (99.50%) and cefotaxime (97.46%), as well as for the fourth-generation cephalosporin cefepime (94.38%). These results are consistent with those reported

by Foulal (2013) in Morocco, where ESBL-producing strains exhibited 100% resistance to ticarcillin, piperacillin, and third- and fourth-generation cephalosporins. In contrast, a study by Dia (2024) revealed lower resistance rates than ours: 84.31% for amoxicillin, 87.50% for ticarcillin, and 67.71% for amoxicillin-clavulanic acid. This very high level of resistance may be attributed to the excessive and sometimes inappropriate use of beta-lactams. This resistance is linked to the production of ESBLs, plasmid-mediated β -lactamases capable of hydrolyzing third-generation cephalosporins. ESBL genes are often carried on plasmids that also promote co-resistance to other classes of antibiotics (Paterson & Bonomo, 2005). Susceptibility to aminoglycosides remains generally preserved for amikacin (89.10%), unlike other drugs in this class, specifically gentamicin (44.31%), kanamycin (49.40%), and tobramycin (52.20%), which show higher resistance rates. These results align with those reported by Ebongue et al. (2015), who observed low susceptibility to amikacin (12%). Furthermore, a study conducted by Sow et al. (2024) reports comparable rates for gentamicin (39.50%) and tobramycin (40%). This high level of susceptibility supports the use of amikacin, an effective aminoglycoside, for treating urinary tract infections caused by multidrug-resistant bacteria, particularly extended-spectrum beta-lactamase (ESBL)-producing strains. ESBL-producing Enterobacteriaceae strains exhibited high resistance rates to fluoroquinolones, notably ciprofloxacin (78.24%), levofloxacin (80.10%), and pefloxacin (77.31%). These values are close to those reported by Sow et al. (2024), who found resistance rates of 80% for levofloxacin and 80% for ciprofloxacin. This level of resistance is concerning and may be attributed to the selective pressure resulting from the widespread use of fluoroquinolones. Furthermore, the fact that this acquired resistance is predominantly plasmid-mediated facilitates its dissemination (Sbiti et al., 2017). Regarding quinolones, a high resistance rate of 85% was observed in our study, consistent with the findings of Sow et al. (2024), who reported a rate of 84.76%. The high level of resistance to nalidixic acid could be explained by the plasmid location of genes encoding ESBLs, which are frequently associated with resistance genes for other antibiotics, particularly aminoglycosides and fluoroquinolones (Shi et al., 2015). Significant resistance to sulfamethoxazole-trimethoprim was also observed (71.94%). This result is comparable to that of Ebongue et al. (2015), 81.6%, and higher than the 64% reported by Abderrahim and Salem (2025). Moreover, this resistance could be explained by the frequent association of ESBL genes with resistance genes for other drug classes (Eddair et al., 2024). In our study, resistance to fosfomycin was 27.78%, a rate close to the 20% reported by Sow et al. (2024). This drug retains good activity, despite being strongly recommended for the treatment of uncomplicated acute cystitis, due to its low prescription rate (Sbiti et al., 2017). Colistin demonstrated good activity in our study population, with a resistance rate of only 5.15%. These results align with those reported by Niang et al. (2020), who found a rate of just 6%, highlighting the value of this drug as a last-resort option. Finally, imipenem retains good activity, showing a susceptibility rate of 92.42%. This result is close to that reported by Abderrahim and Salem (2025) in Mauritania, who observed a low resistance rate (1%). This situation may be attributed to its mode of administration, cost, and limited availability (Abderrahim and Salem, 2025).

CONCLUSION, RECOMMENDATIONS, AND FUTURE PROSPECTS

Urinary tract infections remain a significant public health issue today, both in hospital and community settings. Resistance levels among uropathogenic bacteria are rising, reaching alarming figures, particularly regarding extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae. This study aimed to assess the frequency of urinary tract infections

caused by Enterobacteriaceae and to examine their resistance profiles against the primary antibiotics used in our setting. We found a 33% prevalence of urinary tract infections caused by ESBL-producing Enterobacteriaceae among 260 strains isolated at the Abass Ndao Hospital Center between April 2020 and December 2024. Patients over the age of 60 were the most affected. Our results indicate a higher frequency of urinary tract infections in men than in women. The bacteriological profile remained largely unchanged, with *Escherichia coli* predominating as the leading uropathogen, followed by *Klebsiella pneumoniae*. The rate of ESBL-producing strains was concerning, reflecting the progressive spread of these resistance mechanisms within the study population. Analysis of the antibiograms for the isolated organisms revealed the following: susceptibility to imipenem, colistin, and amikacin; and significant resistance to penicillins and to second-, third-, and fourth-generation cephalosporins. This situation poses a growing threat to public health, compromising the efficacy of available treatments. It underscores the need for continuous surveillance of bacterial resistance and the prudent use of antibiotics to preserve their effectiveness in the years to come. Therefore, the public is advised to avoid self-medication and the inappropriate use of antibiotics without a medical prescription; pharmacists are urged to limit the sale of antibiotics without a prescription; and health authorities are encouraged to strengthen epidemiological surveillance to better control the spread of resistant bacterial strains. When a treatment is prescribed by a doctor, the indicated dosage must be followed exactly.

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Tableau I: Distribution of patients by gender

Sex	Number(n)	Percentage (%)
Women	95	37%
Men	165	63%
Total	260	100%

Tableau II: Distribution of ESBL-producing patients by age and gender

Age range	Women	Men	Total
] under14	7	6	13
[15–29[	17	13	30
[30–44[	14	15	29
[45–59[	20	22	42
[60 years and older [	37	109	146
Total	95	165	260

Tableau III: Distribution of ESBL-producing bacterial species

Bacterial species	Number (n)	Percentage (%)
<i>Escherichia coli</i>	168	65%
<i>Klebsiella pneumoniae</i>	56	22%
<i>Klebsiella oxytoca</i>	18	7%
<i>Proteus mirabilis</i>	8	3%
<i>Proteus vulgaris</i>	5	2%
<i>Enterobacter spp</i>	4	2%
<i>Klebsiella ozaenae</i>	1	0.4%
Total	260	100%

Tableau IV: Distribution of pathogens by gender

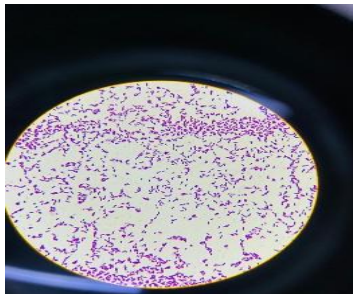
Bacterial Species	Women	Men	Total
<i>Escherichia coli</i>	68	100	168
<i>Enterobacter sp</i>	1	3	4
<i>Klebsiella ozaenae</i>	0	1	1
<i>Klebsiella oxytoca</i>	6	12	18
<i>Klebsiella pneumoniae</i>	17	39	56
<i>Proteus mirabilis</i>	2	6	8
<i>Proteus vulgaris</i>	1	4	5
Total	95	165	260

Tableau V: Distribution of pathogens by hospital department

Bacterial Species	External	Internal	Total
<i>Escherichia coli</i>	40	128	168
<i>Enterobacter sp</i>	0	4	4
<i>Klebsiella ozaenae</i>	0	1	1
<i>Klebsiella oxytoca</i>	5	13	18
<i>Klebsiella pneumoniae</i>	11	45	56
<i>Proteus mirabilis</i>	1	7	8
<i>Proteus vulgaris</i>	1	4	5
Total	58	202	260



Figure 1 : Macroscopic assessment of urine appearance (clear, turbid, hematuric); a drop of whole urine was placed at the upper end. Observation was performed using a microscope with a 40x objective



A



B

Figure 2 : Gram stain of isolated bacteria (A: Gram-positive bacteria; B: Gram-negative bacteria)



Figure 3 : Urine culture on CLED medium



Figure 4: Visualization on EMB agar

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Figure 5 :Simmons citrate test showing the use of citrate as the sole carbon source

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Figure 6:Kliger-Hajna test showing sugar fermentation and H₂S production

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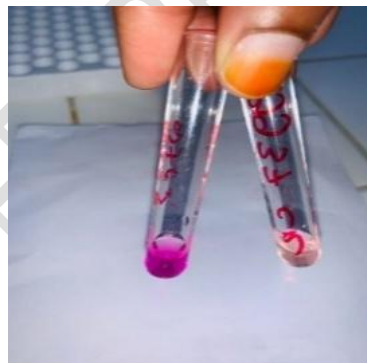
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Figure 7: Mannitol test showing fermentation, with a color change in the medium indicating a positive result

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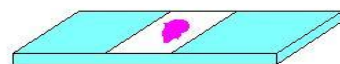
Figure 8: Urea test showing urea hydrolysis by urease, with a color change in the medium

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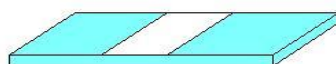


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Figure 9 : Indole test showing indole production via tryptophan degradation, indicated by the appearance of a red ring



Oxydase +



Oxydase -

Figure 10:Oxidase test

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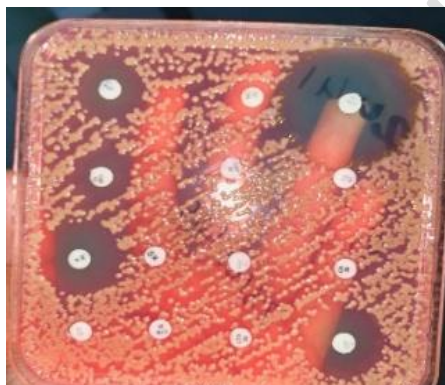
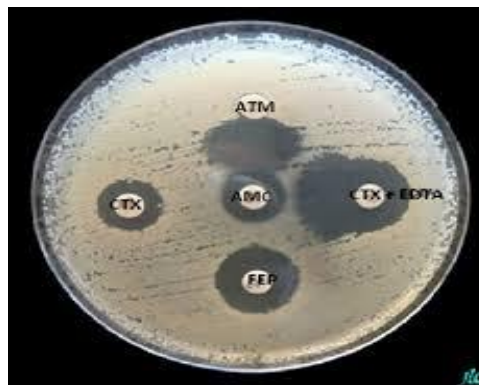


Figure 11 : Agar disk diffusion susceptibility test (Kirby-Bauer method)

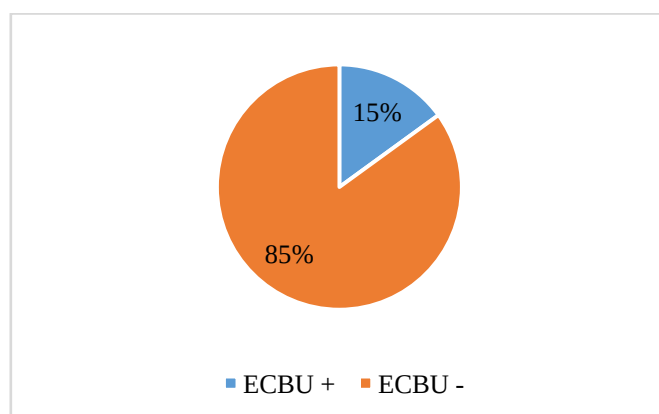
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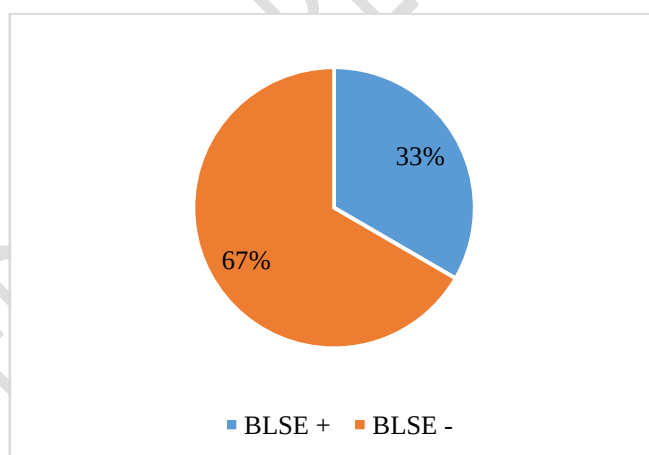
Figure 12:Detection of ESBL production (clavulanic acid-CTX/CAZ synergy test)

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Figure 13: Distribution of Enterobacteriaceae urinary tract infections among the analyzed urine samples



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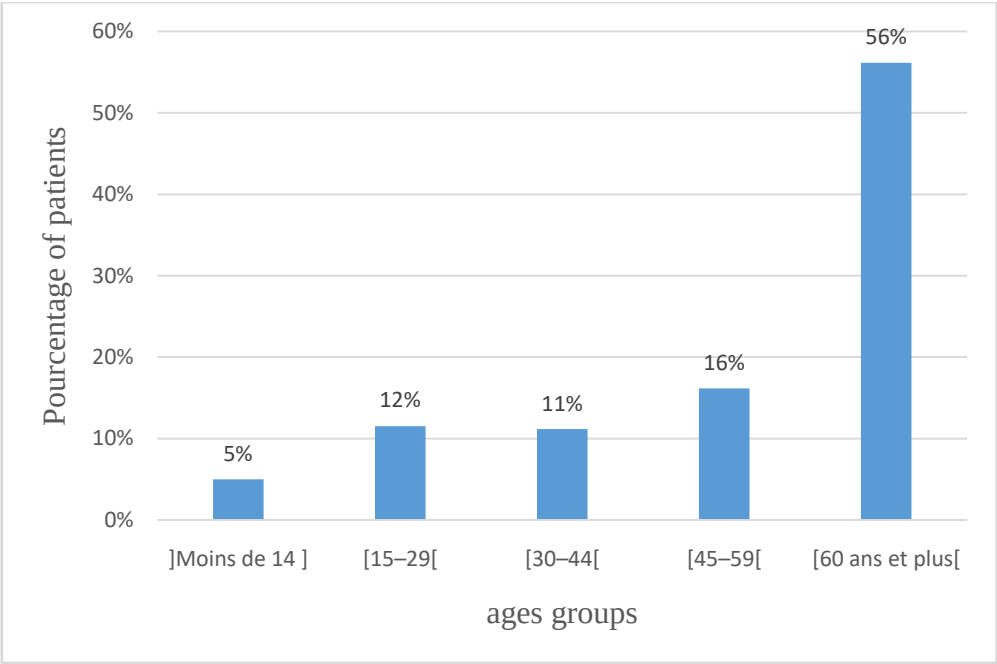
Figure 14: Prevalence of ESBL-producing Enterobacteriaceae urinary tract infections

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BLSE=ESBL

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Figure 15: Distribution of patients by age group

Under 14 Years

60 years and older

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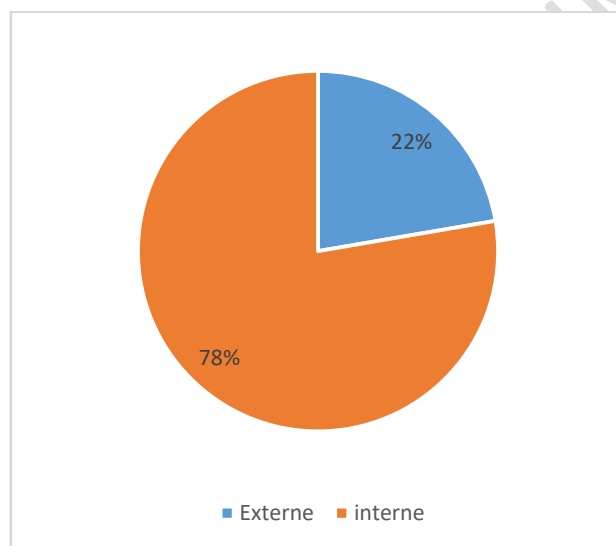
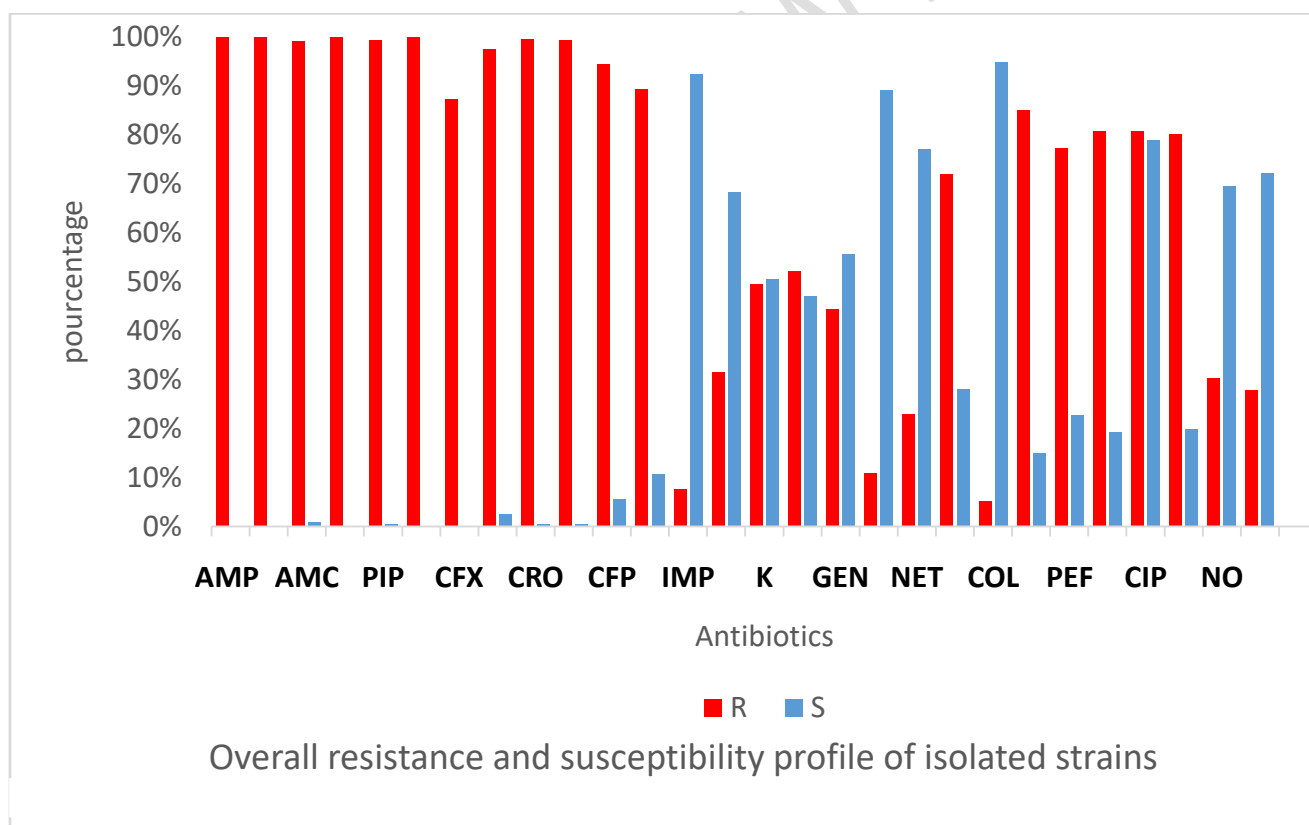


Figure 16: Distribution of patients by hospital department

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Figure 17:Overall resistance and susceptibility profile of isolated strains

R=Resistant; S= Sensitive

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