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Emerging Antimicrobial Resistance Patterns among Uropathogens in Baghdad

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Abstract

Urinary tract infections (UTIs) are a common bacterial illness worldwide, but rising antimicrobial resistance (AMR) poses a therapeutic issue. Iraq lacks current local data on UTI-causing pathogens and their resistance patterns. The aim of this research is to examine the progression of uropathogens isolated from urine samples in Baghdad and assess their antibiotic susceptibility profiles. Between May 2023 and December 2024 in Baghdad gathered a total of 163 urine samples. Standard microbiological techniques were used to identify isolates, and antimicrobial susceptibility testing was carried out in accordance with CLSI guidelines. Escherichia coli was the most common isolate (64.4%), followed by Klebsiella pneumoniae (14.1%), Enterococcus faecalis (11.0%), and Pseudomonas aeruginosa (9.2%). Beta-lactams and fluoroquinolones showed high resistance, although carbapenems and Amikacin were still effective. There was no statistically significant relationship detected between gender and pathogen type ($p > 0.05$). The data reveal the worrying levels of resistance to common uropathogens in Baghdad, emphasizing the importance of culture-based treatment and national AMR surveillance.

Keywords: Urinary Tract Infection, Antimicrobial Resistance, Escherichia Coli

Introduction

Urinary tract infections (UTIs) continue to be a leading cause of morbidity in all age groups worldwide (Flores-Mireles et al., 2015). They account for a significant percentage of outpatient visits and antibiotic prescriptions. Women are at a higher risk because of physical predispositions such as a shorter urethra and hormonal influences on urinary tract bacteria (World Health Organization, 2023).

Among the various bacterial agents that cause UTIs, uropathogenic *Escherichia coli* (UPEC) is the most commonly isolated (Gupta et al., 2011). Other prominent pathogens are *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Acinetobacter* species (Kahlmeter, 2019). The microbial ecology of UTIs has experienced major modifications in recent years, mainly due to widespread antibiotic usage and the rise of multidrug-resistant (MDR) strains (Al-Hasan et al., 2014). Antimicrobial resistance (AMR) among uropathogens is a growing global threat, particularly in resource-constrained settings where empirical treatment is common and laboratory facilities for routine susceptibility testing may be scarce (Al-Jebouri & Al-Daamy, 2013). Studies in Middle Eastern countries, notably Iraq, have shown an increase in resistance to first-line antibiotics such as fluoroquinolones and trimethoprim-sulfamethoxazole, complicating treatment decisions (Al-Badr & Al-Shaikh, 2013).

Despite the clinical relevance of UTIs, there is a lack of current surveillance data in Iraq. This study seeks to close this gap by providing extensive information about the prevalence and antibiotic resistance patterns of urine bacterial isolates collected from clinical settings in Baghdad. The results are intended to help build locally tailored treatment guidelines and influence national AMR monitoring initiatives.

Objectives

To determine which bacterial infections are most frequently responsible for UTIs in Baghdad.

To assess these isolates' patterns of antibiotic resistance.

To evaluate the relationship between uropathogen type and gender.

To offer proof to support policy and optimize empirical treatment.

Methods

The study was broad and ran from May 2023 to December 2024. In private labs in Baghdad, a total of 163 midstream urine samples were taken from 128 female and 35 male patients. Standard culture techniques were used to blood agar, MacConkey, and CLED. Biochemical assays were used for identification, and if necessary, API 20E was used for confirmation (Clinical and Laboratory Standards Institute, 2024).

According to CLSI 2023 recommendations, antimicrobial susceptibility testing was conducted using the disk diffusion method (Kirby-Bauer) (Magiorakos et al., 2012). Among the antibiotics studied were carbapenems, aminoglycosides, fluoroquinolones, and β-lactams. The data was summarized using descriptive statistics, and associations were evaluated using the Chi-square test, with $p < 0.05$ being deemed statistically significant.

Results and Discussion

Total number of male and female urine specimens. Males (109 samples) and females (59 samples) were between the ages of 20 and 50. Data gathered from various private laboratories in Baghdad between May 2023 and December 2024. There were 128 female and 35 male volunteers, and a whole of 163 urine specimens were inspected. *Escherichia coli* were the furthermost organism between the bacterial isolates, occurring in 105 cases (24 males and 81 females). *Pseudomonas aeruginosa* (15 cases), *Enterococcus faecalis* (18 cases), *Klebsiella pneumoniae* (23 cases), and less commonly *Staphylococcus haemolyticus*, *Staphylococcus epidermidis*, *Acinetobacter baumannii*, *Proteus mirabilis, Streptococcus agalactiae, and Klebsiella oxytoca* were among the other bacteria found. Most isolates came from patients who were female. Female patients accounted for the majority of urinary tract infections (UTIs). The most common uropathogen in both sexes is still *E. coli*.

Table 1. Bacterial Species and Frequency

Bacterial Species	Total Cases	Male (n)	Female (n)	%
Escherichia coli	105	24	81	64.4%
Klebsiella pneumoniae	23	5	18	14.1%
Pseudomonas aeruginosa	15	5	10	9.2%
Enterococcus faecalis	18	5	13	11.0%
Staphylococcus haemolyticus	3	0	3	1.8%
Staphylococcus epidermidis	3	0	3	1.8%
Acinetobacter baumannii	2	1	1	1.2%
Proteus mirabilis	1	0	1	0.6%

Streptococcus agalactiae	1	0	1	0.6%
Klebsiella oxytoca	1	0	1	0.6%

While the prevalence of other bacteria is moderate to low. These findings are consistent with the usual microbial makeup of UTIs acquired in the community.

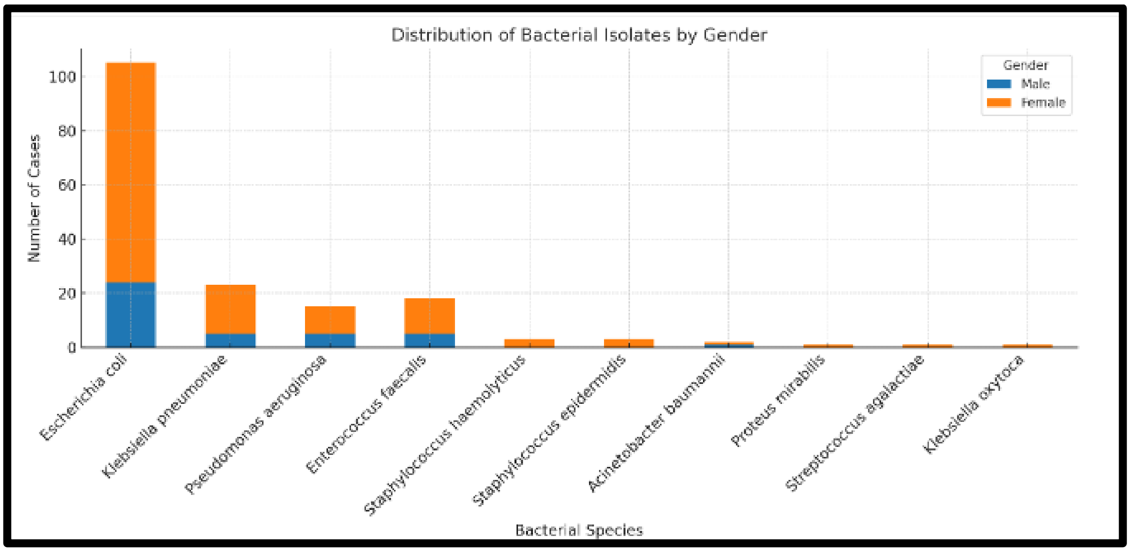

Figure 1. Bacterial Species and Frequency by gender

To determine whether there was a significant relationship between gender and the type of bacterial isolate, a Chi-Square Test of Independence was employed. The four most frequently isolated bacteria *Escherichia coli*, *Klebsiella pneumoniae, Pseudomonas aeruginosa*, and *Enterococcus faecalis* were included in the analysis, while the less common species were classified under "Other Bacteria" to maintain statistical validity. The test revealed no statistically significant relationship between gender and bacterial kind ($\chi^2(4, N = 163) = 1.36$, $p = 0.851$). This implies that there was no appreciable variation in the distribution of bacterial species between male and female patients. Escherichia coli were the most commonly isolated organism in both sexes.

The susceptibility of 163 Escherichia coli isolates to a panel of widely used antibiotics was examined. According to the findings, resistance rates to a number of β-lactam antibiotics, such as cefazolin and cefuroxime, exceeded 85%. Likewise, a significant percentage of isolates exhibited resistance to both Ciprofloxacin (about 69%) and Trimethoprim/Sulfamethoxazole (nearly 72%). However, with susceptibility rates ranging from 90 to 98 percent, the isolates shown strong resistance to Amikacin, Fosfomycin, and carbapenems such Meropenem, Imipenem, and Ertapenem. Amoxicillin/Clavulanic Acid and Piperacillin/Tazobactam showed moderate resistance patterns, suggesting some residual effectiveness. These results show that carbapenems and aminoglycosides are still effective against *E. coli*, but they also raise concerns about the increasing resistance to oral first-line antibiotics.

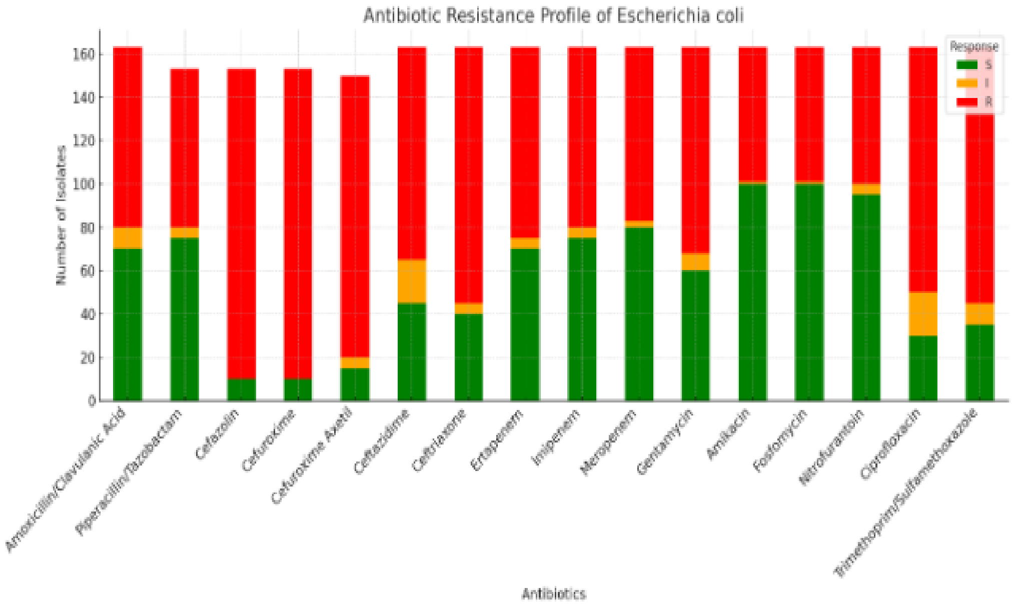

Figure 2. antibiotic resistance profile of *Escherichia coli.*

Table 2. Antibiotic resistance test for Escherichia coli isolates

Code of bacteria Antibiotic	**Escherichia coli**													
	1	9	14	15	20	21	23	25	28	31	32	37	39	43
Amoxicillin/Clavulanic Acid	+	+	-	+	-	+	+	-	±	+	+	+	+	+
Piperacillin/Tazobactam	+	+	-	+	-	+	+	-	+	+	+	+	+	+
Cefazolin	-	-	-	-	-	+	+	-	-	+	-	-	-	-
Cefuroxime	-	-	-	-	-	+	+	-	-	+	-	-	-	-
Cefuroxime Axetil	-	-	±	-	-	+	+	-	-	+	-	-	-	-
Ceftazidime	+	±	+	±	-	+	+	+	±	+	±	-	+	±
Ceftriaxone	-	-	+	-	-	+	+	+	-	+	-	-	-	-
Ertapenem	+	+	+	+	-	+	+	-	+	+	+	+	+	+
Imipenem	+	+	+	+	-	+	+	+	+	+	+	+	+	+
Meropenem	+	+	+	+	-	+	+	+	+	+	+	+	+	+
Gentamycin	-	+	+	+	+	+	+	-	-	+	+	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitrofurantoin	+	+	+	+	+	+	±	+	-	+	+	+	+	+
Ciprofloxacin	-	±	+	±	-	±	-	+	-	+	±	-	-	±
Trimethoprim/Sulfamethoxazole	-	-	+	-	-	+	-	-	-	-	-	+	-	-

Table 3. Antibiotic resistance test for *Escherichia coli* isolates.

Code of bacteria Antibiotic	**Escherichia coli**													
	45	46	49	50	51	52	56	58	61	62	63	64	65	70
Amoxicillin/Clavulanic Acid	±	±	-	-	±	-	±	±	±	+	±	+	-	+
Piperacillin/Tazobactam	+	+	-	-	+	-	+	+	+	+	+	+	-	+
Cefazolin	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Cefuroxime	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Cefuroxime Axetil	-	-	+	-	-	-	-	-	-	+	-	-	-	+
Ceftazidime	-	-	-	-	-	±	-	+	-	+	-	+	±	+
Ceftriaxone	-	-	+	-	-	-	-	+	-	+	-	-	+	+

Ertapenem	+	+	+	-	+	+	+	-	+	+	+	+	+	+
Imipenem	+	+	+	±	+	+	+	+	+	+	+	+	+	+
Meropenem	+	+	+	-	+	+	+	+	+	+	+	+	+	+
Gentamycin	+	-	+	-	-	+	+	-	-	+	-	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitrofurantoin	+	+	+	+	-	+	±	+	+	+	+	+	+	+
Ciprofloxacin	-	±	±	-	-	±	-	-	-	+	-	±	-	-
Trimethoprim/Sulfamethoxazole	-	-	+	-	-	-	-	-	+	+	-	-	+	+

Table 4. Antibiotic resistance test for *Escherichia coli isolates.*

Code of bacteria Antibiotic	***Escherichia coli***													
	12	13	35	36	66	68	76	77	78	79	82	84	86	87
Amoxicillin/Clavulanic Acid	+	+	±	±	-	+	-	+	-	-	-	±	-	±
Piperacillin/Tazobactam	+	+	+	+	+	+	-	+	-	-	-	+	+	+
Cefazolin	-	+	-	-	-	-	-	+	-	-	-	-	-	-
Cefuroxime	-	+	+	+	-	-	-	+	-	-	-	-	-	-
Cefuroxime Axetil	+	+	+	+	±	-	-	+	-	+	-	-	-	-
Ceftazidime	±	+	+	+	-	+	-	+	-	-	-	-	±	-
Ceftriaxone	-	+	+	+	-	+	-	+	-	+	-	-	-	-
Ertapenem	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Imipenem	+	+	+	+	+	+	-	+	+	+	-	+	+	+
Meropenem	+	+	+	+	+	+	-	+	+	-	-	+	+	+
Gentamycin	+	+	-	-	-	+	+	+	-	+	-	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	-	+	+	+	+
Nitrofurantoin	+	+	+	+	+	+	-	+	+	+	-	+	+	+
Ciprofloxacin	±	±	-	-	-	±	-	+	-	-	-	-	±	-
Trimethoprim/Sulfamethoxazole	+	+	+	+	-	-	-	+	-	-	-	-	-	-

Table 5. Antibiotic resistance test for *Escherichia coli isolates.*

Code of bacteria Antibiotic	**Escherichia coli**											
	90	93	94	95	97	99	100	101	102	103	104	105
Amoxicillin/Clavulanic Acid	+	+	+	±	+	±	-	+	+	-	-	+
Piperacillin/Tazobactam	-	+	+	+	+	+	-	+	+	-	+	+
Cefazolin	-	+	-	-	+	-	-	-	-	-	-	+
Cefuroxime	-	+	-	-	+	-	-	-	-	-	-	+
Cefuroxime Axetil	+	+	-	-	+	-	-	-	-	-	+	+
Ceftazidime	-	+	-	-	+	-	-	-	+	-	+	+
Ceftriaxone	-	+	-	-	+	-	-	-	+	-	+	+
Ertapenem	+	+	+	+	+	+	-	+	+	-	+	+
Imipenem	+	+	+	+	+	+	±	+	+	+	+	+
Meropenem	+	+	+	+	+	+	+	+	+	+	+	+
Gentamycin	+	+	+	-	+	+	-	+	+	+	-	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	±	+	+
Nitrofurantoin	+	+	±	+	+	+	+	+	-	±	+	+
Ciprofloxacin	-	±	+	-	+	-	-	-	+	+	-	+

Trimethoprim/Sulfamethoxazole	+	+	+	-	+	-	-	+	+	+	-	+

Table 6. Antibiotic resistance test for *Escherichia coli isolates.*

Code of bacteria	**Escherichia coli**											
Antibiotic	106	107	108	110	111	119	120	121	122	124	125	126
Amoxicillin/Clavulanic Acid	+	-	-	±	+	±	+	+	+	+	±	+
Piperacillin/Tazobactam	+	-	-	-	+	+	+	+	+	+	+	+
Cefazolin	-	-	-	-	+	-	-	-	-	-	-	+
Cefuroxime	-	-	-	-	+	-	-	-	-	-	-	+
Cefuroxime Axetil	-	-	-	-	+	-	-	+	-	-	-	+
Ceftazidime	-	-	-	-	+	+	+	+	-	-	-	+
Ceftriaxone	-	-	-	-	+	+	-	+	-	-	-	+
Ertapenem	+	±	-	+	+	+	+	+	+	+	+	+
Imipenem	+	+	±	+	+	+	+	+	+	+	+	+
Meropenem	+	+	-	+	+	+	+	+	+	+	+	+
Gentamycin	-	-	+	+	+	-	+	-	-	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+	±
Nitrofurantoin	+	+	+	-	+	+	+	+	±	+	+	-
Ciprofloxacin	-	-	-	-	+	-	-	-	-	+	-	+
Trimethoprim/Sulfamethoxazole	-	-	-	-	+	+	+	-	-	+	-	+

Table 7. Antibiotic resistance test for *Escherichia coli isolates.*

Code of bacteria	***Escherichia coli***											
Antibiotic	**128**	**131**	**132**	**133**	**134**	**135**	**138**	**139**	**140**	**141**	**142**	**144**
Amoxicillin/Clavulanic Acid	-	-	+	+	-	-	+	-	-	+	±	-
Piperacillin/Tazobactam	-	+	+	+	-	-	+	-	+	+	+	-
Cefazolin	-	-	-	-	-	-	-	-	-	+	-	-
Cefuroxime	-	-	-	-	-	-	-	-	-	+	-	-
Cefuroxime Axetil	-	-	-	+	-	-	-	+	-	+	-	-
Ceftazidime	-	-	-	-	-	-	+	+	+	+	-	-
Ceftriaxone	-	-	-	-	-	-	-	+	+	+	-	-
Ertapenem	+	+	+	+	+	+	+	+	+	+	+	+
Imipenem	+	+	+	+	+	+	+	+	+	+	+	+
Meropenem	+	+	+	+	+	+	+	+	+	+	+	+
Gentamycin	-	+	+	-	-	-	+	+	+	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+	+
Nitrofurantoin	+	±	+	+	+	±	+	+	+	+	+	+
Ciprofloxacin	-	+	-	-	-	-	-	±	-	±	-	-
Trimethoprim/Sulfamethoxazole	-	+	+	-	-	-	+	+	+	-	-	+

Table 8. Antibiotic resistance test for *Escherichia coli isolates.*

Code of bacteria	***Escherichia coli***										
Antibiotic	**145**	**146**	**149**	**151**	**154**	**157**	**158**	**159**	**160**	**161**	**162**
Amoxicillin/Clavulanic Acid	+	-	±	+	-	-	-	±	+	+	-
Piperacillin/Tazobactam	+	-	+	+	-	+	-	+	+	+	-
Cefazolin	-	-	-	-	-	-	-	-	-	+	-

Cefuroxime	-	-	-	-	-	-	-	-	-	+	-
Cefuroxime Axetil	-	-	-	-	-	-	-	-	-	+	-
Ceftazidime	-	-	-	+	-	±	-	-	-	+	-
Ceftriaxone	-	-	-	+	-	+	-	-	-	+	-
Ertapenem	+	+	+	+	-	+	-	+	+	+	-
Imipenem	+	+	+	+	-	+	-	+	+	+	±
Meropenem	+	+	+	+	+	+	-	+	+	+	-
Gentamycin	+	+	+	-	+	+	-	+	+	+	-
Amikacin	+	+	+	+	+	+	-	+	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+
Nitrofurantoin	+	+	+	+	+	+	+	+	+	+	+
Ciprofloxacin	±	-	-	±	-	+	-	-	-	±	-
Trimethoprim/Sulfamethoxazole	-	+	-	-	-	+	+	+	-	-	-

Pseudomonas aeruginosa isolates' antibiotic susceptibility profiles show varying patterns of resistance to various drugs. The majority of isolates shown high susceptibility to Ceftazidime/Avibactam, Ceftolozane/Tazobactam, and Amikacin, suggesting that these antibiotics are still useful therapeutic alternatives. However, notable resistance to Colistin and Ciprofloxacin was found, especially in isolates 38, 74, 114, 127, and 136, indicating that these drugs are not very effective. Imipenem, Meropenem, Ceftazidime, Cefepime, and Piperacillin/Tazobactam all showed inconsistent patterns, with some isolates exhibiting resistance, underscoring the significance of individual susceptibility testing. Overall, the data highlight the need for customized antibiotic therapy based on sensitivity findings and highlight the evolution of multidrug-resistant *P. aeruginosa* in certain isolates.

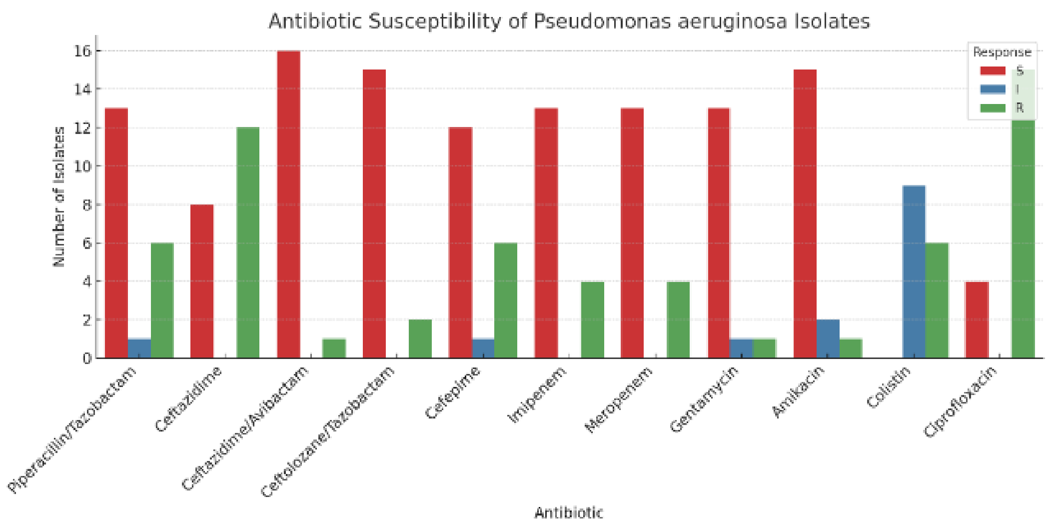

Figure 3. antibiotic resistance profile of *Pseudomonas aeruginosa*

Table 9. Antibiotic resistance test for *Pseudomonas aeruginosa* isolates.

Code of bacteria	***Pseudomonas aeruginosa***									
Antibiotic	**2**	**10**	**38**	**54**	**69**	**74**	**75**	**88**	**89**	**91**
Piperacillin/Tazobactam	+	+	+	+	-	-	+	+	+	+
Ceftazidime	+	+	+	-	-	-	+	+	+	+
Ceftazidime/Avibactam	+	+	+	+	+	+	+	+	+	+
Ceftolozane/Tazobactam	+	+	+	+	+	-	+	+	+	+

Cefepime	+	+	+	+	-	-	+	+	+	+
Imipenem	+	+	+	+	+	-	+	+	+	+
Meropenem	+	+	+	+	-	-	+	+	+	+
Gentamycin	+	+	+	+	+	+	-	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+
Colistin	±	±	-	±	±	-	±	±	±	±
Ciprofloxacin	-	+	-	+	-	-	-	-	+	-

Table 10. Antibiotic resistance test for Pseudomonas aeruginosa isolates.

Code of bacteria Antibiotic	***Pseudomonas aeruginosa***						
	67	**40**	**41**	**114**	**116**	**127**	**136**
Piperacillin/Tazobactam	±	-	-	+	+	+	-
Ceftazidime	-	+	-	+	+	+	-
Ceftazidime/Avibactam	+	-	+	+	+	+	-
Ceftolozane/Tazobactam	+	-	+	+	+	+	-
Cefepime	+	-	±	+	+	+	-
Imipenem	+	-	+	+	+	+	-
Meropenem	+	-	+	+	+	+	-
Gentamycin	±	-	+	+	+	+	-
Amikacin	±	-	+	+	+	+	-
Colistin	±	-	±	±	±	±	±
Ciprofloxacin	-	-	-	-	-	-	-

Amikacin, Fosfomycin, and carbapenems (Imipenem, Meropenem, and Ertapenem) are the most effective antibiotics, according to the antibiotic susceptibility profile of *Klebsiella pneumoniae* isolates, which also shows significant rates of susceptibility across isolates. On the other hand, significant resistance rates for earlier beta-lactams like cefazolin, cefuroxime, and ceftriaxone suggested decreased efficacy. Significant resistance to ciprofloxacin and nitrofurantoin was also observed, indicating their poor effectiveness in treating infections brought on by these isolates. Different isolates responded differently to some antibiotics, such as trimethoprim/sulfamethoxazole and piperacillin/tazobactam. Overall, these results highlight the significance of conducting susceptibility testing prior to therapy selection and imply that controlling resistant *K. pneumoniae* infections still requires the use of broad-spectrum or last-resort medicines.

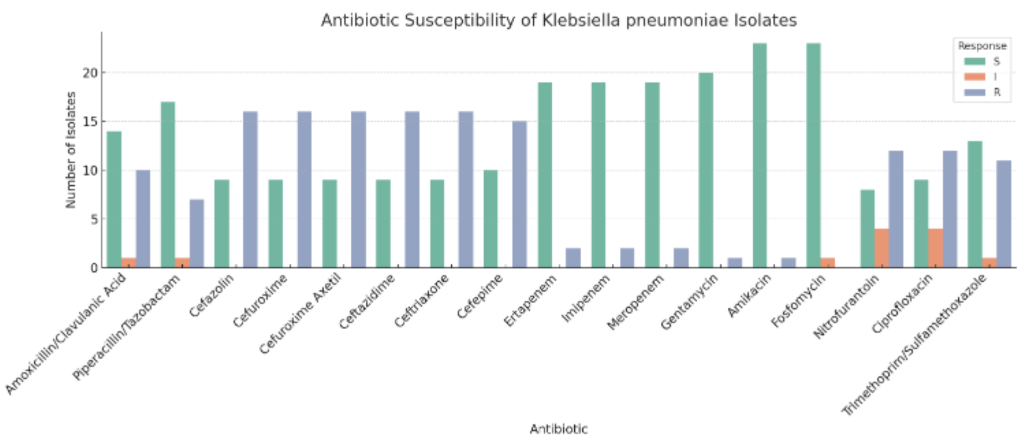

Figure 4. antibiotic susceptibility patterns of *Klebsiella pneumoniae* isolates.

Table 11. Antibiotic resistance test for *Klebsiella pneumoniae* isolates.

Code of bacteria	**Klebsiella pneumoniae**											
Antibiotic	**3**	**6**	**17**	**18**	**22**	**26**	**30**	**33**	**34**	**47**	**55**	**72**
Amoxicillin/Clavulanic Acid	-	-	+	+	±	+	-	+	+	-	+	+
Piperacillin/Tazobactam	+	+	-	±	+	+	-	+	+	-	+	-
Cefazolin	-	-	-	-	+	+	-	-	+	-	+	+
Cefuroxime	-	+	-	-	+	+	-	-	+	-	+	+
Cefuroxime Axetil	-	+	-	-	+	+	-	-	+	-	+	+
Ceftazidime	-	+	-	-	+	+	-	-	+	-	+	+
Ceftriaxone	-	+	-	-	+	+	-	-	+	-	+	+
Cefepime	-	+	-	-	+	+	+	-	+	-	+	+
Ertapenem	+	+	+	+	+	+	+	+	+	-	+	+
Imipenem	+	+	+	+	+	+	+	+	+	-	+	+
Meropenem	+	+	+	+	+	+	+	+	+	-	+	+
Gentamycin	-	+	+	+	+	+	+	+	+	+	+	+
Amikacin	+	+	+	+	+	+	+	+	+	+	+	+
Fosfomycin	+	+	+	+	+	+	±	+	+	+	+	+
Nitrofurantoin	+	-	-	-	+	±	-	±	±	+	±	+
Ciprofloxacin	-	+	+	±	-	+	±	±	+	+	+	+
Trimethoprim/Sulfamethoxazole	-	+	+	-	+	+	+	-	+	+	+	+

Table 12. Antibiotic resistance test for *Klebsiella pneumoniae* isolates.

Code of bacteria	***Klebsiella pneumoniae***												
Antibiotic	73	92	98	112	113	115	117	118	137	147	150*	153	11
Amoxicillin/Clavulanic Acid	+	+	-	+	+	+	+	+	+	-	+	+	+
Piperacillin/Tazobactam	+	+	-	+	+	+	±	+	+	-	+	+	+
Cefazolin	+	-	-	+	+	-	-	+	+	-	+	+	+
Cefuroxime	+	-	-	+	+	-	-	+	+	-	+	+	+
Cefuroxime Axetil	+	-	-	+	+	-	-	+	+	-	+	+	+
Ceftazidime	+	-	-	+	+	-	-	+	+	-	+	+	+
Ceftriaxone	+	-	-	+	+	-	-	+	+	-	+	+	+
Cefepime	+	-	-	+	+	+	-	+	+	-	+	+	+
Ertapenem	+	+	-	+	+	+	+	+	+	-	+	+	+
Imipenem	+	+	-	+	+	+	+	+	+	-	+	+	+
Meropenem	+	+	-	+	+	+	+	+	+	-	+	+	+
Gentamycin	+	+	+	+	+	+	+	+	+	-	+	+	+
Amikacin	+	+	-	+	+	+	+	+	+	-	+	+	+
Fosfomycin	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitrofurantoin	-	±	-	+	+	-	-	±	+	-	+	±	+
Ciprofloxacin	-	-	-	+	+	+	-	+	+	-	+	+	+
Trimethoprim/Sulfamethoxazole	-	-	+	+	+	-	-	+	+	-	+	+	+

With the exception of Ceftazidime, where one isolate (sample 19) exhibited resistance (R), the antibiotic susceptibility profile of *Acinetobacter baumannii* isolates (samples 8 and 19) demonstrates that both strains were entirely susceptible (S) to all tested antibiotics. Overall, this shows a good sensitivity pattern, indicating that common antibiotics such as fluoroquinolones (Ciprofloxacin), aminoglycosides (Gentamycin, Amikacin), carbapenems (Imipenem, Meropenem), and colistin continue to work against these isolates. Despite the small sample size, these results indicate that there are many treatment choices for *A. baumannii* in these situations; nonetheless, because of the organism's recognized propensity to build resistance quickly, ongoing monitoring is required..

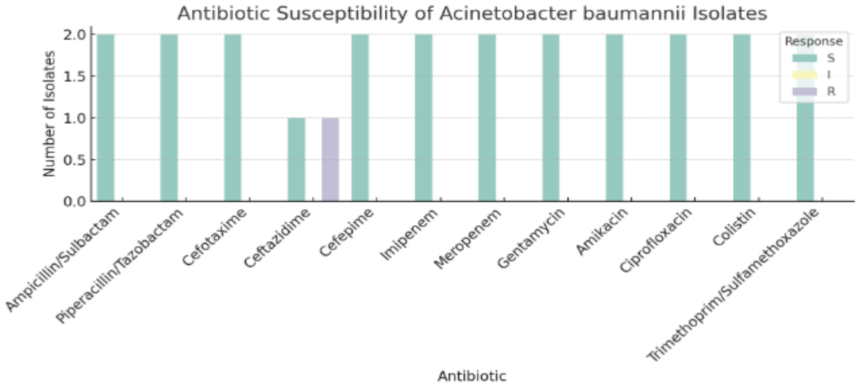

Figure 5. Antibiotic susceptibility of *Acinetobacter baumannii* isolates.

Table 13. Antibiotic resistance test for *Acinetobacter baumannii* isolates.

Code of bacteria Antibiotic	***Acinetobacter baumannii***	
	8	19
Ampicillin/Sulbactam	+	+
Piperacillin/Tazobactam	+	+
Cefotaxime	+	+
Ceftazidime	+	-
Cefepime	+	+
Imipenem	+	+
Meropenem	+	+
Gentamycin	+	+
Amikacin	+	+
Ciprofloxacin	+	+
Colistin	+	+
Trimethoprim/Sulfamethoxazole	+	+

The Proteus mirabilis isolate (sample 57) has a complete susceptibility profile to all 17 tested antibiotics, including beta-lactams (e.g., Amoxicillin/Clavulanic Acid, Ceftriaxone), carbapenems (Imipenem, Meropenem), aminoglycosides (Gentamycin, Amikacin), and other agents such as Fosfomycin, Nitrofurantoin, Ciprofloxacin, and Trimethoprim/Sulfamethoxazole. This suggests that the isolate is extremely sensitive and non-resistant, which means that a variety of widely used antibiotics can be used to treat it with ease.

Table 14. Antibiotic resistance test for *Proteus mirabilis* isolates.

Code of bacteria Antibiotic	**Proteus mirabilis**
	57
Amoxicillin/Clavulanic Acid	+
Piperacillin/Tazobactam	+
Cefazolin	+
Cefuroxime	+

Cefuroxime Axetil	+
Ceftazidime	+
Ceftriaxone	+
Cefepime	+
Ertapenem	+
Imipenem	+
Meropenem	+
Gentamycin	+
Amikacin	+
Fosfomycin	+
Nitrofurantoin	+
Ciprofloxacin	+
Trimethoprim/Sulfamethoxazole	+

The *Enterococcus faecalis* isolates' susceptibility to eight different antibiotics. Notably, all isolates are sensitive to tigecycline, indicating its total efficacy. Erythromycin, on the other hand, is ineffective against these strains due to its universal resistance. Mixed susceptibility patterns for levofloxacin, vancomycin, and tecoplanin indicate that isolates' efficacy varies. Although some isolates show resistance, linezolid is still often effective. While nitrofurantoin is generally effective with only a few isolated cases of resistance, tetracycline exhibits widespread resistance. The isolates of Streptococcus agalactiae (163 and 129) exhibit resistance to Erythromycin, Teicoplanin, Moxifloxacin, and Clindamycin, but are susceptible to the majority of antibiotics, such as Linezolid, Nitrofurantoin, and Tigecycline.

Table 15. Antibiotic resistance test for *Enterococcus faecalis* isolates

Code of bacteria Antibiotic	***Enterococcus faecalis***															
	4	5	7	16	29	42	44	48	53	60	80	83	85	96	143	148
Levofloxacin	+	+	+	-	±	+	+	+	+	-	+	+	+	+	-	+
Erythromycin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linezolid	+	+	+	-	+	+	+	+	+	+	-	+	+	+	±	+
Vancomycin	-	+	+	-	+	+	+	+	-	+	-	+	+	+	+	+
Teicoplanin	-	+	+	-	+	+	+	+	-	+	-	+	+	+	+	+
Tetracycline	+	+	-	-	-	-	-	-	+	-	-	+	+	-	-	-
Nitrofurantoin	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
Tigecycline	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 16. Antibiotic resistance test for *Enterococcus faecalis* and *Streptococcus agalactiae* isolates

Code of bacteria Antibiotic	***Enterococcus faecalis***				***Streptococcus agalactiae***
	152	**155**	**156**	**163**	**129**
Levofloxacin	±	±	-	+	-
Erythromycin	-	-	-	-	
Linezolid	+	+	+	+	+
Vancomycin	+	+	+	-	+
Teicoplanin	+	+	+	-	-
Tetracycline	-	-	-	+	-

Nitrofurantoin	+	+	+	+	+
Tigecycline	+	+	+	+	-
Moxifloxacin	-	-	-	-	-
Clindamycin	-	-	-	-	-

According to their antibiotic susceptibility profiles, *Staphylococcus aureus and Staphylococcus epidermidis* are consistently susceptible to the very effective antibiotics Linezolid, Vancomycin, Tigecycline, and Nitrofurantoin. All isolates, however, exhibit extensive resistance to erythromycin, with the exception of one *S. epidermidis* isolate, and to benzylpenicillin, oxacillin, and fusidic acid. The action of Teicoplanin, Gentamicin, Tobramycin, and Clindamycin varies, and certain isolates react in an intermediate or resistant manner. Although isolated susceptibility occurs in a few instances, levofloxacin and tetracycline are often ineffective, especially against S. aureus. While trimethoprim/sulfamethoxazole and morifloxacin have inconsistent effects, particularly when applied to isolates of *S. epidermidis*, rifampicin is often successful.

Table 17. Antibiotic resistance test for *Staphylococcus aureus and Staphylococcus epidermidis* isolates.

Code of bacteria	**Staphylococcus aureus**				**Staphylococcus epidermidis**		
Antibiotic	**27**	**59**	**123**	**130**	**24**	**81**	**109**
Linezolid	+	+	+	+	+	+	+
Vancomycin,	+	+	+	+	+	+	+
Benzylpenicillin	-	-	-	-	-	-	-
Oxacillin	-	-	-	-	-	-	-
Teicoplanin	+	+	±	±	+	±	+
Gentamicin	-	+	-	+	+	+	+
Tobramycin	-	+	-	+	+	+	+
Levofloxacin	-	+	-	-	-	-	-
Tetracycline	-	-	-	+	-	-	-
Tigecycline	+	+	+	+	+	+	+
Clindamycin	-	-	-	+	+	-	+
Erythromycin	-	-	-	-	-	-	+
Fusidic acid	-	-	-	-	-	-	-
Morifloxacin	-	+	-	-	±	±	±
Rifampicin	+	+	+	+	-	+	+
Nitrofurantoin	+	+	+	+	+	+	+
Trimethoprim/ Sulfamethoxazoe	+	-	-	+	+	+	-

Discussion

E. coli is the most common cause of UTIs in Baghdad (Zowawi et al., 2020), which is consistent with results from regional and international research (El-Kholy et al., 2021). Concerns regarding empirical treatment methods are raised by the high rates of resistance to widely used antibiotics as cefazolin and ciprofloxacin (Tängdén & Giske, 2015). High efficacy was shown by carbapenems and aminoglycosides, which is in line with their continued potency in other Middle Eastern regions (Foxman, 2010). To stop the emergence of resistance, their application must be restricted to severe or resistant patients. *P. aeruginosa and K. pneumoniae* multidrug resistance is especially concerning and necessitates stricter infection control and surveillance measures (Karam et al., 2022). The lack of gender-related variations lends credence to the hypothesis that exposure risks and host variables might be more important than gender alone (Okeke et al., 2005).

These findings underline the necessity of continued AMR surveillance in Iraq and better antibiotic management (Ibrahim et al., 2019).

Conclusion

The most common uropathogen in Baghdad is still E. coli. The necessity to update empirical treatment procedures is highlighted by the high level of resistance to first-line antibiotics (Bush et al., 2020). Amikacin and carbapenems exhibit consistent efficacy and ought to be saved for more complex situations (Livermore, 2004) Therapy should be guided by routine susceptibility and culture testing (Al-Tamimi et al., 2018). Programs for local surveillance and stewardship are crucial to the management of AMR (European Centre for Disease Prevention and Control & World Health Organization, 2023).

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