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Antibiotic Resistance and Susceptibility Patterns of *Klebsiella pneumoniae* Isolated from Urine Cultures at the Medical Tobruk Center in 2024

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ABSTRACT

Antibiotic resistance in uropathogenic Klebsiella pneumoniae has increasingly complicated the empirical treatment of urinary tract infections, necessitating the availability of locally relevant susceptibility data to guide therapy. Aim: This study aimed to determine the antibiotic resistance and susceptibility patterns of Klebsiella pneumoniae isolated from urine cultures at the Medical Tobruk Center during 2024. Methods: A retrospective descriptive laboratory-based study was conducted at the Medical Tobruk Center, Libya, between 1 January and 31 December 2024. All urine cultures processed during this period were reviewed, and non-duplicate Klebsiella spp. isolates with available susceptibility data were included. Specimens were collected aseptically and cultured on blood and MacConkey agar, followed by incubation at 37°C for 18–24 hours. Identification and antimicrobial susceptibility testing were performed using standardised methods, and results were categorised as susceptible, intermediate, or resistant. Demographic and clinical data were analysed using SPSS version 25. Results: A total of 60 isolates were analysed, with a mean patient age of 28.57 ± 24.26 years. Patients aged ≤30 years accounted for 53.3% of cases. The outpatient department contributed the highest proportion of isolates (50.0%). Complete resistance to ampicillin was observed (100%), while high resistance was noted for ceftriaxone (68.0%) and cefotaxime (68.6%). Amikacin demonstrated the highest susceptibility (79.6%), followed by ertapenem (65.5%) and imipenem (61.7%). Fluoroquinolone susceptibility was moderate. Conclusion: Significant resistance to commonly used antibiotics was identified, whereas amikacin and carbapenems retained better efficacy. These findings highlight the need to revise empirical treatment guidelines, strengthen antimicrobial stewardship, and promote routine antibiogram surveillance.

Keywords: Klebsiella pneumoniae; urinary tract infection; antimicrobial susceptibility; antibiotic resistance; multidrug resistance.

أنماط مقاومة المضادات الحيوية والحساسية لدى كليبسيلا الرئوية المعزولة من مزارع البول في مركز طبرق الطبي خلال عام 2024

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ملخـــــــص البحـــــــث

أصبحت مقاومة المضادات الحيوية لدى بكتيريا Klebsiella pneumoniae المرِضة للمسالك البولية تمثل تحدياً متزايداً في العلاج التجريبي لالتهابات المسالك البولية، مما يستدعي توافر بيانات محلية دقيقة حول أنماط الحساسية

للمضادات الحيوية لتوجيه القرارات العلاجية. هدفت هذه الدراسة إلى تحديد أنماط مقاومة وحساسية المضادات الحيوية لبكتيريا Klebsiella pneumoniae المعزولة من مزارع البول في مركز طبرق الطبي خلال عام 2024. تم إجراء دراسة وصفية استعادية معتمدة على بيانات المختبر في مركز طبرق الطبي، ليبيا، خلال الفترة من 1 يناير إلى 31 ديسمبر 2024، حيث جرت مراجعة جميع مزارع البول، وتم تضمين العزلات غير المكررة من أنواع Klebsiella التي توفرت لها بيانات الحساسية. جُمعت العينات بطريقة معقمة وزُرعت على أوساط آغار الدم وماكونكي، ثم حُضّنت عند 37 درجة مئوية لمدة 18–24 ساعة، وأُجري التعرف على البكتيريا واختبار حساسيتها باستخدام طرق معيارية، مع تصنيف النتائج إلى حساسة أو متوسطة أو مقاومة، كما تم تحليل البيانات باستخدام برنامج SPSS الإصدار 25. أظهرت النتائج تحليل 60 عزلة بمتوسط عمر للمرضى بلغ 28.57 ± 24.26 سنة، حيث شكّل المرضى بعمر ≥30 سنة نسبة 53.3% من الحالات، وسجّل قسم العيادات الخارجية أعلى نسبة من العزلات (50.0%). لوحظت مقاومة كاملة للأمبيسيلين (100%)، في حين سُجّلت مقاومة مرتفعة لكل من السيفترياكسون (68.0%) والسيفوتاكسيم (68.6%)، بينما أظهر الأميكاسين أعلى نسبة حساسية (79.6%)، يليه الإرتابينيم (65.5%) والإيميبينيم (61.7%)، وكانت حساسية الفلوروكينولونات متوسطة. تشير هذه النتائج إلى وجود مقاومة ملحوظة للمضادات الحيوية الشائعة الاستخدام مقابل احتفاظ الأميكاسين ومجموعة الكاربابينيم بفعالية أفضل، مما يؤكد أهمية مراجعة بروتوكولات العلاج التجريبي، وتعزيز برامج ترشيد استخدام المضادات الحيوية، ودعم المراقبة الروتينية لأنماط الحساسية البكتيرية.

الكلمات المفتاحية: كليبسيلا الرئوية؛ عدوى المسالك البولية؛ الحساسية للمضادات الحيوية؛ مقاومة المضادات الحيوية؛ مقاومة متعددة للأدوية.

1. Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections in humans after respiratory tract infections, a pattern that has been partly associated with broad-spectrum and indiscriminate antibiotic utilization .[1]UTIs account for approximately 150–200 million cases worldwide each year, with nearly 40% of females and 12% of males experiencing at least one symptomatic episode during their lifetime. .[2]These infections constitute nearly 40–50% of all bacterial infections acquired in hospitals, contributing to increased morbidity, prolonged hospitalisation, and substantial economic burden .[3]

Patients with UTIs may be categorised into complicated and uncomplicated groups; complicated infections are frequently associated with immunosuppression, diabetes mellitus, or anatomical and functional abnormalities of the urinary tract, whereas uncomplicated infections typically occur in otherwise healthy individuals .[4] Gram-negative bacteria represent the primary causative agents of UTIs, with Escherichia coli being the most prevalent pathogen, followed by Klebsiella pneumoniae and Proteus mirabilis. [5] Certain Gram-positive bacteria, including Enterococcus faecalis and Staphylococcus saprophyticus, have also been implicated in UTI aetiology [6,7].

Klebsiella pneumoniae is an encapsulated Gram-negative bacillus recognised for causing hospital-acquired infections such as septicaemia, pneumonia, and urinary tract infections .[8] Global antimicrobial resistance surveillance has identified K. pneumoniae as one of the leading pathogens associated with multidrug resistance and increased mortality, with carbapenem-resistant strains reported in several regions, including prevalence estimates of 20–30% in parts of Europe .[9]Similarly, European surveillance data have indicated that E. coli and K.

pneumoniae remain among the most frequently isolated resistant bloodstream pathogens across European Union countries, demonstrating resistance to commonly used antibacterial classes .[10]

International clinical guidelines have recommended antibiotics such as nitrofurantoin monohydrate, trimethoprim-sulfamethoxazole, fosfomycin trometamol, pivmecillinam, fluoroquinolones, and beta-lactams for UTI management .[7]However, widespread and inappropriate antibiotic utilisation has contributed to the emergence of extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria, which are frequently resistant to most available antibiotics except carbapenems .[11] The increased prevalence of multidrug-resistant pathogens has been associated with inadequate susceptibility testing prior to treatment initiation, thereby reducing therapeutic effectiveness .[12]

Recent evidence has indicated that the likelihood of multidrug-resistant UTI pathogens increases when antibiotic exposure has occurred within four weeks to one year prior to infection, particularly with fluoroquinolones and antipseudomonal penicillins [13,11] Enzymatic mechanisms, particularly the production of beta-lactamases and ESBLs, have been recognised as major contributors to resistance against beta-lactam antibiotics. [14,15] These organisms often harbour additional resistance genes, leading to multidrug-resistant phenotypes. [16] Similarly, target-site modification and antibiotic-inactivating enzymes such as aminoglycoside-modifying enzymes further reduce antimicrobial efficacy .[17]

Despite extensive international surveillance and guideline development, locally specific resistance patterns may differ considerably due to variations in prescribing behaviour, infection control practices, and laboratory capacity.[13] In the absence of up-to-date institutional antibiogram data, empirical therapy may not accurately reflect current susceptibility profiles within a given healthcare setting. According to the European Association of Urology guidelines, antibiotics with resistance rates exceeding defined thresholds may not be appropriate for empirical therapy [18]. Therefore, systematic evaluation of regional resistance patterns of K. pneumoniae isolated from urinary samples at the Medical Tobruk Center may provide contextually relevant evidence to guide empirical treatment decisions and antimicrobial stewardship strategies.

The present study aims to determine the antibiotic resistance and susceptibility patterns of Klebsiella pneumoniae isolated from urine cultures of patients attending the Medical Tobruk Center in 2024. Findings from this investigation may contribute to optimisation of empirical prescribing practices, refinement of local antimicrobial stewardship programmes, and strengthening of regional antimicrobial resistance surveillance efforts.

2. Literature Review

Recent investigations into antibiotic resistance patterns of Klebsiella pneumoniae in urinary tract infections have highlighted substantial geographical variation and evolving multidrug resistance profiles. Aytaç (2024) conducted a large-scale retrospective laboratory study in a tertiary care hospital in Türkiye, analysing urine cultures collected from outpatient clinics, hospital wards and intensive care units between 2018 and 2022. Identification and susceptibility testing were performed using the automated VITEK 2 Compact system in accordance with EUCAST criteria. The study revealed that cefixime demonstrated the highest resistance rate, while imipenem retained comparatively low resistance. Resistance levels were markedly higher

among ward and intensive care patients than outpatients, suggesting the influence of healthcare exposure and antimicrobial pressure. Temporal fluctuations were observed, with a peak in resistance during 2020, potentially linked to altered prescribing behaviours during the COVID-19 period. Although the large sample size strengthened external validity, the retrospective design and absence of extended-spectrum beta-lactamase confirmation or molecular characterisation limited mechanistic interpretation. Consequently, the study emphasised the importance of institutional surveillance while revealing a gap in molecular epidemiology and prospective risk-factor analysis.[19]

Similarly, Jalil and Al Atbee (2022)explored multidrug-resistant Escherichia coli and K. pneumoniae among UTI patients in Basrah, Iraq, using a cross-sectional laboratory-based design. One hundred and twenty midstream urine samples were cultured, and antimicrobial susceptibility testing was conducted via the VITEK 2 Compact system following CLSI guidelines. The findings indicated high resistance rates to third-generation cephalosporins, fluoroquinolones and ampicillin, whereas imipenem maintained substantial activity. The study highlighted a considerable burden of multidrug resistance within recurrent UTI cases and underscored the clinical relevance of local antibiograms to guide empirical therapy. However, the relatively small sample size and recruitment from private clinics limited generalisability. In addition, absence of molecular testing restricted identification of ESBL or carbapenemase-producing strains. The study therefore contributed valuable baseline regional data while exposing a gap in comprehensive institutional surveillance and genetic resistance profiling.[20]

In contrast, Azar and Ebadi (2017) focused specifically on paediatric patients in Iran, conducting a cross-sectional study of 198 K. pneumoniae isolates obtained from children with UTIs. Standard microbiological identification and Kirby–Bauer disc diffusion testing were applied according to CLSI standards. The highest resistance rates were reported for gentamicin and tetracycline, while amikacin and imipenem demonstrated high susceptibility. Nearly half of isolates were classified as multidrug resistant. Although the study provided important insight into paediatric resistance patterns, its single-centre design and reliance solely on phenotypic testing limited broader applicability and mechanistic interpretation.

Collectively, these studies demonstrate substantial resistance variability across clinical settings and populations. However, consistent limitations include absence of molecular confirmation, limited longitudinal analysis, and lack of region-specific surveillance in North African contexts. These gaps reinforce the need for updated, centre-specific resistance profiling that integrates phenotypic susceptibility testing with contextual epidemiological evaluation to inform empirical therapy and antimicrobial stewardship strategies.[21]

3. Materials and Methods

A retrospective descriptive laboratory-based study was conducted at the Medical Tobruk Center, Libya, from 1 January to 31 December 2024. All urine cultures processed during this period were screened, and non-duplicate Klebsiella spp. isolates with available susceptibility data were included. Urine specimens were collected using aseptic techniques and cultured on blood and MacConkey agar, followed by incubation at 37°C for 18–24 hours. Identification and antimicrobial susceptibility testing were performed using standardised laboratory methods, with results interpreted as susceptible, intermediate, or resistant. Demographic and ward data were extracted, and statistical analysis was conducted using SPSS version 25.

4. Results

Sample characteristics and distribution.

A total of 60 culture-positive isolates of Klebsiella spp. were included. All analysed specimens were urine samples (100.0%), and all isolates were reported as Klebsiella spp. (100.0%).

Table 1 summarises the demographic profile and clinical distribution. The age range was wide (0.01–83 years) with a mean age of 28.57 ± 24.26 years. More than half of the cases were aged ≤30 years (53.3%), while 46.7% were aged >30 years.

Ward distribution indicated that isolates were obtained across multiple clinical areas. The Outpatient Department (OPD) contributed the largest proportion (50.0%), followed by the Postpartum Ward (PW) (10.0%) and Paediatric Intensive Care Unit (PICU) (6.7%). Several wards contributed smaller numbers, and 8.3% of cases had the ward not recorded.

Table (1): Distribution of cases by demographic and clinical parameters (n = 60)

Variable	Category	No. (%)
Age (years)	≤30	32 (53.3)
	>30	28 (46.7)
	Min–Max	0.01–83
	Mean ± SD	28.57 ± 24.26
	Median (IQR)	28.50 (4–46)
Sample type	Urine	60 (100.0)
Organism	Klebsiella spp.	60 (100.0)
Ward/Unit	OPD	30 (50.0)
	PW	6 (10.0)
	PICU	4 (6.7)
	MAT	3 (5.0)
	NICU	2 (3.3)
	FMW	2 (3.3)
	AK	2 (3.3)
	PIW	1 (1.7)
	PD	1 (1.7)
	FSW	1 (1.7)
	EYE	1 (1.7)
	DW	1 (1.7)
	CCU	1 (1.7)
	Not mentioned	5 (8.3)

Abbreviations: IQR = interquartile range; SD = standard deviation.

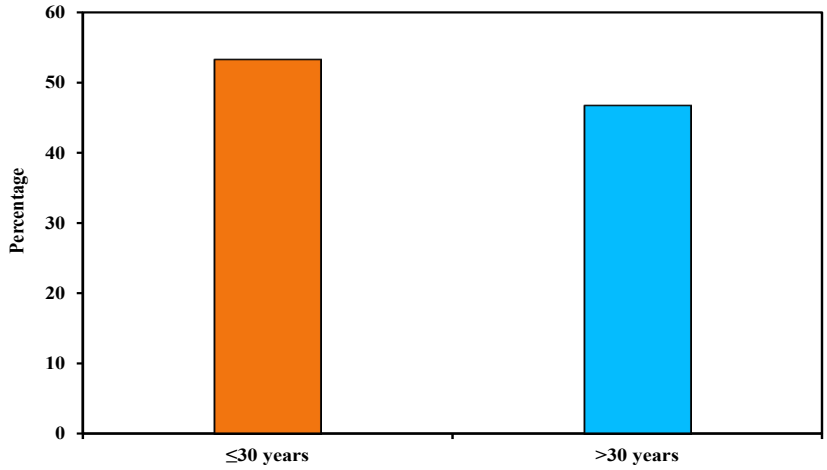

Figure 1. Distribution of the studied cases according to age group (≤30 vs >30 years).

2) Distribution of isolates by clinical location (ward/department)

Isolates originated from multiple hospital areas. The Outpatient Department (OPD) contributed 30/60 (50.0%), representing the largest single source. Additional isolates were distributed across Postpartum Ward (6/60; 10.0%), Paediatric Intensive Care Unit (4/60; 6.7%), and several other wards with smaller proportions (Table 1). Five records (8.3%) did not specify ward location.

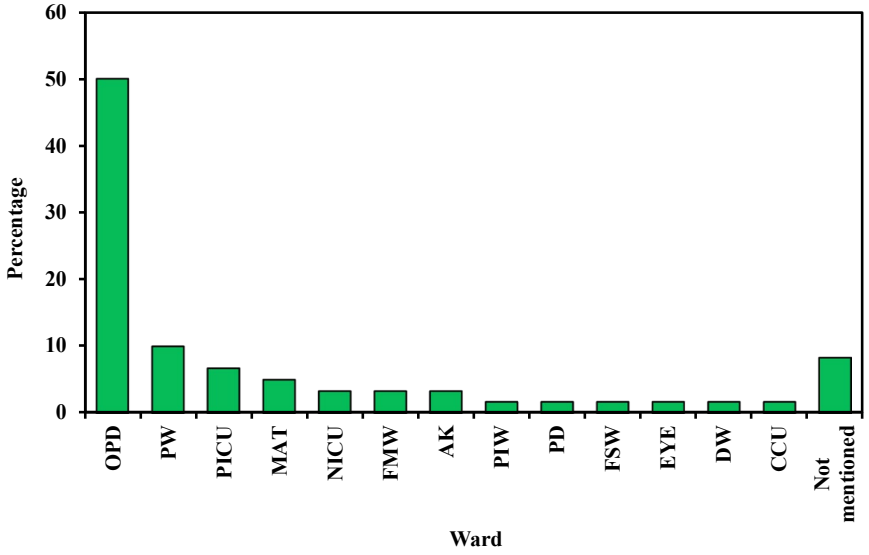

Figure 2. Distribution of the studied cases according to ward/department

(Insert column chart with wards on the x-axis and percentage on the y-axis, using Table 1.)

3) Antimicrobial susceptibility profile

Susceptibility testing outcomes were reported as Resistant (R), Intermediate (I), or Susceptible (S) across antibiotic classes (Table 2). A notable finding concerned ampicillin, where 42/42 (100.0%) tested isolates were resistant. Within cephalosporins, resistance levels were frequently high, including ceftriaxone (Cr) 17/25 (68.0%) resistant and cefotaxime (Ctx) 35/51 (68.6%) resistant. Several agents retained higher proportions of susceptibility, including amikacin (Ak) 39/49 (79.6%) susceptible, ertapenem (Ept) 19/29 (65.5%) susceptible, and imipenem (Ipm) 29/47 (61.7%) susceptible.

Table (2): Antimicrobial susceptibility results for Klebsiella spp. . isolates from urine cultures (R/I/S)

Class	Antibiotic (code)	No. tested	Resistant n (%)	Intermediate n (%)	Susceptible n (%)
Penicillins	Ampicillin (Amp)	42	42 (100.0)	0 (0.0)	0 (0.0)
	Amoxicillin (Amx)	26	16 (61.5)	0 (0.0)	10 (38.5)
	Amoxicillin–clavulanate (Amc)	42	26 (61.9)	2 (4.8)	14 (33.3)
	Piperacillin (Prl)	3	1 (33.3)	0 (0.0)	2 (66.7)
Cephalosporins	(Cr)	25	17 (68.0)	3 (12.0)	5 (20.0)
	(Cl)	10	6 (60.0)	0 (0.0)	4 (40.0)
	Ceftriaxone (Ctx)	51	35 (68.6)	2 (3.9)	14 (27.5)
	(Crd)	28	21 (75.0)	0 (0.0)	7 (25.0)
	(Cxm)	21	15 (71.4)	1 (4.8)	5 (23.8)
	Cefoxitin (Fox)	35	20 (57.1)	0 (0.0)	15 (42.9)
	(Cfm)	9	4 (44.4)	0 (0.0)	5 (55.6)
	Cefotetan (Ctt)	18	7 (38.9)	0 (0.0)	11 (61.1)
	(Kf)	5	4 (80.0)	0 (0.0)	1 (20.0)
	(Pep)	11	3 (27.3)	2 (18.2)	6 (54.5)
Glycopeptides	Vancomycin (Va)	7	6 (85.7)	0 (0.0)	1 (14.3)
	Polymyxin B (Pb)	1	1 (100.0)	0 (0.0)	0 (0.0)
Tetracycline group / others	Tetracycline (Te)	44	17 (38.6)	3 (6.8)	24 (54.5)
	Oxytetracycline (Ot)	8	6 (75.0)	1 (12.5)	1 (12.5)
	Doxycycline (Do)	10	5 (50.0)	1 (10.0)	4 (40.0)
	TMP–SMX (Sxt)	42	20 (47.6)	0 (0.0)	22 (52.4)
	Nalidixic acid (Na)	6	4 (66.7)	1 (16.7)	1 (16.7)
	Nitrofurantoin (F)	32	14 (43.8)	5 (15.6)	13 (40.6)
	Chloramphenicol (C)	1	0 (0.0)	0 (0.0)	1 (100.0)
Aminoglycosides	Gentamicin (Cn)	51	18 (35.3)	0 (0.0)	33 (64.7)
	(N)	3	2 (66.7)	0 (0.0)	1 (33.3)
	Streptomycin (S)	2	0 (0.0)	0 (0.0)	2 (100.0)
	Amikacin (Ak)	49	10 (20.4)	0 (0.0)	39 (79.6)
	Tobramycin (Tob)	20	7 (35.0)	1 (5.0)	12 (60.0)
Carbapenems	Imipenem (Ipm)	47	16 (34.0)	2 (4.3)	29 (61.7)
	Ertapenem (Ept)	29	9 (31.0)	1 (3.4)	19 (65.5)
Fluoroquinolones	Ciprofloxacin-labelled (Clp)	47	22 (46.8)	4 (8.5)	21 (44.7)
	Levofloxacin (Lev)	52	23 (44.2)	1 (1.9)	28 (53.8)
	Norfloxacin (Nor)	22	10 (45.5)	1 (4.5)	11 (50.0)

***Note**:* Antibiotic abbreviations are presented as recorded in the dataset/table.

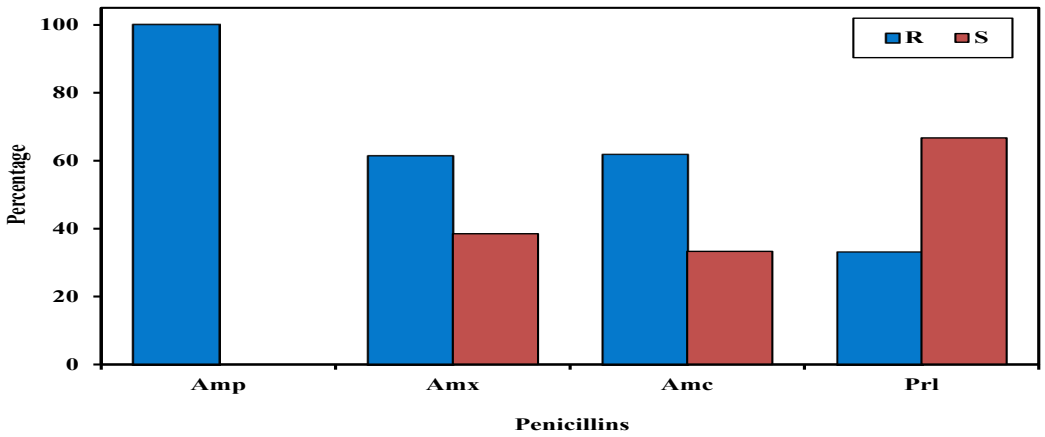

Figure 3. Penicillin susceptibility profile (R vs S) among tested isolates.

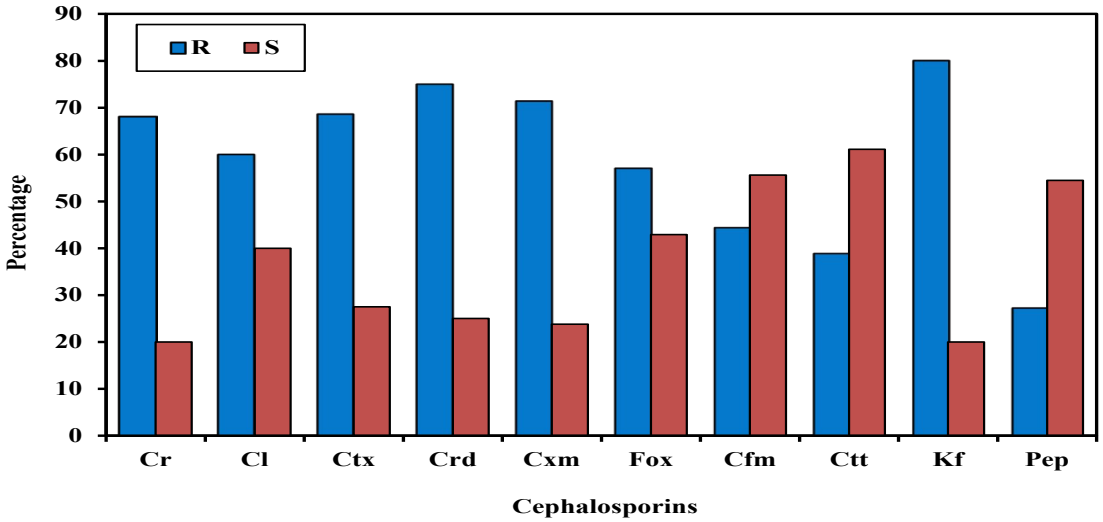

Figure 4. Cephalosporin susceptibility profile (R vs S) among tested isolates.

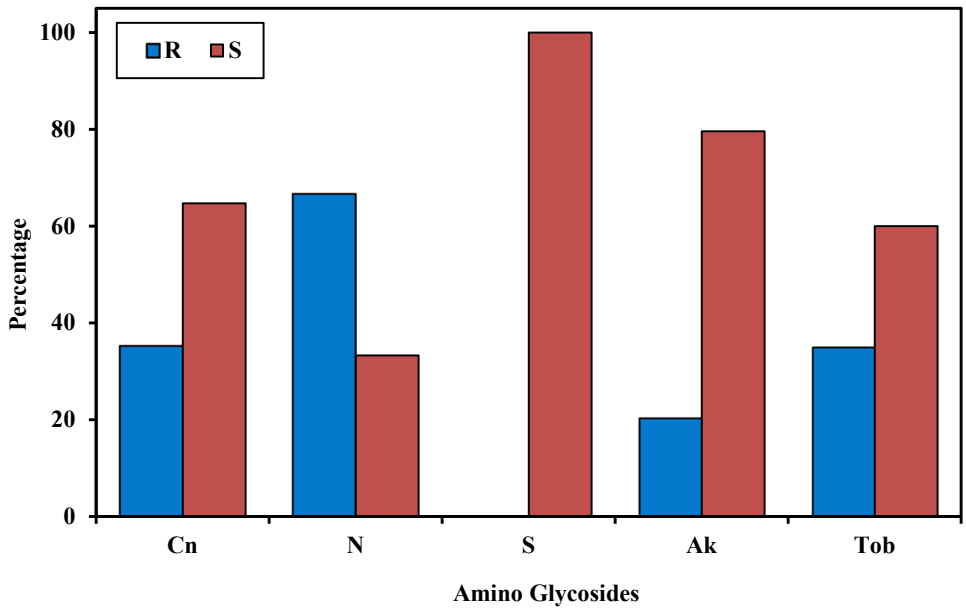

Figure 5. Aminoglycoside susceptibility profile (R vs S) among tested isolates.

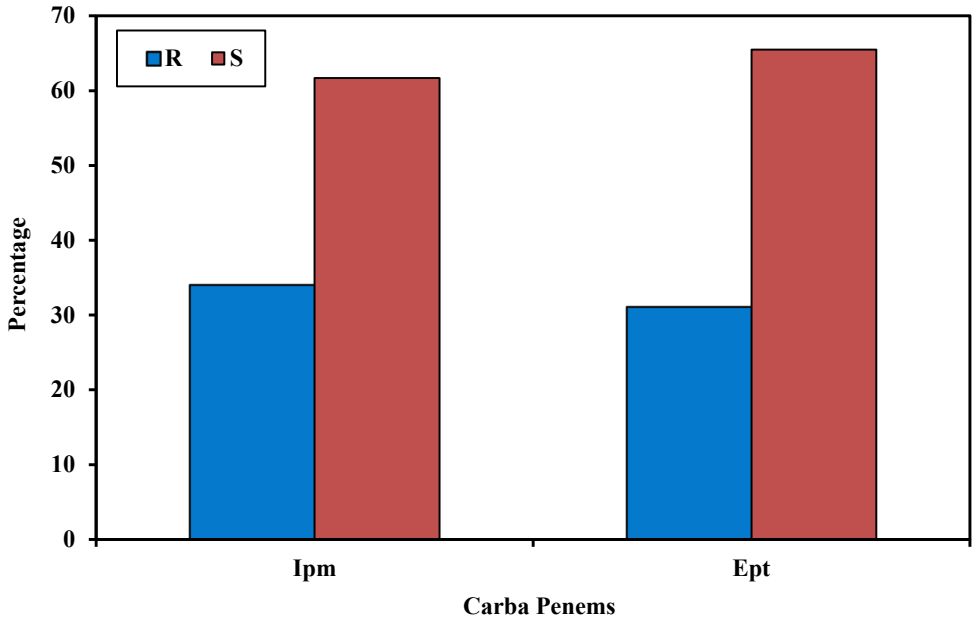

Figure 6. Carbapenem susceptibility profile (R vs S) among tested isolates.

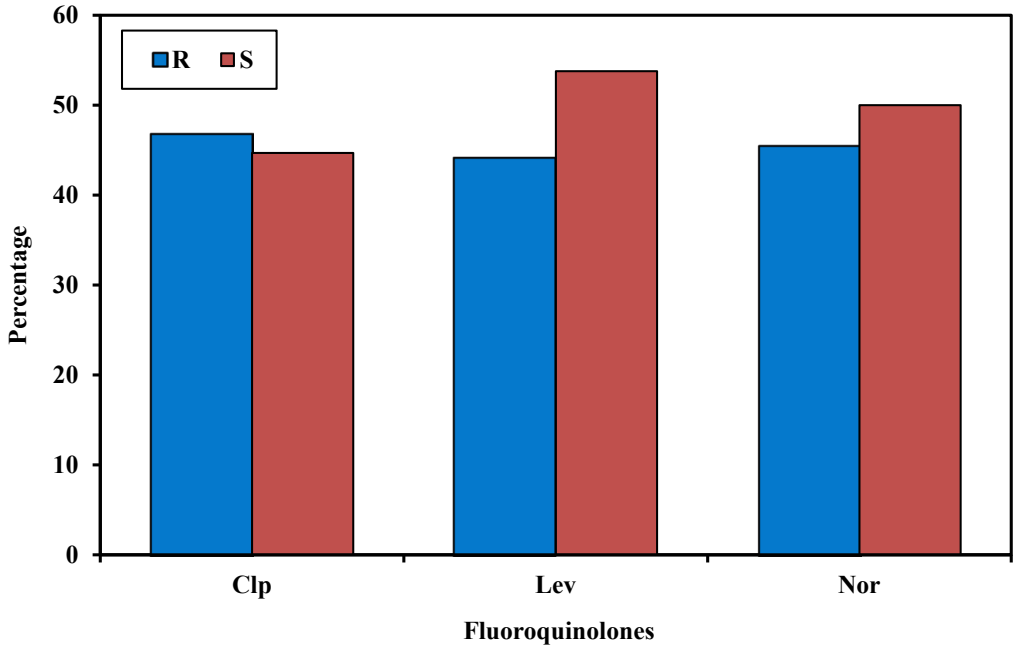

Figure 7. Fluoroquinolone susceptibility profile (R vs S) among tested isolates.

4) High-activity and high-resistance signals within the tested panel

Across the tested antibiotics, amikacin showed the highest susceptibility proportion (79.6%) among agents with substantial testing volume, followed by ertapenem (65.5%), gentamicin (64.7%), and imipenem (61.7%). In contrast, complete resistance was observed for ampicillin (100.0%), with high resistance also recorded for multiple cephalosporins, including Cr (68.0%) and Ctx (68.6%).

Table 3. Suggested "summary table" for the manuscript (top susceptibility vs top resistance) (Insert as an optional table to make the findings easier to scan.)

Category	Antibiotics (code)	Key percentage
Higher susceptibility signals	Ak, Ept, Cn, Ipm	79.6%, 65.5%, 64.7%, 61.7%
Higher resistance signals	Amp, Ctx, Cr, Crd	100.0%, 68.6%, 68.0%, 75.0%

5. Disscusion

The present study examined antibiotic resistance and susceptibility patterns among Klebsiella spp. isolated from urine cultures at the Medical Tobruk Center during 2024, with the aim of clarifying which agents retained comparatively higher activity in the local setting. The interpreted of findings the main microbiological and clinical signals emerging from the dataset, linking observed resistance and susceptibility profiles to the study aim while situating the findings within the wider literature on uropathogenic Klebsiella and antimicrobial resistance. Key areas of focus included the demographic and ward distribution of isolates, resistance to commonly used beta-lactams and cephalosporins, relative activity of aminoglycosides and carbapenems, and the pattern of fluoroquinolone susceptibility, thereby supporting a clearer understanding of empirical treatment challenges and stewardship priorities in routine UTI management.

The result of the study revealed that Klebsiella spp. isolated from urine samples affected a wide age range, with more than half of cases occurring in patients aged ≤30 years and a substantial proportion originating from the outpatient department. This pattern reflects the well-documented epidemiology of urinary tract infections (UTIs), which remain among the most common infectious diseases worldwide, affecting approximately 150 million individuals annually. [1,5] The predominance of outpatient isolates suggests that Klebsiella spp. are not confined to hospital-acquired infections but increasingly contribute to community-associated UTIs, a trend also reported in European and Middle Eastern settings. [22,18] Such findings reinforce the importance of continuous local surveillance beyond intensive care units, particularly in community-facing services, in order to support evidence-based empirical prescribing.

The research showed that complete resistance to ampicillin (100%) and high resistance rates to several cephalosporins, including ceftriaxone and cefotaxime, were prominent features of the antimicrobial profile. This observation aligns with the intrinsic resistance of Klebsiella species to ampicillin due to chromosomal beta-lactamase production[8] and is consistent with regional and international reports demonstrating elevated resistance to third-generation cephalosporins. [11] Comparable studies have documented cefotaxime resistance exceeding 60% in Klebsiella isolates, particularly in hospital-based cohorts. [20,19] However, resistance levels in the present findings appear variable across antibiotic classes, which may reflect differences in prescribing practices, infection control measures, and antimicrobial stewardship implementation. These resistance patterns underscore the diminishing utility of commonly prescribed beta-lactams for empirical UTI treatment within similar healthcare contexts.

The result of the study revealed that amikacin retained the highest susceptibility rate (79.6%), followed by ertapenem and imipenem, indicating comparatively preserved activity of aminoglycosides and carbapenems. This finding is in agreement with several investigations

reporting sustained effectiveness of carbapenems against Klebsiella pneumoniae, even in settings with high multidrug resistance[15,19]. Nevertheless, global surveillance data indicate a gradual increase in carbapenem resistance, particularly in invasive isolates across Europe and low- to middle-income countries[23,9]. The relatively higher susceptibility observed in the present analysis may reflect limited carbapenem exposure locally or restricted access to these agents, although the emergence of carbapenemase-producing strains remains a documented threat[24]. Preservation of carbapenem efficacy requires judicious use and integration within structured antimicrobial stewardship frameworks.

The research showed that fluoroquinolone resistance approached nearly half of tested isolates, with moderate susceptibility to ciprofloxacin and levofloxacin. Similar resistance magnitudes have been reported in studies from Asia, the Middle East, and Europe, where fluoroquinolone resistance in uropathogenic Enterobacteriaceae frequently exceeds 40%[12,13]. Such levels exceed the threshold recommended by international guidelines for safe empirical use. [7]The coexistence of resistance across multiple classes suggests possible underlying extended-spectrum beta-lactamase (ESBL) production or plasmid-mediated resistance determinants, although molecular confirmation was not undertaken. Strengthening laboratory capacity for phenotypic and genotypic resistance detection would enhance the precision of future institutional antibiograms and inform targeted therapeutic strategies within comparable regional healthcare systems.

5.Conclusion

Marked resistance to several first-line and commonly prescribed agents has been identified, while amikacin and carbapenems have retained comparatively higher activity. Local empirical prescribing policies have required revision, with stronger reliance on culture-guided therapy and stewardship enforcement. Hospital policymakers have been supported to prioritise routine antibiogram reporting, restricted use of last-line agents, and strengthened infection prevention. Future studies have been recommended to expand sample size, include multi-centre surveillance, and incorporate molecular resistance testing to explain mechanisms and track emerging high-risk strains.

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