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Prevalence and Antimicrobial Resistance Profiles of *Klebsiella Pneumoniae* in Karbala, Iraq Hospitals

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ABSTRACT

Background: *Klebsiella pneumoniae* a common pathogen emerging as Multidrug-resistant bacteria with high prevalence of infections in all clinical sites, having two pathotypes; classical *K. pneumoniae* (cKp) and hypervirulent K. pneumonia (HvKp), able to spread the resistance via Horizontal Gene Transfer mechanics.

Objectives: We aim to determine the rate of infections caused by *K. pneumoniae* in Kerbala and check their phenotypic antimicrobial characteristics to assess the empirically used antibiotics.

Materials and methods: Different clinical samples were collected from Al-Imam Al-Hassan Al-Mujtaba teaching hospital and Al-Hussien Medical City then screened for K. pneamoniae, 70 isolates were confirmed by VITEK-2 system, these samples were tested for aminoglycoside resistance, resistant isolates underwent a further investigation for 10 other antibiotics.

Results: This study found (n=70, 13.01%) prevalence of K. pnuemoniae infections in urine, sputum, swab and blood samples, out of the 70 isolates only 20 (28.60%) of the isolates were HvKp, the samples manifested a high resistance rate against AMP (100%) and cephalosporins FOX (82.50%), CTX (73.0%), CRO (66.70%), FEB (66.70%), and fluroquinolones CIP (66.70%) and LEV (52.40%). The highest resisted aminoglycoside was KN (52.90%) while CN, TOB performed moderately showing only (37.10%) and (38.60%) resistance respectively, least resisted antibiotics were AK (31.40%), NET (28.60%) and carbapenems (30.20%) for MEM and (27.00%) for IMI, only 4 isolates were resistant to colistin (6.30%).

Conclusion: With our results we concluded that *K. pneumoniae* has a high rate of infection in all clinical sources, *K. pneumoniae* isolates were highly resistant to cephalosporins and fluroquinolones due to improper and overuse of these antibiotics empirically, moderately resistant to aminoglycosides (KN, CN, TOB) and should not be used empirically while (AK, NET) are a good second-line treatment for ESBL-producing *K. pneumoniae*.

انتشار وخصائص مقاومة المضادات الميكروبية لبكتيريا الكلبسيلة الرئوية في مستشفيات كربلاء

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الخلاصة

المقدمة

الكلبسيلة الرئوية هي بكتيريا شائعة سلبية لصبغة غرام تنتمي لعائلة الامعائيات تسبب الكثير من أنواع الإصابات منها إصابات المجاري البولية، إصابات الحروق والجروح، الإصابات الرئوية واصابات مجرى الدم وتسبب إصابات خفيفة وشديدة قد تؤدي الى الوفاة، تمتاز هذه البكتيريا بمقاومتها الشديدة للمضادات الحيوية الشائعة المستخدمة مباشرة بدون تحديد نوع الإصابة. وجدنا ان نسبة الإصابة بالكلبسيلة الرئوية كانت 13.01 من جميع الإصابات البكتيرية. انتشر في الأوراق العلمية الجديدة نوع جديد من هذه البكتيريا يدعى الكلبسيلة الرئوية فائقة الضراوة المنتجة لكبسولة سميكة توفر الحماية لهذه البكتيريا من البلعمة والمواد القاتلة للبكتيريا الموجودة في الدم

المواد والطرق

تم جمع عينات سريرية مختلفة من مستشفى الإمام الحسن المجتبى التعليمي ومدينة الحسين الطبية، ثم فُحِصت للكشف عن *Klebsiella pneumoniae*، حيث تم تأكيد *70* عزلة باستخدام نظام *VITEK-2*. خضعت هذه العينات لاختبار مقاومة الأمينوغليكوزيدات، كما خضعت العزلات المقاومة لمزيد من الفحوصات ضد *10* مضادات حيوية أخرى.

النتائج

أظهرت الدراسة معدل انتشار بلغ ***13.01% (n=70)*** لعدوى ***K. pneumoniae*** في عينات البول والبلغم والمسحات والدم. ومن بين العزلات السبعين، كانت ***20* عزلة *(28.60%)*** من النمط شديد الضراوة ***HvKp***. أظهرت العينات معدل مقاومة مرتفعًا ضد **الأمبيسيلين*(100%)*** ، والجيل الثاني والثالث من السيفالوسبورينات***(82.50%) FOX*** :، ***(73.0%) CTX***، ***(66.70%) CRO***، ***(66.70%) FEB***، وكذلك ضد الفلوروكينولونات ***CIP*** : ***(66.70%)*** و***LEV (52.40%)***.

كان أعلى معدل مقاومة بين الأمينوغليكوزيدات ضد **الكانامايسين*(52.90%) KN*** ، بينما أظهر كل من ***CN*** و ***TOB*** مقاومة متوسطة بلغت ***37.10%*** و ***38.60%*** على التوالي. أما المضادات الأقل مقاومة فكانت :**الأميكاسين*(31.40%) AK*** ، و***(28.60%) NET***، والكاربابينيمات ***(30.20%) MEM*** : و ***(27.00%) IMI*** ولم تُسجّل مقاومة للكوليستين إلا في ***4* عزلات*(6.30%)***.

الاستنتاج:

تشير نتائجنا إلى أن ***K. pneumoniae*** تمتلك معدل إصابة مرتفعًا في مختلف المصادر السريرية. كما أن العزلات تُظهر مقاومة عالية للسيفالوسبورينات والفلوروكينولونات نتيجة الاستخدام الخاطئ والمفرط لهذه المضادات بشكل تجريبي. أما مقاومة الأمينوغليكوزيدات*(KN)* ، *CN*، *(TOB* فكانت متوسطة، وبالتالي لا يُنصح باستخدامها تجريبيًا، بينما يُعد كل من ***AK*** و ***NET*** خيارًا علاجيًا جيدًا كخط ثانٍ في حالات العزلات المنتجة لإنزيمات ***ESBL*** من *K. pneumoniae.*

1. Introduction

Klebsiella pneumoniae, a bacterium belonging to the family Enterobacteriaceae, a gram-negative opportunistic pathogenic microorganism which may causes many hospitals and community acquired infections(Melot et al., 2015). *K. pneumoniae* is encapsulated non-motile bacterium. Its virulence stems from multiple factors, including the polysaccharide capsule, which is the most critical virulence determinant. That capsule covering the cell protects the bacterial cell and prevents phagocytosis by blocking opsonization thus enhancing survival in serum by resisting complement-mediated lysis(Ashurst and Dawson, 2023). As it is widely known *K. pneumoniae* is an opportunistic pathogen with a broad ecological range, including transient survival in soil, water, plants, and associations with insects, birds, and mammals. In humans, it primarily colonizes the gastrointestinal tract as part of the commensal microbiota and can also asymptomatically inhabit the oropharynx. However, in hospitalized or immunocompromised individuals, it may transition to a pathogenic lifestyle, causing infections at these sites(Abbas et al., 2024). According to recent literature *K. pneumoniae* can be categorized into two distinct types: classical *K. pneumoniae* (cKp) and hypervirulent *K. pneumoniae* (HvKp), distinguished by characteristics such as hypermucoviscosity in HvKp and the presence of K1 and K2 capsular serotypes along with siderophores that enhance virulence(Russo and Marr, 2019). cKp strains are often multidrug-resistant and cause nosocomial infections, while HvKp strains, though usually antibiotic-sensitive, are highly virulent and cause severe community-acquired infections (Liu and Guo, 2019). *K. pneumoniae* is a prevalent pathogen and a major cause of nosocomial infections, particularly in immunocompromised patients, and with the emergence of Multidrug resistant *K. pneumoniae* especially ESBL producing KP and CRKP the need to assess its resistance is vital (Karampatakis et al., 2023). *K. pneumoniae* exhibited high resistance to several classes of antibiotics in recent reports**.** Resistance arises via: **(1) enzymatic antibiotic inactivation;** Antibiotic inactivation is a major resistance mechanism in *K. pneumoniae*. β-Lactamases hydrolyze the β-lactam ring of β-lactam antibiotics and are classified as extended-spectrum β-lactamases (ESBLs), AmpC cephalosporinases, and carbapenemases (Tooke et al., 2019). For aminoglycosides, resistance primarily arises via Aminoglycosides modifying enzymes that chemically modify aminoglycosides rendering them ineffective (Garneau-Tsodikova and Labby, 2016) **(2) target modification:** Fluoroquinolone resistance in *K. pneumoniae* stems from *gyrA/parC* mutations (Solano-Gálvez et al., 2020). Aminoglycoside resistance involves 16S rRNA methylation by 16S rRNA methyltransferases (16S-RMTases) (e.g., *rmtB*) (Papa-Ezdra et al., 2024). Polymyxin resistance relies on lipid A cationic modification (PhoPQ/PMrAB) (Haeili et al., 2017). **(3) porin loss/mutations**; *K. pneumoniae* develops acquired resistance to antibiotics by reducing outer membrane permeability, often through mutations or loss of major porins like OmpK35 and OmpK36 , that facilitate antibiotic entry thus lowering the uptake of antibiotics (Maher and Hassan, 2023) **(4) efflux pump overexpression;** efflux pumps like AcrAB-TolC are membrane proteins that reduce intracellular antibiotic concentrations by expelling drugs such as fluoroquinolones, tetracyclines, and macrolides, contributing to low-level resistance (Tang et al., 2020). and (5) **biofilm formation, which enhances tolerance to antibiotics;** *K. pneumoniae* forms biofilms via surface structures like type 1 fimbriae (*fimH)*, which mediate adhesion. Biofilms enhance antibiotic tolerance through EPS matrix interactions, reduced diffusion, and persister cell formation, reducing efficacy of antibiotics.(Karami-Zarandi et al., 2023). Many of these resistances may be present simultaneously providing extensive resistance to antibiotics.

The **global spread** of antimicrobial overuse **in clinical practice, agriculture, and communities** has driven the emergence of drug-resistant pathogens, increasing morbidity and mortality worldwide (Gebremeskel et al., 2023). In response to escalating antimicrobial resistance, the World Health Organization (WHO) released the **2024 Bacterial Priority Pathogens List (BPPL)**, categorizing *K. pneumoniae* (carbapenem-resistant strains) as **"Critical"** to guide R&D and containment strategies. Available treatments, including last-resort antibiotics, face **severe limitations** due to acquired resistance, though efficacy varies by resistance mechanism and region (WHO, 2024).

MDR *K. pneumoniae* strains pose major public health threats, complicating treatment and increasing morbidity/mortality. Key antibiotics—including third-generation cephalosporins, fluoroquinolones, carbapenems, and (to a lesser extent) aminoglycosides—show declining global efficacy, though susceptibility varies by resistance mechanism and geography (Lin et al., 2024). the aims of this study were to evaluate prevalence of K. pneumoniae infections and antibiotic resistance to assess the rate of resistance and determine a proper first-line treatment in efforts to lower the resistance.

2. Materials and Methods

2.1. Ethical Approval

Written informed consent was obtained from all participants prior to sample collection, and all individuals included in the study were fully informed of the research procedures. The study was approved by the Publication Ethics Committee of the College of Medicine at the University of Jabir Ibn Hayyan for Medical and Pharmaceutical Sciences.

2.2. Study Setting, Period, and Design

Cross-sectional study was conducted at two hospitals in Karbala city (Al-Imam Al-Hassan Al-Mujtaba teaching hospital and Al-Hussien Medical City*)* for the period from August of 2024 to January of 2025. Samples have been collected from different clinical sources including urine, swab, sputum, blood samples from inpatients and outpatients, information of patients were registered including gender, age, specimen source and consent from patients and/or their warden confirmed.

2.3. Identification and Testing

Samples were obtained from clinical sources suspected with infections and primarily cultured immediately after acquisition on blood agar and MacConkey agar incubating the inoculated plates aerobically at 37ºC for 18-24hr and checked for growth after that, the only exception was blood samples in which they were cultured in aerobic blood culture bottle and when growth detected the samples followed the similar process of other samples. No growth and samples with insignificant growth were discarded and all the plate with significant growth were screened for general morphological characteristics. Suspected *K. pneumoniae* isolates were subjected to biochemical testing.

The early identification was indicated by finding mucoid pink gram-negative lactose fermenting colonies on MacConkey and large, grayish, mucoid colonies on blood agar, single isolated colonies were checked first with gram stain, finding gram-negative bacilli in scattered fashion. Further investigations were performed to suspected isolates testing the samples for the biochemical tests listed in the Table1. After initial biochemical identification the isolates were further confirmed via VITEK 2 Compact system (BioMérieux) to confirm the species and subspecies.

Table1: Biochemical Test Results for the Isolated Bacterial Strain

Test	Result	Interpretation
Citrate Test	Positive	Utilization of citrate as a carbon source
Urease Test	Positive	Ammonia production observed
Indole Production	Negative	No indole production
Motility	Negative	Non-motile
Kligler's iron Test	Acidic/Acidic	Fermentation with acidic slant and bottom
- Gas Production	Positive	Gas production observed
String Test	5mm string	To differentiate between cKP and HvKP

2.4. String Test

String test was done to differentiate between classical and hypervirulent strains, a sterile loop used to touch a single isolated colony then lifted up slowly and if the colony produced a string 5mm or longer string it is positive thus hypervirulent/hypermucoviscus and if the colony failed to produce a string or the string was <5 it would be designated as classical *K. pneumoniae*(Hagiya et al., 2014).

2.5. Antibiotic Susceptibility

The antibiotic susceptibility testing was done according to Kirby-Bauer disk diffusion antibiotic susceptibility testing. Performing it in two successive steps, starting first with the primarily five aminoglycosides antibiotics (Gentamicin, Tobramycin, Amikacin, Kanamycin, Netilmycin) after detecting resistance to at least one aminoglycoside further antibiotic resistance investigation was done in which twenty-four antibiotics categorized into fourteen groups were tested according to CLSI 2024, Enterobacteriales order guidelines, the tested antibiotics are as follow: **Penicillins**, Ampicillin (AM, 10 µg); **Cephalosporins**—2nd generation (Cefoxitin, FOX, 30 µg), 3rd generation (Cefotaxime CTX 30 µg, Ceftriaxone, CRO, 30 µg), and 4th generation (Cefepime, FEP, 30 µg); **Carbapenems** (Imipenem, IMP, 10 µg; Meropenem, MEM, 10 µg); **Aminoglycosides** (Amikacin, AK, 30 µg; Tobramycin, TOB, 10 µg; Gentamicin, CN, 10 µg; Kanamycin, KAN, 30 µg; Netilmicin, 30 µg); **Fluoroquinolones** (Levofloxacin, LEV, 5 µg; Ciprofloxacin, CIP, 5 µg); **Folate pathway inhibitors** (Trimethoprim-sulfamethoxazole, SXT, 1.25/23.75 µg).

On the other hand, Lipopeptides (Colistin, 10 µg); were testing using the broth disc elution method instead of disc diffusion(Nirmal et al., 2023).

3. Results

3.1. Bacterial Isolates and Demographic Distribution

In this study cross sectional study, a total of 538 isolates were cultured on blood and MacConkey agar from different clinical sources during the study period in between August of 2024 and January of 2025 at Al-Imam Al-Hassan AL Mujtaba teaching hospital and Al-Hussien medical city, Table2.

Table 2: Distribution and Characteristics of Pathogen Culture According to the Sample Source

Sample Source	Culture	Percentage	*K. pneumoniae* isolates	% of thier source	P. value
Urine	301	55.95%	37	12.29% (of urine)	0.00003
Swab	121	22.49%	19	15.70% (of swabs)	
Sputum	81	15.06%	10	12.34% (of sputum)	
Blood	35	6.51%	4	11.42% (of blood)	
Total	538	100%	70	13.01% (of total)	0.0099

After the screening and the biochemical testing to identify the pathogenic bacteria, out of the 538 samples, only (n=70, 13.01%) of the samples were identified as *K. pneumoniae* and the remaining were either no significant growth or other bacteria. The obtained n=70 K. pnaumoniae samples were confirmed via VITEK-2 compact system.These isolates collected were mainly obtained from urine samples from UTI patients account for more than half of the K.pneumoniae isolates (n=37, 52.9%), while fewer were isolated from burn and wound swabs (n=19, 27.1%), sputum (n=10, 14.3%), and blood (n=4, 5.7%), Fig.1.

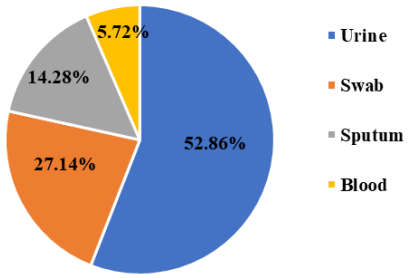

Figure1: Distribution of clinical sample types positive for *Klebsiella pneumoniae*.
The pie chart shows the proportion of *K. pneumoniae* isolates obtained from different clinical sources. The majority of isolates were recovered from urine samples (52.86%), followed by swab samples (27.14%), sputum samples (14.28%), and blood samples (5.72%).

The string test yielded that CKp were the majority of the isolated strains, being (n=50, 71.42%) of the total number meanwhile HvKp accounted for (n=20, 28.58%) of the isolates. Females represented more than half of the samples being (n=42, 60.00%) and males formed only (n=28, 40.00%), Table3.

Table 3: Distribution and Characteristics of Patients According to The Study Subjects

Parameters	Group	Number	Percentage %	P. value
Sex	Male	28	40.00%	0.09426
	Female	42	60.00%	
Age Group	<= 30	22	31.43%	0.08648
	31 - 40	17	24.29%	
	41 - 50	10	14.29%	
	51 - 60	11	15.71%	
	> 60	10	14.29%	
Strain	CKP	50	71.43%	0.00034
	HVKP	20	28.57%	
Source	Blood	4	5.72%	0.00003
	Sputum	10	14.28%	
	Swab	19	27.14%	
	Urine	37	52.86%	
Hospitalization	Inpatient	15	21.43%	0.00002
	Outpatient	55	78.57%	

3.2. Antibiotic Resistance Results

Seventy isolates were initially screened for phenotypic aminoglycoside resistance. Isolates exhibiting resistance were then tested against a panel of ten other antibiotics according to CLSI 2024, Table4 and Table5.

Table4: Aminoglycoside Resistance Distribution

Antibiotic Families	Antibiotics	Resistance	Susceptibility	Intermediate	P value
Aminoglycosides	CN	26	33	11	**0.00445**
		37.10%	47.10%	15.70%	
	TOB	27	33	10	**0.0039**
		38.60%	47.10%	14.30%	
	K	37	17	16	**0.0033**
		52.90%	24.30%	22.90%	
	AK	22	43	5	**0.000005**
		31.40%	61.40%	7.10%	
	NET	20	48	2	**0.0000001**
		28.60%	68.60%	2.90%	

Table5: Distribution and Characteristics of the 63 Resistant Isolates Against the Remaining Antibiotic Families

Antibiotic Families	Antibiotics	Resistance	Susceptibility	Intermediate	P value
Penicillin	AMP	**63**	0	0	**n/a**
		100.00%			
Cephalosporins	FOX	**52**	4	7	**0.000001**
		82.50%	6.30%	11.10%	
	CTX	**46**	11	6	**0.000001**
		73.00%	17.50%	9.50%	
	CRO	**42**	18	3	**0.000001**
		66.70%	28.60%	4.80%	
	FEB	**42**	18	3	**0.000001**
		66.70%	28.60%	4.80%	
Carbapenems	IMI	17	40	6	**0.000001**
		27.00%	63.50%	9.50%	
	MEM	19	41	3	**0.000001**
		30.20%	65.10%	4.80%	
Fluoroquinolones	CIP	**42**	11	10	**0.000001**
		66.70%	17.50%	15.90%	
	LEV	**33**	25	5	**0.00005**
		52.40%	39.70%	7.90%	
Polymyxin	Colistin	4	59	0	**0.000001**
		6.30%	93.70%	0.00%	

After the analysis of the antibiotic resistance patterns the isolates were as follows, Table6.

Table6: Antibiotic Resistance Profiles of *Klebsiella Pneumoniae* Isolates

Resistance Profiles	Not MDR	11	15.71%	p-value 0.00123
	MDR	37	52.86%	
	XDR	22	31.43%	

4. Discussion

K. pneumoniae is a prevalent pathogen especially in nosocomial infections and according to our study, out of the total 538 clinical samples *K. pneumoniae* had a prevalence of 13.01% of the total diagnosed cultured samples from clinical sources agreeing perfectly with (Hasani et al., 2020) and (Kadher and Jarallah, 2018) as they found 13.03% and 12% respectively, also manifesting close relation with a similar study conducted in 2022 in Kirkuk in which they found 20% prevalence of *K. pneumoniae* among all clinical sources indicating a slight significant difference(Abdullah et al., 2023), another study conducted in Baghdad by (Kudaer et al., 2023) revealed 30 out of 105 samples were *K. pneumoniae* (28.57%) which slightly disagree with our findings. Enterobacteriaceae is widely known for their high uropathogenicity with *K. pneumoniae* being second only to E. coli, which is also proven in a study previously done in Karbalaa (Abdulhussein et al., 2024). In our study out of the 70 isolated *K. pneumoniae* samples, it was highly prevalent in urine (n=37 52.90%) followed by swab (n=19, 27.14%) and sputum (n=10, 14.28%) then blood (n=4, 5.71%) almost fully agreeing with a study conducted by (Ajimuda et al., 2022), and we were also in line with (Vandhana et al., 2022) by having urine at the highest prevalence and disagree with them in the prevalence of sputum and blood samples, a similar study done by (Altememe and Alsaadi, 2023) indicated that sputum has higher rate than urine infection disagreeing with our results. Age distribution in our study showed 31.43% of the isolates belonged to individuals below 30 years of age and with 31-40 being slightly lower at 24.29%, while 51-60 of age represented 15.71% and lastly 41-50 and above >60 individuals set at similar stands 14.29% for both. These results are agreed upon by (Abdullah et al., 2023) and our results disagreed with the findings stated in (Khan et al., 2010) in which they demonstrated a higher rate 27.33% of infections in elderly patients (>60 of age), but they found 18.89% percentage of infections in younger individuals slightly aligning with our findings, also (Parrott et al., 2021) findings disagreed with our results as they indicate that *K. pneumoniae* is prominent in elderly the higher rate in younger patients may be due to some disorders and predisposing factors causing or might be bias caused by collecting higher sample numbers from that specific age group. Our study presented 60.00% of the isolated samples and 40.00% were males, similar to the studies (Abdullah et al., 2023; Khan et al., 2010; Zuber and Ganjo, 2023) in which they found female percentage at 66.33%, 54.24% and 53.8% respectively, being higher in all the studies compared to males, nevertheless (Parrott et al., 2021) displayed that males had higher infection rate conflicting with our results. The insignificant difference (p-value >0.05) in gender and sample sources indicates that *K. pneumoniae* has the ability to cause all types of infections despite the age, gender and source. Strains results acquired via string test yielded n=20, 28.57% of the isolates being HvKp and n=50, 71.43% of the isolates as cKp, our results are in slightly line with (Vandhana et al., 2022) finding 13.9% HvKp, while conflicting with (Zuber and Ganjo, 2023) as they found 43.3% of their samples as HvKp strains, meanwhile (Parrott et al., 2021) isolates displayed only 7.1% HvKp strain. *K. pneumoniae* is notorious nosocomial pathogen, in our results Inpatients represented n=15, 21.43% of the samples and outpatients were n=55, 78.57%, similar to (Le et al., 2021) as they found nosocomial infections at 25.9%, and conflicting with (Mohamed and Rasheed Al-Taai, 2023) displaying that nosocomial infections are significantly higher that community acquired infections.

Aminoglycoside resistance tested for all the 70 samples, n=37 52.90% of the isolates was resistant to Kanamycin similar to the findings provided by (Kadher and Jarallah, 2018) in which they found 50% resistance to Kanamycin, another study presented that susceptibility to Kanamycin was as high as 44.8% disagreeing with our 22.90%

susceptibility rate (Swedan et al., 2024). Our isolates manifested 37.10% and 38.60% resistance to gentamicin and tobramycin respectively, our results regarding gentamicin are in line with (Khoshnood et al., 2023) results as they found 36.8% resistance rate, but their tobramycin resistance rate was high at 71.1% conflicting with our rates. A study done in Kerbala (Altememe and Alsaadi, 2023) slightly align with our gentamicin resistance pattern at 51%. As for tobramycin, our resistance rate opposed the 14.28% resistance frequency found by (Ahmed et al., 2021). Nevertheless, amikacin resistance slightly lower rate being 31.40% performing better than tobramycin and gentamicin, agreeing with (Kadher and Jarallah, 2018) as they found the resistance rate to amikacin at 30%. Netilmicin on the other hand had the lowest resistance rate among the tested amingolycosides at 28% agreeing with (Ahmed et al., 2021).

Among the 70 isolates 19(27.14%) were fully resistant to all tested aminoglycosides. The sixty-three aminoglycoside resistant isolates had been tested for MDR pattern. The isolates manifested high level of resistance to the tested antibiotics especially Ampicillin and Cephalosporins, All the 63 tested isolates were resistant to ampicillin providing an insight about the intrinsic resistance exhibited by SHV-1 penicillinase(Holt et al., 2015), Cefoxitin a 2nd generation cephalosporin was highly resisted by the isolate with n=52 82.50% resistance rate, 3rd generation represented by cefotaxime and ceftriaxone had 73.00%, 66.70% rate of resistance respectively, and 4th generation cefepime displayed identical resistance rate to ceftriaxone 66.70%. Carbapenems proven to be a good choice against complicated *K. pneumoniae* infection with imipenem manifesting resistance rate of 27.00% and 30.20% for meropenem. These findings are in line with (Al-Jelehawy and Saihood, 2022), (Kadher and Jarallah, 2018) and (Ahmed et al., 2021)

Out of the tested isolates 66.70% resistant to ciprofloxacin and 52.40% were resistant to levofloxacin agreeing with (Zuber and Ganjo, 2023) and (Altememe and Alsaadi, 2023). Only 4 isolates were resistance to colistin indicating that it is a good last resort antibiotic.

More than half of our samples n=36, 51.40 isolates were designated as MDR because they resisted at least one antibiotic in ≥3 families, and XDR ratio was 15.70% represented by 11 isolates as they were only susceptible to ≤2 antibiotic classes(Magiorakos et al., 2012).

4. Conclusion

In this study we notice an increase in the infections caused by *K. pneumoniae* in all clinical sources with urine samples having the highest prevalence. The results indicate gentamicin, tobramycin and kanamycin have high resistance rates thus we suggest avoiding using them empirically, aminoglycosides like amikacin and netilmicin maintained a proper susceptibility pattern thus providing a good second line for ESBL-producing *K. pneumoniae*. The antibiotic resistance pattern shown by this study indicated the major resistance of *K. pneumoniae* to the frequently used empirical antibiotics including ciprofloxacin and cephalosporins across all generations, thus we emphasize on the proper antibiotic stewardship and further investigations about the possibility to use antibiotic combinations to fight the increase in resistance especially after the emergence of CRKP. Bacteriophages would be a significant help to fight MDR bacteria according to (Mohammed et al., 2018). Colistin proven to be a proper last resort for *K. pneumoniae* XDR isolates.

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