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Research Article

Epidemiology and Antibiotic Resistance of *Klebsiella pneumoniae* Infections in Saudi Long-Term Care Facility: A Comparison Study

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Abstract

Background: *Klebsiella pneumoniae* is an opportunistic pathogen commonly found in the normal flora of the gastrointestinal tract. It can lead to severe healthcare-associated infections, particularly among immunocompromised individuals and those in long-term care settings. This study examined the epidemiology of *K. pneumoniae* infections and compared antibiotic resistance patterns (males vs. females) in long-term care hospital in Riyadh, SA.

Methods: A retrospective cross-sectional study compared microbial culture data from 56 inpatients (29 males and 27 females) with confirmed *K. pneumoniae* infections. Data were collected on demographic characteristics, culture sites, and antibiotic susceptibility test results. Statistical analyses explored associations between patient characteristics and resistance patterns, focusing on carbapenem-resistant Enterobacterales (CRE) and extended-spectrum beta-lactamase (ESBL) producing strains.

Results: Around 51.8% of the *K. pneumoniae* isolates were resistant to carbapenems, and 35.7% were classified as ESBL producers. Patients with tracheostomies exhibited a higher prevalence of CRE infections (35.7%) compared to those without tracheostomies (16.1%, p = 0.431). Similarly, patients with bedsores showed a slightly higher prevalence of CRE infections (28.6%) than those without (23.2%, p = 0.184). Resistance levels against commonly used antibiotics were high for cotrimoxazole (64.3%), ciprofloxacin (33.9%), and gentamicin (39.3%). In contrast, imipenem and meropenem showed relatively higher susceptibility rates, with 50.0% and 37.5%, respectively.

Conclusion: Significant prevalence of multidrug-resistant K. pneumoniae infections, with CRE and ESBL strains posing substantial challenges. These findings emphasize the need for improved infection control measures and robust antibiotic stewardship programs. Future studies should include molecular analyses and broader patient populations to understand resistance mechanisms further and inform treatment strategies.

Keywords: Antibiotic Resistance; Carbapenem-Resistant Enterobacterales; Extended-Spectrum Beta-Lactamases; *Klebsiella pneumoniae*

Introduction

Klebsiella pneumoniae is a gram-negative, facultatively anaerobic, non-motile, and non-flagellated bacterium belonging to the Enterobacteriaceae family. It is part of the normal flora that resides in the human gastrointestinal tract and upper respiratory tract [1,2]. This bacterium is present in the respiratory system and stool of approximately 5% of healthy individuals, but it can cause severe infections under certain conditions.

Klebsiella pneumoniae is a main cause of hospital-acquired pneumonia, accounting for about 10% of all nosocomial infections [3,4]. It is responsible for approximately 1% of bacterial pneumonia cases and is ranked among the top 10 bacteria causing hospital-acquired infections, particularly in Intensive Care Units (ICUs), where it contributes to urinary tract infections, pneumonia, and soft tissue infections [5,6]. Its primary transmission mode is through the gastrointestinal tract and the hands of healthcare workers [7,8]. Furthermore, *K. pneumoniae* is considered a common cause of hospital-acquired infections, where it is able to colonize human skin hospital environment [9].

The risk of infection with K. pneumoniae is affected by several factors such as diabetes mellitus, liver diseases, cancer, and chronic respiratory conditions, which significantly increase the risk, especially among the elderly [10,11]. Previous use of antibiotics and invasive medical procedures such as endotracheal intubation and catheterization also elevate the risk by providing opportunities for the bacterium to enter the body and cause severe infections [12]. The situation becomes more concerning with hypervirulent strains of *K. pneumoniae*, which can lead to life-threatening conditions such as liver abscesses, pneumonia, meningitis, and endophthalmitis [13].

In addition, epidemiological data indicates that K. pneumoniae strains that are hypervirulent and multidrug-resistant (MDR) are spreading worldwide, especially in Southeast Asia, with significant implications. These strains are associated with severe infections, including pneumonia, urinary tract infections (UTIs), and bloodstream infections (BSIs), which have become increasingly resistant to last-line antibiotics like carbapenems [14]. Effective infection control procedures and antimicrobial stewardship programs are needed, especially in long-term care settings where patients are extremely vulnerable, as this worrying trend makes clear [14] patients admitted at long-term care facilities are more vulnerable to infections caused by K. pneumonia since they have chronic diseases such cardiovascular diseases, diabetes, and respiratory disorders [15,16]. These infections often begin with bacterial colonization of the gastrointestinal tract or skin, which is common among these patients due to their weakened immune systems and prolonged stays in such facilities [17]. These circumstances provide a perfect habitat for bacteria to proliferate, which highlights the importance of improving preventive measures in order to decrease the risk of infection [18].

In this context, the increased use and continuous exposure to antimicrobial agents have elevated the risk of MDR strains of *K. pneumoniae*. The spread of these strains in hospitals has led to outbreaks due to their rapid transmission, particularly among ESBL-producing strains [19]. where it has steadily risen in recent years, reducing the therapeutic options available to clinicians [20,21].

The World Health Organization (WHO) has identified the rise of carbapenem-resistant K. pneumoniae as a critical public health priority, making it an alarming issue worldwide [22], previous studies conducted in Saudi Arabia support these international worries, showing that MDR strains are more common in medical institutions. However, there is a lack of information regarding prevalence rates, resistance patterns, and contributory factors in certain facilities, which emphasizes the necessity of more studies to gain a better knowledge and create efficient countermeasures [23].

The study is conducted to compare the epidemiological characteristics and antibiotic resistance of *Klebsiella pneumoniae* infections in a long-term care hospital in Riyadh, Saudi Arabia [24,25]. It focused on infection prevalence rates, contributing factors, antibiotic resistance patterns, and treatment outcomes. In addition, a sex-based comparison (males vs. females) was included as an exploratory analysis, given the observed distribution of cases in the facility and the need to determine whether certain demographic groups were more affected than others, since there are a separate warde for each gender. The results aim to enhance infection control procedures in this hospital, facilitate the development of effective infection-fighting strategies, and provide valuable insights into resistance trends.

Study objectives

(i) To compare the epidemiological data of *K. pneumoniae* infections between males and females. (ii) To determine the antibiotic resistance of multidrug-resistant (MDR) *K. pneumoniae* infections in hospitalized patients.

Materials and Methods

Retrospective cross-sectional analysis to compare microbiological culture data of *Klebsiella pneumoniae* from males and females admitted at the long-term care hospital in Riyadh, Saudi Arabia.

The study period covered two consecutive years: samples from male patients were collected between January 1, 2023, and December 31, 2023, while samples from female patients were collected between January 1, 2024, and December 31, 2024.

Inclusion criteria encompassed all inpatients with confirmed infections based on positive microbiological cultures during the study period. Exclusion criteria included cultures obtained from outpatients and those indicating non-pathogenic colonization with *K. pneumoniae*.

Data were collected from paper records of microbiological cultures maintained by the infection control department and subsequently transferred to a dedicated spreadsheet using Excel software (Microsoft Corp., Redmond, USA). The collected data included patients' demographic characteristics, culture sites, antibiotic susceptibility test results, 30-day mortality data (to verify whether deaths within this period were directly related to *K. pneumoniae* infection).

Antibiotic susceptibility testing was conducted using the disk diffusion method following the Clinical and Laboratory Standards Institute guidelines (CLSI). These guidelines outline standard procedures for determining microbial resistance to antibiotics by measuring the inhibition zones around antibiotic disks [26]. The results of these tests were used to identify resistance patterns of *K. pneumoniae* strains to 17 different antibiotics.

The study received ethical approval from the Saudi Ministry of Health Institutional Review Board (#H1RI-17-Mar24-01). It adhered to the principles of the Declaration of Helsinki, current legislation regarding research on human subjects, and Good Clinical Practice guidelines. The subjects' confidentiality and privacy were maintained throughout the study.

Descriptive statistics were applied to describe patients' demographic characteristics, culture site distribution, and antibiotic resistance patterns. Chi-square tests were employed to explore potential relationships between medical factors, carbapenem-resistant Enterobacterales (CRE) prevalence, and extended-spectrum beta-lactamase (ESBL) resistance patterns in *K. pneumoniae* infections. Statistical analysis was performed using SPSS version 25 (IBM Corp., Armonk, USA). A P-value of less than 0.05 was considered statistically significant.

Result

56 samples were obtained from patients with *Klebsiella pneumoniae* infections, comprising 51.8% males (n = 29) and 48.2% females (n = 27). The patients' ages ranged from less than 30 years to 60 years and above, with 14.3% being under 30 years, 28.6% aged 30 to 44 years, 33.9% aged 45 to 59 years, and 23.2% aged 60 years or older. The duration of hospital stays varied widely among the patients, with 32.1% staying less than 65 days, 35.7% staying between 65 and 270 days, 17.9% staying between 271 and 629 days, and 14.3% staying for 630 days or more.

Among the patients, 46.4% had bedsores, while 53.6% did not. All patients (100%) had Foley catheters during their hospitalization; 64.3% had tracheostomies, whereas 35.7% did not. Specimen cultures were obtained from various sites, including blood (8.9%), sputum (19.6%), urine (35.7%), and wounds (35.7%). Antibiotic resistance patterns revealed that 51.8% of isolates were classified as CRE, 35.7% were ESBL producers, and 12.5% were recorded as "Unknown resistance profiles", These cases represented situations where antimicrobial susceptibility testing was incomplete or confirmatory ESBL/CRE classification was not performed. Notably, no deaths were recorded within 30 days of diagnosis, indicating a 100% survival rate (Table 1).

Table 1 provides a detailed summary of the clinical characteristics of patients with *K. pneumoniae* infections. CRE: Carbapenem-resistant Enterobacterales; ESBL: Extended-spectrum beta-lactamases.

Characteristics	Frequency	Percent
Gender		
Female	27	48.2%
Male	29	51.8%
Age Group		
Less than 30	8	14.3%
30 to 44	16	28.6%
45 to 59	19	33.9%
60 and above	13	23.2%
Stay Duration Group		
Less than 65 days	18	32.1%
65 to 270 days	20	35.7%
271 to 629 days	10	17.9%
630 days and above	8	14.3%
Bedsores		
Yes	26	46.4%
No	30	53.6%
Foley catheter		
Yes	56	100.0%
Tracheostomy		
Yes	36	64.3%
No	20	35.7%
Place culture		
Blood	5	8.9%
Sputum	11	19.6%
Urine	20	35.7%
Wound	20	35.7%
Antibiotic Resistance		
CRE	29	51.8%
ESBL	20	35.7%
Unknown	7	12.5%
Death within 30 Days		
No	56	100.0%

Table 1: Clinical Characteristics of Patients with *Klebsiella pneumoniae* (n = 56).

Analysis of antimicrobial susceptibility among the bacterial isolates highlighted a concerning rise in resistance levels, particularly against commonly prescribed antibiotics. High resistance rates were observed for cotrimoxazole (64.3%), ciprofloxacin (33.9%), gentamicin (39.3%), imipenem (39.3%), meropenem (32.1%), and amikacin (32.1%). Other antibiotics with comparatively lower resistance included cefepime (17.9%), piperacillin/tazobactam (Tazocin) (14.3%), and ertapenem (23.2%). Imipenem and meropenem demonstrated the highest susceptibility percentages at 50.0% and 37.5%, respectively, suggesting their potential as effective treatment options. Tigecycline showed no resistance, with 3.6% intermediate susceptibility and 10.7% susceptibility. Several antibiotics, including ceftriaxone, cefotaxime, and ampicillin, exhibited notable resistance with minimal or no intermediate or susceptible isolates (Table 2).

Type	Resistant	Intermediate	Sensitive
Ampicillin	11 (19.6%)	-	-
amoxicillin/ clavulanate (Augmentin)	4 (7.1%)	-	7 (12.5%)
Amikacin	18 (32.1%)	-	20 (35.7%)
Cefepime	10 (17.9%)	-	3 (5.4%)
Cefotaxime	7 (12.5%)	1 (1.8%)	9 (16.1%)
Ceflazidme	8 (14.3%)	-	2 (3.6%)
Cerftriaxone	6 (10.7%)	-	4 (7.1%)
Ciprofloxacin	19 (33.9%)	-	6 (10.7%)
Cotrimoxazole	36 (64.3%)	-	19 (33.9%)
Gentamicin	22 (39.3%)	-	18 (32.1%)
Imipenem	22 (39.3%)	-	28 (50.0%)
Meropenem	18 (32.1%)	2 (3.6%)	21 (37.5%)
Ertapenem	13 (23.2%)	1 (1.8%)	15 (26.8%)
piperacillin/ tazobactam (Tazocin)	8 (14.3%)	-	4 (7.1%)
Colistin	1 (1.8%)	4 (7.1%)	1 (1.8%)
Tigecycline	-	2 (3.6%)	6 (10.7%)
Nitrofurantoin	4 (7.1%)	8 (14.3%)	9 (16.1%)
Total	207(21.7)	18(1.9%)	172(18%)

Table 2: Antimicrobial Susceptibility Testing for *Klebsiella pneumoniae* (n = 56).

Table 2 details the antimicrobial susceptibility testing results for the 56 *K. pneumoniae* isolates obtained from the study participants. Antibiotics are categorized by type, and each antibiotic's percentages of resistance, intermediate susceptibility, and susceptibility are determined.

As shown in Table 3, we found a significant association between gender and CRE infections (p = 0.012). Male patients were slightly more likely to demonstrate CRE infections (26.8%) compared to female patients (25.0%). Conversely, ESBL-producing isolates were more common in females (23.2%) compared to males (12.5%). Unknown resistance patterns were only observed in males (12.5%) and not in females. The age group was not significantly associated with CRE or ESBL infections (p = 0.698). Patients aged 45 to 59 years had the highest proportion of CRE infections (17.9%), while those aged less than 30 years had the lowest (3.6%). ESBL-producing isolates were most common in patients aged less than 30 years (8.9%) and least common in those aged 60 years and above (5.4%). Unknown resistance patterns were distributed similarly across age groups, with no significant variation.

The relation between duration of hospital stay and CRE or ESBL infections was not statistically significant (p = 0.666). CRE infections were most prevalent in patients with stays between 65 and 270 days (21.4%) and least prevalent in those with 630 days or more (3.6%). ESBL-producing isolates were most common in patients with shorter stays (less than 65 days, 12.5%) and least common in those with intermediate stays (271 to 629 days; 5.4%).

Bedsores were not significantly associated with CRE or ESBL infections (p = 0.184). Patients with bedsores had a slightly higher prevalence of CRE infections (28.6%) compared to those without (23.2%). In contrast, ESBL-producing isolates were more common in patients without bedsores (25.0%) than those with bedsores (10.7%). Unknown resistance patterns were observed slightly more frequently in patients with bedsores (7.1%) than those without (5.4%).

A tracheostomy was not significantly associated with CRE or ESBL infections (p = 0.431). However, patients with a tracheostomy were more likely to have CRE infections (35.7%) than those without (16.1%). ESBL-producing isolates were also more common in patients with a tracheostomy (23.2%) than those without (12.5%). Unknown resistance patterns were slightly more prevalent in patients without a tracheostomy (7.1%).

The distribution of resistance patterns relative to the culture site was also non-significant (p = 0.957). CRE was most prevalent in wound cultures (19.6%) and least prevalent in blood cultures (5.4%). ESBL-producing isolates were most common in urine cultures (14.3%) and least common in blood cultures (3.6%). Unknown resistance patterns were rare across all culture sites, with the highest prevalence in urine and wound cultures (5.4%).

All subjects had Foley catheters, making statistical analysis of their association with resistance patterns infeasible. There were no deaths within 30 days, so this characteristic was not analyzed for association with resistance patterns (Table 1).

Items	Characteristic	CRE	ESBL	Unknown	Total	P-value
Gender	Female	14 (25.0%)	13 (23.2%)	0 (0.0%)	27 (48.2%)	0.012
	Male	15 (26.8%)	7 (12.5%)	7 (12.5%)	29 (51.8%)	
Age Group	<30 days	2 (3.6%)	5 (8.9%)	1 (1.8%)	8 (14.3%)	0.698
	30 to 44	9 (16.1%)	5 (8.9%)	2 (3.6%)	16 (28.6%)	
	45 to 59	10 (17.9%)	7 (12.5%)	2 (3.6%)	19 (33.9%)	
	≥60 days	8 (14.3%)	3 (5.4%)	2 (3.6%)	13 (23.2%)	
Stay Duration	<65 days	9 (16.1%)	7 (12.5%)	2 (3.6%)	18 (32.1%)	0.666
	65 to 270 days	12 (21.4%)	5 (8.9%)	3 (5.4%)	20 (35.7%)	
	271 to 629 days	6 (10.7%)	3 (5.4%)	1 (1.8%)	10 (17.9%)	
	≥630 days	2 (3.6%)	5 (8.9%)	1 (1.8%)	8 (14.3%)	
Bedsores	Yes	16 (28.6%)	6 (10.7%)	4 (7.1%)	26 (46.4%)	0.184
	No	13 (23.2%)	14 (25.0%)	3 (5.4%)	30 (53.6%)	
Tracheostomy	Yes	20 (35.7%)	13 (23.2%)	3 (5.4%)	36 (64.3%)	0.431

	No	9 (16.1%)	7 (12.5%)	4 (7.1%)	20 (35.7%)	
Place culture	Blood	3 (5.4%)	2 (3.6%)	0 (0.0%)	5 (8.9%)	0.957
	Sputum	6 (10.7%)	4 (7.1%)	1 (1.8%)	11 (19.6%)	
	Urine	9 (16.1%)	8 (14.3%)	3 (5.4%)	20 (35.7%)	
	Wound	11 (19.6%)	6 (10.7%)	3 (5.4%)	20 (35.7%)	
Foley catheter	Yes	29 (51.8%)	20 (35.7%)	7 (12.5%)	56 (100.0%)	N/A
Death within 30 days	No	29 (51.8%)	20 (35.7%)	7 (12.5%)	56 (100.0%)	N/A

Table 3: Medical and Other Factors Associated with CRE and ESBL Resistance Patterns.

Table 3 highlights the associations between *Klebsiella pneumoniae* infections, CRE prevalence, and ESBL resistance patterns while identifying potential risk factors for multidrug-resistant (MDR) strains. CRE: Carbapenem-resistant Enterobacterales; ESBL: Extended-spectrum beta-lactamases; MDR: Multidrug-resistant.

Discussion

The current study investigated the epidemiological characteristics and antibiotic resistance of *Klebsiella pneumoniae* infections among patients hospitalized in a long-term care hospital. The main findings revealed a high prevalence of CRE at 51.8%, alongside 35.7% of ESBL. This concerning trend highlights the challenges of managing infections caused by CRE and ESBL isolates, as they are associated with limited treatment options and increased mortality, particularly in critically ill and immunocompromised patients (Table 1).

Patients with tracheostomies demonstrated a higher prevalence of CRE (35.7%) compared to those without tracheostomies (16.1%, p = 0.431). Similarly, patients with bedsores exhibited a slightly higher prevalence of CRE infections (28.6%) compared to those without (23.2%, p = 0.184). Although these differences were not statistically significant, they suggest that specific clinical conditions may contribute to the risk of CRE infections. Moreover, the distribution of resistance patterns relative to culture sites showed that CRE was most frequently isolated from wound and urine cultures, each accounting for 35.7% of isolates.

The high prevalence (51.8%) of CRE among *K. pneumoniae* isolates aligns with concerning trends reported by other studies conducted in Saudi Arabia. One study conducted in Riyadh identified that 36.1% of *K. pneumoniae* isolates from blood cultures exhibited CRE resistance [23]. Another study conducted in Makkah highlighted a significant rise in carbapenem resistance rates, with imipenem resistance increasing from 6.6% in 2011 to 59.9% in 2021 [26]. These findings underscore the alarming levels of antibiotic resistance associated with *K. pneumoniae* infections in healthcare facilities across the region, emphasizing the urgent need for enhanced infection control measures and antibiotic stewardship programs.

The current study also reported high resistance rates to several commonly used antibiotics, including cotrimoxazole (64.3%), ciprofloxacin (33.9%), gentamicin (39.3%), imipenem (39.3%), and meropenem (32.1%). These findings are consistent with a previous study conducted in Medina, which reported resistance rates exceeding 50% for carbapenems, fluoroquinolones, and cephalosporins [8]. Furthermore, similar resistance rates were reported among *K. pneumoniae* urinary isolates, with high resistance to piperacillin (81.6%), levofloxacin (78.9%), and ampicillin (76.3%). Other antibiotics, such as cefotaxime (73.7%), trimethoprim-sulfamethoxazole (71.1%), ceftazidime (65.8%), and gentamicin (63.2%), also showed elevated resistance rates [27].

Notably, ceftriaxone resistance in a hospital in southern Saudi Arabia was exceptionally high at 94.3%, alongside elevated resistance rates to aztreonam (92.2%) and cefuroxime (97.9%) [28]. In contrast, the current study recorded a relatively lower ceftriaxone resistance rate of 39.3%. Despite being conducted in different regions of the same country, this variation in resistance rates across studies may reflect differences in sample types, hospital settings, or treatment protocols implemented in each healthcare facility. These findings underscore the need to strengthen antibiotic

resistance monitoring and develop unified strategies to combat the spread of multidrug-resistant (MDR) strains. Such measures would contribute significantly to improving healthcare quality across Saudi Arabia.

Interestingly, the current study did not identify a significant association between age groups and CRE or ESBL infections ($p = 0.698$). However, patients aged 45 to 59 years old exhibited the highest proportion of CRE infections (17.9%), while ESBL-producing isolates were most common among patients under 30 years of age (8.9%). These findings partially diverge from prior research, which reported higher resistance rates in older patients [27]. This variability highlights the complex interplay of demographic and clinical factors in the epidemiology of *K. pneumoniae* infections.

Despite the widespread use of Foley catheters among the study patients, no significant association was observed between catheter use and resistance patterns. While invasive devices are recognized risk factors for healthcare-associated infections, they may not directly drive the prevalence of MDR *K. pneumoniae*.

A noteworthy finding in this study was the absence of 30-day mortality among patients with K. pneumoniae infections. When compared with international literature, where CRE and ESBL infections are often linked to high morbidity and mortality, our findings suggest that outcome variations may be explained by differences in patient populations, infection types, and healthcare settings. Thus, the absence of deaths in this cohort should not be interpreted as evidence of a benign clinical course, but rather as a reflection of timely infection management in the LTC setting, the predominance of non-bacteremic cases, and the relatively small sample size that may have limited the ability to capture mortality events.

The findings emphasize the urgent need to strengthen infection control measures and implement robust antibiotic stewardship programs to combat the spread of multidrug-resistant strains. Our results should be interpreted in light of certain limitations, including the relatively small sample size and single-center focus, which may limit the generalizability of the findings. Additionally, the hospital had a limited bed rotation rate and capacity, contributing to the relatively small sample size.

In conclusion, the findings emphasize significant associations between risk factors such as tracheostomies, bedsores, and prolonged hospital stays with multidrug-resistant infections, underscoring the urgent need for targeted interventions to address these healthcare-associated challenges. Improving infection control protocols and implementing robust antibiotic stewardship programs seem to be necessary. Furthermore, future epidemiological studies with larger populations, including detailed molecular analyses, are recommended to improve the understanding of resistance patterns and optimize strategies for effective antibiotic management in long-term care settings.

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