

Research Article



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EVALUATION OF HOSPITAL AND COMMUNITY-ACQUIRED INFECTION RATES FOR KLEBSIELLA PNEUMONIAE THAT PRODUCES CARBAPENEMS

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ABSTRACT

Background: The most frequent pathogens in the Enterobacteriaceae family that cause fatal infections include Klebsiella pneumoniae, for which carbapenems are used as a last option to treat drug-resistant Gram-negative bacterial infections. The growing incidence of carbapenem-resistant Klebsiella species has been blamed for a number of treatment failures in recent years.

Aim: The purpose is to determine how common hospital and community-acquired infections are caused by Klebsiella pneumoniae that produces carbapenems.

Methods: During the designated study period, samples submitted to the Institute's Microbiology Laboratory were evaluated for this investigation. Klebsiella pneumoniae was isolated from a variety of clinical samples among processed samples, and the isolates were categorized based on clinical history of hospital-acquired and community-acquired illnesses. The Kirby-Bauer disc diffusion method was used for antibiotic susceptibility testing, or AST. The Modified Carbapenemase Inactivation Test (m-CIM) was used to identify carbapenemase manufacturers.

Results: 246 Klebsiella pneumonia isolates were obtained from various clinical samples during the study period. Of these isolates, 58% (n=142) were linked to hospital-acquired infections, 27% (n=66) tested positive for the m-CIM test, and 42% (n=104) caused community-acquired illnesses. Tigecycline had the highest sensitivity for community-acquired infections (89%; 92 samples), followed by imipenem and meropenem (87%; 45 samples). K. pneumoniae-producing carbapenems exhibited complete resistance to ampicillin and piperacillin-tazobactam.

Conclusion: The current investigation finds that K. pneumoniae isolates have a high rate of carbapenemase synthesis. When treating K. pneumoniae that produces carbapenemase empirically, tigecycline is the recommended medication. Better knowledge of the threat posed by antibiotic resistance is made possible by the current study, which also helps doctors utilize and select the best treatments.

Keywords: Carbapenemase, Community acquired infection, Hospital infection, Klebsiella pneumonia, antibiotic resistance

INTRODUCTION

The number of multidrug-resistant organisms that cause healthcare-associated infections (HAI) and community-acquired infections (CAI) has been reported to be rapidly increasing. These organisms represent a significant threat to society and public health. This condition's primary cause is the rise in antibiotic overuse in veterinary care, agriculture, and human medicine. A concerning rise in antibiotic-resistant bacteria is being caused by microorganisms that cause hospital-acquired infections or illnesses in the general population. Of these, Enterobacteriaceae, especially Klebsiella pneumoniae, are frequently responsible for fatal illness.¹

All beta lactams, with the exception of carbapenems, are ineffective against organisms that produce ESBL (Extended-spectrum β -Lactamase) and AmpC (Ampicillin cephalosporinase). As a result, carbapenems are frequently used to treat a variety of illnesses brought on by these substances. As a major source of transferable antibiotic resistance, *Klebsiella pneumoniae* treatment failure has been linked to a rise in carbapenem-resistant *Klebsiella* species in recent years. These microorganisms can cause serious infections that are life-threatening and increase morbidity and mortality, as well as colonization of mucous membranes and skin.²

Determining the risk factors for CRE (Carbapenem-Resistant Enterobacterales) colonization is essential for both clinical and epidemiological comprehension. Immunosuppression, prior operations, invasive procedures, long-term use of broad-spectrum antibiotics, and prolonged hospital stays are all important risk factors. The clinical importance and prevalence of CRE infections that originate in the community are not well characterized, despite the fact that the function of CRE transmission in healthcare settings is widely documented.³

Doctors have a lot of difficulties because of carbapenem resistance, which makes the spread and development of carbapenem-resistant *Klebsiella pneumoniae* a serious clinical and public health issue. Numerous factors contribute to this resistance. Inappropriate antibiotic coverage, de-escalation treatment, delayed diagnosis, resistance development, and antibiotic abuse are all greatly impacted by incorrect antibiotic prescribing. As time goes on, the problem worsens because there aren't many antimicrobials that can treat these infections.³

Identification and screening of carbapenemase manufacturers, as well as the implementation and selection of suitable treatment strategies, are essential for controlling and preventing the rise in community and hospital-acquired infections.⁴

Even though molecular methods are regarded as the gold standard, they may not be able to detect undiscovered carbapenemase genes that are not included in gene panels. To get around these restrictions, biochemical tests based on methods for detecting the hydrolysis of a carbapenem's β lactam rings have been created. There are now few management options due to the isolation of resistance genes from hospitals and communities throughout the world as well as the rise in organisms that produce carbapenemase enzymes.⁴ to determine the frequency of hospital and community-acquired infections caused by *Klebsiella pneumoniae* that produces carbapenems.

MATERIALS AND METHODS

The purpose of the current study was to determine the frequency of hospital and community-acquired infections caused by *Klebsiella pneumoniae* that produces carbapenems. The research participants were from the Institute's Department of Microbiology's Outpatient Department. Prior to research participation, informed permission was obtained verbally and in writing from all participants and school officials.

246 distinct clinical isolates of pneumonia were evaluated in this study from a variety of clinical samples that were gathered for analysis. One isolate was taken into consideration for each person in the investigation. Based on a number of criteria, the study's samples were gathered over the allotted research time, and diseases were classified as either hospital-acquired infections (HAI) or community-acquired infections (CAI).

The Sastry AR8 criteria from 2019 were taken into consideration for hospital-acquired infections. These criteria included the following: the infection should not be incubating or have no symptoms at the time of admission; the patient must have been admitted for a reason other than the infection; and the infection must have manifested within 30 days of leaving the facility or within 48 hours of admission. Subjects with CAI had no prior encounters and were diagnosed within 48 hours of admission. If an isolate had a history of repeated hospitalizations, they were categorized as either CAI or HAI. Mueller Hinton Agar was used for antibiotic sensitivity testing using the Kirby Bauer disc diffusion technique in accordance with CLSI guidelines, any antibiotic regimen used during the stay, and a thorough patient history pertaining to prior hospital stays. All *K pneumoniae* isolates were tested for the generation of carbapenemase on Mueller Hinton agar using 10 μ g of Ertapenem. The samples were then subjected to the Modified Carbapenemase Inactivation Test (mCIM) to confirm that they produced carbapenemase.

The findings of the mCIM test were divided into three zones: carbapenemase intermediate (16–18 mm), carbapenemase negative (>19 mm), and carbapenemase positive (6–15 mm), in accordance with Zahedi BA et al. 10 from 2021.

Utilizing the chi-square test, Fisher's exact test, Mann Whitney U test, and SPSS (Statistical Package for the Social Sciences) software version 24.0 (IBM Corp., Armonk, NY, USA), the collected data was statistically examined using the student's t-test, chi-square test, and ANOVA. A significance threshold of less than 0.05 was taken into consideration.

RESULTS

The purpose of the current study was to determine the frequency of hospital and community-acquired infections caused by *Klebsiella pneumoniae* that produces carbapenems. The samples submitted to the Institute's Microbiology Laboratory

throughout the designated research period were evaluated in this investigation. *Klebsiella pneumoniae* was isolated from a variety of clinical samples among processed samples, and the isolates were categorized based on clinical history of hospital-acquired and community-acquired illnesses. Among the 52% (n=128) female and 48% (n=118) male research participants, it was observed that 48% (n=68) of the male and 59% (n=84) of the female individuals had a hospital-acquired infection. In terms of age distribution, 35% (n=88) of the participants were between the ages of 1 and 30, and 30% (n=74) were between the ages of 31 and 60.

According to Table 1, hospital acquired infection was seen in 22% (n=32) of the 14% (n=36) newborns less than 23 days. According to the study's findings, *K pneumoniae* was isolated from wound swabs in 35% (n=86) of the hospital-acquired infections related to surgical site infections (SSIs), followed by urine samples in 27% (n=68) of the subjects and 23% (n=32) of the samples related to catheter-associated urinary tract infections (CAUTIs). In addition to causing newborn bloodstream infections, the majority of the blood samples that were obtained were linked to hospital-acquired illnesses in 17% (n=24) of the samples. The pattern of antibiotic sensitivity to hospital and community-acquired infections revealed that ampicillin, cefotaxime, and levofloxacin sensitivity were statistically significant ($p < 0.001$, 0.002, and 0.01 to 0.01 correspondingly).

Similar noteworthy findings were seen for nitrofurantoin and fosfomycin, which were considerably lower in hospital-acquired infections than in community-acquired infections ($p < 0.05$). The opposite was true for hospital-acquired infections, which showed increased susceptibility to tigecycline, meropenem, imipenem, gentamycin, and tobramycin. Additionally, the study found that 42.2% (n=60) of the CP-KP were associated with hospital settings, whereas 5.7% (n=6) of the CP-KP were acquired in the community. Ampicillin, cefotaxime, piperacillin, and tazobactam all exhibited 100% resistance, indicating higher levels of resistance (Table 2 and 3).

The pattern of resistance in common aminoglycosides was highlighted by the observation of high resistance of over 60% with Gentamycin and Tobramycin. Non-CP-KP showed less resistance to several antibiotics than CPKP. Resistance was seen in 14% and 16% of imipenem and meropenem cases, respectively, indicating that these carbapenems are still effective against non-CP-KP.

DISCUSSION

Samples submitted to the Institute's Microbiology Laboratory throughout the designated research period were evaluated for the current investigation. *Klebsiella pneumoniae* was isolated from a variety of clinical samples among processed samples, and the isolates were categorized based on clinical history of hospital-acquired and community-acquired illnesses. Among the 52% (n=128) female and 48% (n=118) male research participants, it was observed that 48% (n=68) of the male and 59% (n=84) of the female individuals had a hospital-acquired infection. In terms of age range, 35% (n=88) of the respondents were between the ages of 1 and 30, and 30% (n=74) were between the ages of 31 and 60. 22% (n=32) of the 14% (n=36) infants under 23 days of age had a hospital-acquired infection.

The findings were similar to those from earlier research by Arnold RS et al. (2011) and Karaikos I et al, in which the authors evaluated specimens with similar demographic features to the current study. *K pneumoniae* was isolated from wound swabs in 35% (n=86) of the study's subjects who had hospital-acquired infections, primarily associated with surgical site infections (SSIs). Urine samples were isolated from 27% (n=68) of the subjects, and 23% (n=32) of the samples were associated with catheter-associated urinary tract infections (CAUTIs). In addition to causing newborn bloodstream infections, the majority of the blood samples that were obtained were linked to hospital-acquired illnesses in 17% (n=24) of the samples.

These results were consistent with those of Pitout JD et al (2015) and Kaushal SK et al, who reported that the cultures and isolates of *K pneumoniae* from wound swabs to SSI (surgical site infection) followed by urine samples and CAUTI were similar to the findings of the current study.

In terms of the pattern of antibiotic sensitivity to hospital and community-acquired infections, the study's findings indicated that ampicillin, cefotaxime, and levofloxacin sensitivity were statistically significant ($p < 0.001$, 0.002, and 0.01 correspondingly). Similar noteworthy outcomes were observed for nitrofurantoin and fosfomycin, which were considerably lower in hospital-acquired infections than in community-acquired infections ($p < 0.05$).

In contrast, hospital-acquired infections were shown to be more susceptible to tigecycline, meropenem, imipenem, gentamycin, and tobramycin. Furthermore, 42.2% (n=60) of the study's participants had CP-KP associated with hospital settings, while 5.7% (n=6) of the participants had CP-KP acquired in the community. Ampicillin, cefotaxime, piperacillin, and tazobactam all exhibited 100% resistance, indicating higher levels of resistance. These results aligned with those of Machuca I et al. and Matovina M et al, who also showed a similar pattern of antibiotic sensitivity to hospital and community-acquired illnesses in their respective investigations.

A pattern of resistance in common aminoglycosides was highlighted by the study's findings, which also revealed that Gentamycin and Tobramycin had a high resistance of over 60%. The non-CP-KP showed less resistance to numerous antibiotics than the CPKP. Ipenem and meropenem had resistance in 14% and 16% of patients, respectively, indicating that these carbapenems are still effective against non-CP-KP, although some resistance was seen. These results aligned with the findings of Mukherjee S et al. and Pawar S et al, who revealed a pattern of resistance in common aminoglycosides and showed high resistance of over 60% with Gentamycin and Tobramycin.

CONCLUSION

Given its limitations, the current investigation comes to the conclusion that *K. pneumoniae* isolates produce carbapenemase at a significant rate. When treating *K. pneumoniae* that produces carbapenemase empirically, tigecycline is the recommended medication. Better knowledge of the threat posed by antibiotic resistance is made possible by the current study, which also helps doctors utilize and select the best treatments.

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S. No	characteristics	Community acquired		Hospital acquired	
		n=104	%	n=142	%
1.	Age range				
a)	1-23 days (n=36)	4	4	32	22
b)	1-30 years (n=88)	40	38	48	34
c)	31-60 years (n=74)	36	35	38	27
d)	61-90 years (n=48)	24	23	24	17
2.	Gender				
a)	Females (n=128)	48	46	84	59
b)	Males (n=118)	50	48	68	48
3.	Sample type				
a)	Mothers milk (n=2)	2	2	-	-
b)	Pleural fluid (n=2)	2	2	-	-

c)	Tracheal aspirate (n=10)	-	-	10	7
d)	Ear swab (n=6)	6	6	-	-
e)	Blood (n=30)	6	6	24	17
f)	Sputum (n=42)	20	19	22	15
g)	Urine (n=68)	36	31	32	23
h)	Wound swab (n=86)	32	31	54	38

Table 1: Comparison of community acquired infections (CAI) and hospital acquired infections (HAI) in study subjects concerning demographic data

S. No	Antibiotics	CAI sensitivity		HAI sensitivity		p-value
		n=104	%	n=142	%	
1.	Nitrofurantoin	34	71	8	44	<0.001
2.	Levofloxacin	60	48	52	36	<0.001
3.	Tigecycline	92	89	72	54	<0.001
4.	Piperacillin-Tazobactam	76	73	44	31	<0.001
5.	Ertapenem	94	90.3	64	45	<0.001
6.	Meropenem	90	87	64	45	<0.001
7.	Imipenem	90	87	68	48	<0.001
8.	Cefotaxime	58	46	40	28	0.002
9.	Amoxiclav	48	46	54	38	0.344
10.	Gentamycin	88	85	62	44	<0.001
11.	Tobramycin	86	83	58	41	<0.001
12.	Ampicillin	20	19	8	6	0.01

Table 2: Antibiotic sensitivity pattern comparison of K. pneumoniae causing HAI and CAI

S. No	Infection type	m-CIM positive		Ertapenem resistant		Ertapenem sensitive	
1.	CAI	6	5.7	10	9.6	94	90.3
2.	HAI	60	42.2	78	54	64	45
3.	Total	66	27	88	35.7	246	

Table 3: Carbapenemase producing K pneumoniae detection by m-CIM in study samples