

Original article

Prevalence of carbapenem-resistant *Klebsiella pneumoniae* in King Chulalongkorn Memorial Hospital, 2019–2023

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Abstract

Background: Carbapenem-resistant *Klebsiella pneumoniae* (CR-KP) poses a significant threat to public health worldwide as it contributes to high morbidity and mortality rates.

Objective: This study aimed to investigate the prevalence of CR-KP isolated at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, from April 2019 to December 2023, focusing on its distribution across various hospital units, including in-patient department (IPD), out-patient department (OPD), emergency room (ER), and intensive care unit (ICU).

Methods: A total of 8,983 *K. pneumoniae* isolates from patients aged > 15 years at King Chulalongkorn Memorial Hospital between April 2019 and December 2023 were studied. Antimicrobial susceptibility to carbapenems was analyzed using the chi-square test.

Results: The annual prevalence of CR-KP from 2019 to 2023 was 15.2%, 11.7%, 19.8%, 29.0%, and 25.2%, respectively. The ICU had the highest prevalence of CR-KP, followed by IPD and OPD. The resistance rates in the OPD increased 3.5–4.0-fold between 2019 and 2023, whereas the ICU and IPD rates increased 1.5–2.0-fold during the same period. Significant differences in the prevalence of CR-KP were observed across the various units and years ($P < 0.01$). Amikacin exhibited the highest susceptibility (90.4%–96.1%).

Conclusion: The prevalence of CR-KP has increased significantly at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, particularly in the ICU. There are significant differences in resistance across the different hospital units over time, thus emphasizing the need for enhanced infection control and antimicrobial monitoring.

Keywords: Carbapenem resistance, carbapenems, *Klebsiella pneumoniae*.

Antimicrobial resistance is a crucial public health issue that leads to increased infection rates, prolonged hospital stays, higher healthcare costs, and high mortality rates. Among the order Enterobacterales, *Klebsiella pneumoniae* (*K. pneumoniae*) is a foremost pathogen in community- and hospital-acquired infections, which include pneumonia, bloodstream infections, and urinary tract infections. The prevalence of carbapenem-resistant

K. pneumoniae (CR-KP) has been increasing worldwide, including in Thailand. ⁽¹⁻⁹⁾ These resistant strains often produce extended-spectrum beta-lactamases, which confer resistance to cephalosporins and require the use of carbapenems. However, the emergence of carbapenem resistance caused by mechanisms such as carbapenemase production, target modification, and decreased drug uptake or increased efflux pumps poses substantial treatment challenges. ⁽¹⁰⁾ Alternative treatment options, such as colistin, tigecycline, or fosfomycin, have limitations, including toxicity and the need for combination therapy. ⁽¹¹⁾

Therefore, this study aimed to determine the prevalence of CR-KP infection at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, and

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compare the rate of antibiotic-resistant strains among the different patient wards. These findings will help physicians make informed decisions regarding appropriate antibiotic selections.

Materials and methods

This study was reviewed and approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Chulalongkorn University (IRB no. 0646/67; COA no. 1429/2024).

Bacterial isolates

This retrospective cohort study was conducted at King Chulalongkorn Memorial Hospital, Thai Red Cross Society in Bangkok, Thailand, from April 2019 to December 2023. This study focused on *K. pneumoniae* isolations obtained from patients aged >15 years. All isolates were initially identified from clinical samples and subsequently subjected to antimicrobial susceptibility testing in the microbiology laboratory. Carbapenem-resistant and intermediate-resistant strains were included in the study.

Identification and antimicrobial susceptibility testing

All *K. pneumoniae* isolates were identified using conventional biochemical tests and matrix-assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS). The susceptibility of patients to carbapenems and other antimicrobial agents was determined using the VITEK® 2 system (BioMérieux, France) and interpreted according to the Clinical and Laboratory Standards Institute guidelines.

Statistical analysis

Data were expressed as numbers and percentages. Statistical significance was set at $P < 0.05$.

Results

Between April 2019 and December 2023, a total of 8,983 *K. pneumoniae* isolates were obtained from patients in different wards and clinical settings at King Chulalongkorn Memorial Hospital, Thai Red Cross Society. These isolates were derived from various clinical specimens, including blood, body fluids, urine, respiratory secretions, pus, etc., as outlined in **Table 1**.

The prevalence of CR-KP isolates at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, in 2019, there were 248 out of 1,630 *K. pneumoniae* isolates identified as CR-KP, accounting for a rate of 15.2%. This number decreased slightly to 227 of the 1,932 isolates (11.7%) in 2020. Subsequently, there was a steady increase in the number of CR-KP isolates to 355 out of 1,788 isolates (19.8%) in 2021 and 541 out of 1,867 isolates (29.0%) in 2022. However, in 2023, the prevalence decreased to 446 out of 1,766 (25.2%) isolates. Statistically significant differences in the prevalence of CR-KP were observed between the years 2019 and 2023 ($P < 0.05$).

The prevalence of CR-KP in out-patient department (OPD) and in-patient department (IPD) between 2019 and 2023 is shown in **Figure 1**. CR-KP was most prevalent in the intensive care unit (ICU), followed by IPD. The prevalence of CR-KP in OPD was generally lower than that in the other units, except in 2021. In 2020, CR-KP rates were lower across all units than in other years. Conversely, from 2021 to 2023, the prevalence of CR-KP increased in all units compared with 2019 and 2020.

The resistance rates in the OPD from 2021 to 2023 were approximately 3.5–4.0 times higher than those in 2019. In the ICU and IPD, resistance rates in 2022 and 2023 were approximately 1.5–2.0 times

Table 1. *K. pneumoniae* isolated from various clinical specimens and wards.

Types of specimens	Number of isolates				Total
	Emergency unit	Intensive care unit	In-patient department	Out-patient department	
Blood	439	134	309	32	914
Body fluid	64	142	497	19	722
Respiratory secretion	433	987	1,407	124	2,951
Urine	1,226	245	1,423	370	3,264
Pus	102	121	505	102	830
Other specimens	20	76	166	40	302
Total	2,284	1,705	4,307	687	8,983

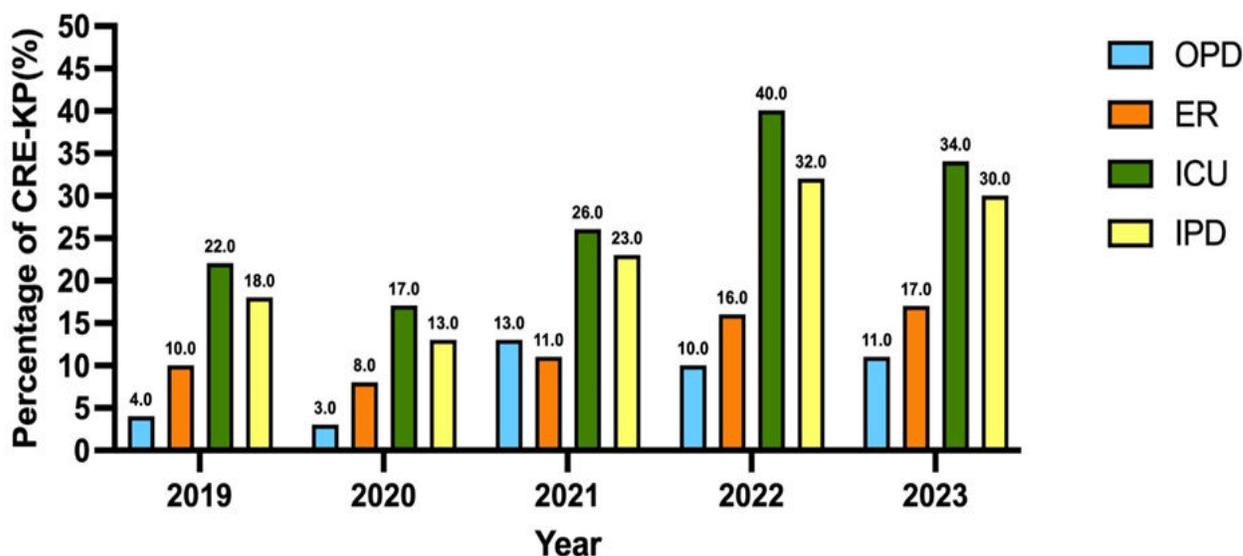


Figure 1. The percentage of CR-KP identified in outpatient and in-patient department at King Chulalongkorn Memorial Hospital, Thai Redcross Society during 2019 and 2023. CR-KP, Carbapenem-resistant *Klebsiella pneumoniae*; ER, emergency room; ICU; intensive care unit; IPD, in-patient; OPD, out-patient department.

Table 2. The percentage of CR-KP identified in specimen distribution at King Chulalongkorn Memorial Hospital, Thai Redcross Society during 2019 and 2023.

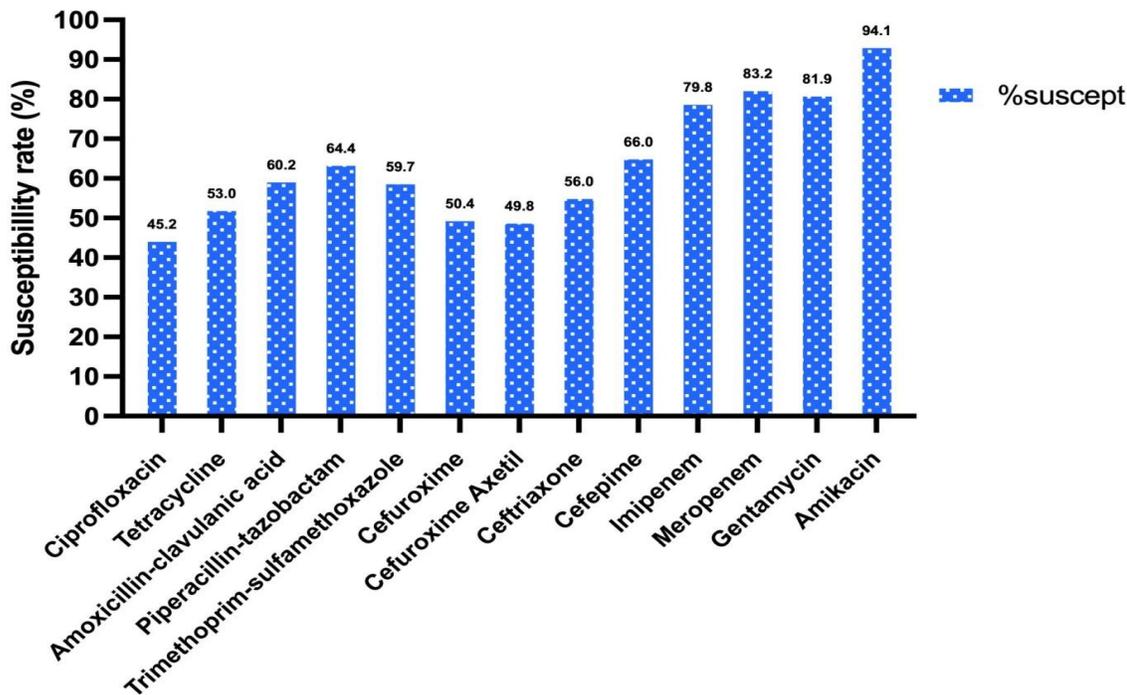
Year	Percentage of CR-KP isolates in each specimen				
	Blood	Body fluid	Urine	Respiratory	Pus
2019	14.5	16.8	22.1	10.1	12.1
2020	10.5	20.2	10.3	10.9	12.3
2021	21.6	27.5	17.5	20.8	13.5
2022	30.4	42.6	24.8	31.7	24.7
2023	22.5	22.6	24.6	27.0	25.7
Overall of CR-KP	19.8	31.1	20.2	37.0	25.7

higher than those in 2019. Statistically significant differences in the prevalence of CR-KP were observed among units in each year ($P < 0.05$) and within units in the same year ($P < 0.05$).

The distribution of CR-KP in the various specimen types is shown in **Table 2**. In 2022, the percentage of CR-KP isolated from blood, body fluids, pus, and respiratory secretions was approximately 2–3 times higher than that in 2019. Between 2022 and 2023, the prevalence of CR-KP isolated from blood, urine, respiratory secretions, and pus was 22.5%–31.7%. CR-KP isolated from body fluid showed the highest rates in 2020, 2021, and 2022, whereas CR-KP isolated from the respiratory system showed the highest rates in 2023 compared with the other specimens. Overall,

CR-KP isolates had the highest rates of respiratory infection, followed by body fluid, pus, urine, and blood.

The antimicrobial susceptibility rates of *K. pneumoniae* indicated the highest susceptibility to amikacin, followed by meropenem, gentamicin, and imipenem, with rates ranging from 79.8% to 94.1%, as shown in **Figure 2**. In contrast, susceptibility rates to other antibiotics, including amoxicillin-clavulanic acid, piperacillin-tazobactam, third- and fourth-generation cephalosporins, tigecycline, trimethoprim-sulfamethoxazole, and ciprofloxacin, ranged from 45.2% to 66.0%. The summary of this study is presented in **Figure 3**.



Antimicrobial agents

Figure 2. The antimicrobial susceptibility rates of *K. pneumoniae* isolates from King Chulalongkorn Memorial Hospital, Thai Redcross Society during 2019 and 2023.

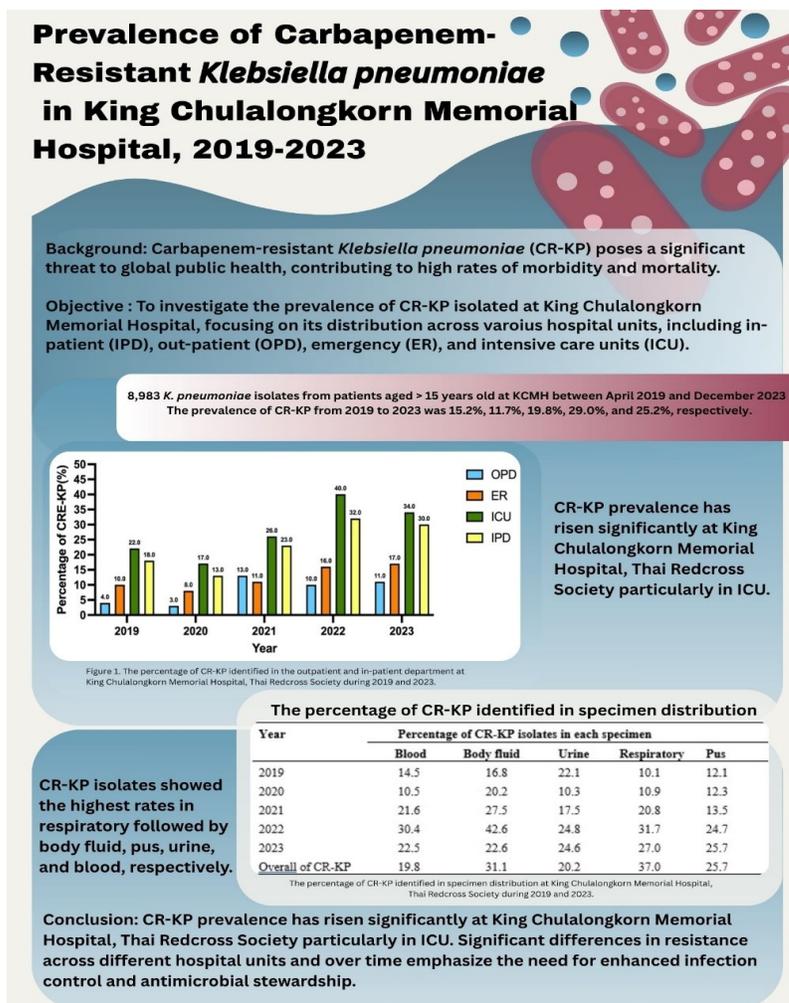


Figure 3. Prevalence and distribution of CR-KP at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, from 2019 to 2023. Distribution of CR-KP isolates across different specimen types (blood, body fluid, urine, respiratory, and pus) during the study period.

Discussion

The prevalence of CR-KP at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, increased significantly from 11.7% in 2020 to 29.0% in 2022. This rate is higher than the previously reported 17.2% across 47 hospitals in Thailand. ⁽⁸⁾ Similarly, the prevalence of CR-KP at Rajavithi Hospital increased from 1.3% in 2009 to 16.4% in 2015. ⁽⁷⁾ In Southeast Asia, CR-KP prevalence rates vary, with Malaysia, Myanmar, Indonesia, and Vietnam reporting rates ranging from 7.9% to 9.5%. ⁽³⁾ In addition, a previous study showed a 29.8% resistance rate to imipenem among *Klebsiella* spp. in the United Arab Emirates and a 58.6% carbapenem resistance rate in *K. pneumoniae* in the US. ^(4, 12) This trend highlights the increasing prevalence of CR-KP across hospitals each year. This increasing incidence of drug-resistant bacteria is due to antibiotic selection, the development of resistant strains, and the ability to transfer resistance genes to other strains. ^(13, 14) Moreover, the excessive or inappropriate use of antimicrobial agents contributes to the increasing prevalence of various drug-resistant strains. ⁽¹⁵⁾

In this study, CR-KP was most prevalent in the ICU, followed by the general ward. Within the general wards, the highest prevalence of CR-KP was observed in the internal medicine wards, followed by the surgical wards (data not shown). This contrasts with findings from Rajavithi Hospital and Songklanagarind Hospital, where the internal medicine wards exhibited the highest prevalence, followed by the surgical wards and ICUs. ^(7, 16) This was similar to the findings from Greece, Korea, and India, where CR-KP was found in up to 58.6%, 77.4%, and 67.6% of patients in the ICU, respectively. ⁽¹⁷⁻¹⁹⁾ This discrepancy may be attributed to King Chulalongkorn Memorial Hospital, Thai Red Cross Society, being a large tertiary care unit where critically ill patients are received who have already been exposed to antibiotics. This increases the likelihood of encountering drug-resistant pathogens in the ICU.

In this study, CR-KP was most frequently isolated from respiratory specimens (37.0%), followed by other body fluids, pus, and urine. Isolates from blood samples exhibited the lowest prevalence (19.8%). However, our results contrast with those of Thongkoom, *et al.*, who reported that CR-KP at Rajavithi Hospital was most frequently isolated from urine (36.5%), followed by pus (25.7%), sputum (22.5%), and blood (13.8%). ⁽⁷⁾

This was similar to the study by Aryal, *et al.* at Songklanagarind Hospital, where CR-KP was most commonly found in urine, followed by sputum, pus, and blood. ⁽¹⁶⁾ In addition, Yungyuen, *et al.* reported that CR-KP was most frequently isolated from sterile sites (5.8%), followed by urine (4.7%), respiratory specimens (4.3%), and blood (3.5%). ⁽⁸⁾ This variation of CR-KP prevalence in the specimen sources may reflect differences in the patient populations and clinical practices.

The appropriate selection of antimicrobial agents and treatment duration plays a critical role in preventing the development of antimicrobial resistance. Previous studies have shown that the prolonged use of glycopeptide antibiotics or cefoperazone in combination with sulbactam can effectively suppress gram-positive bacteria; however, this combination may lead to mutations and increased resistance in gram-negative bacteria. ⁽²⁰⁾ In addition, several studies have identified a correlation between the use of different antibiotic classes and the development of carbapenem resistance in gram-negative bacteria. ⁽²⁰⁻²²⁾ Furthermore, procedures such as prolonged intubation can result in complications, including airway tube rupture or bacterial colonization within the tube, which potentially leads to colonization or infection by resistant bacteria. ⁽²¹⁻²⁷⁾

Although carbapenem-resistant bacteria often exhibit multidrug resistance, this study found that aminoglycosides, such as amikacin and gentamicin, remained effective against CR-KP, which is consistent with previous studies. ^(9, 16) However, there was an increased use of older drugs, such as colistin, fosfomycin, and sulbactam, for treatment. Recent studies suggest that these drugs can be effective when used with appropriate durations and dosages. ^(28, 29) Nevertheless, combination therapies may offer further options for managing carbapenem-resistant infections.

Conclusion

From 2019 to 2023, CR-KP prevalence exhibited a marked increase from 11.7% in 2020 to 29.0% in 2022. Throughout the study period, the highest prevalence of CR-KP was observed in the ICU. Significant differences in CR-KP prevalence were observed between the patient categories and across time. This trend highlights the ongoing challenge of controlling CR-KP in hospital settings, particularly in the critical care units.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Data sharing statement

All data generated or analyzed in this study are included within this published article. Additional details are available for non-commercial purposes from the corresponding author upon reasonable request.

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