

Research Article

Carbapenem and Colistin Resistance Trends in *Klebsiella pneumoniae* Strains Isolated from Blood Cultures: A Pediatric-Adult Comparative Study

 Selin Uğraklı,  Merve Kızılkaya,  Metin Doğan

Department of Medical Microbiology, Necmettin Erbakan University Faculty of Medicine, Konya, Türkiye

Abstract

Objectives: Turkish surveillance data on carbapenem-resistant *Klebsiella pneumoniae* (CRKP) bacteremia are largely restricted to adults. We investigated resistance trends and factors associated with carbapenem resistance among *K. pneumoniae* blood culture isolates at a tertiary center.

Methods: Between October 2022 and November 2024, 625 non-duplicate *K. pneumoniae* blood culture isolates were analyzed. Susceptibilities were tested with BD Phoenix panels except colistin (reference broth microdilution) and interpreted using EUCAST breakpoints, except tigecycline (FDA criteria). Isolates resistant to ertapenem, imipenem or meropenem were defined as CRKP.

Results: CRKP comprised 556 isolates (88.9%). Carbapenem resistance rate was 68.4%, 84.0% and 93.2% in 2022, 2023 and 2024 (p-trend<0.001); colistin resistance increased from 10.5% to 35.0% (p-trend=0.004). Fluoroquinolone resistance rate in isolates from children was lower (ciprofloxacin 30.6% vs. 89.9%; p<0.001), whereas gentamicin resistance rate was higher (68.4% vs. 44.8%; p<0.001) compared to adults. Multivariate regression analysis identified calendar year (adj. OR=2.472) and adult ward versus ICU origin (adj. OR=0.087) as factors independently associated with CRKP (both p<0.001).

Conclusion: CRKP rates were high and rising, and increasing colistin resistance limits treatment options. Distinct pediatric and adult resistance patterns may inform age-stratified interpretation of local antibiograms and empirical therapy. Multicenter studies incorporating outcome data are needed.

Keywords: Blood culture, carbapenems, *Klebsiella pneumoniae*

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Antibiotic-resistant bacterial infections caused the death of about 1.14 million people in 2021, and recent models predict that this number could rise to 8.22 million annually by the middle of the century if policies and clinical practices are not changed.^[1] *K. pneumoniae* has become a pathogen of central concern in this larger crisis. The ECDC

reported a 61% increase in bloodstream infections caused by carbapenem-resistant *K. pneumoniae* (CRKP) in Europe between 2019 and 2024, according to its 2024 surveillance update.^[2] Türkiye is one of the countries most affected by this pressure. OXA-48-type carbapenemases have become the dominant resistance mechanism in this country and

Address for correspondence: Selin Uğraklı, MD, Department of Medical Microbiology, Necmettin Erbakan University Faculty of Medicine, Konya, Türkiye

Phone: +90 332 223 66 96 **E-mail:** dr.selinumakci@gmail.com

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CRKP rates are currently among the highest reported in the region.^[3]

Among ESKAPE pathogens, *K. pneumoniae* stands out as the most frequently isolated Gram-negative organism, largely due to its extraordinary ability to acquire ESBLs and carbapenemases via horizontal gene transfer.^[4,5] This resistance burden has important clinical implications: 60% to 70% of *K. pneumoniae* isolates obtained from tertiary hospitals in Türkiye have been found to be resistant to carbapenems.^[6] This situation is increasingly limiting the treatment options available to clinicians, such as colistin, tigecycline, and a few new beta-lactam/beta-lactamase inhibitor combinations. A meta-analysis compiling 20 years of Turkish laboratory data revealed that colistin resistance, once relatively rare, has begun to show a noticeably faster rate of increase in the post-COVID-19 era.^[7] Bloodstream infections caused by *K. pneumoniae* are associated with significantly higher mortality rates, particularly among critically ill patients in intensive care units.^[8,9] However, one aspect of this problem that is largely overlooked in Türkiye is the extent to which pediatric and adult patients harbor *K. pneumoniae* strains with different resistance profiles. Evidence from other settings suggests that these age-related differences are clinically relevant and may limit the adequacy of a single empirical regimen for both patient groups.^[10,11]

Due to its single-center design, this study primarily contributes to local empirical treatment decisions; however, it also indirectly contributes to antimicrobial resistance surveillance in Türkiye by adding regional resistance data to the literature. Guided by this clinical priority, we analyzed *K. pneumoniae* blood culture isolates from a tertiary university hospital in Türkiye over a 26-month observation period to document changing resistance dynamics and identify variables independently associated with carbapenem-resistant phenotypes. A key feature distinguishing our study from existing Turkish literature is the direct and parallel assessment of pediatric and adult patient groups at the same center. This simultaneous perspective provides information that may inform age-stratified interpretation of local antibiograms and institutional antimicrobial stewardship strategies.

Methods

Study Design and Ethical Approval

For the present study, we retrospectively reviewed the microbiology laboratory database of a tertiary hospital (institutional details were blinded for peer review) to identify patients with a positive blood culture for *Klebsiella pneumoniae* from October 2022 to November 2024. The study protocol was written in accordance with the principles of the Declaration of Helsinki and approved by the Necmet-

tin Erbakan University Non-Interventional Research Ethics Committee (no: 2025/5975, date: 26.09.2025). The committee waived the requirement for individual informed consent because the analysis was performed on existing, de-identified laboratory records only.

Patient Selection

Patients with polymicrobial infections in which another microorganism grew alongside *Klebsiella pneumoniae* in the same blood culture set were excluded from the study. Any case in which susceptibility results were incomplete or the isolate had been recovered from a non-blood specimen was similarly excluded from the final analysis. For patients who yielded more than one positive blood culture over the course of the study period, only the earliest episode was retained. Isolates were assigned to pediatric (NICU, PICU, pediatric ward) or adult (adult ICUs, adult wards) groups according to the admitting clinical unit; blood cultures obtained in the emergency department were grouped with the adult wards.

Microbiological Identification and Susceptibility Testing

Blood samples were loaded into the BACTEC FX system (Becton Dickinson, USA) and held for up to five days. Positive bottles were Gram-stained and subcultured on standard media at 37°C for 24–36 hours. Species identification was performed using VITEK MS (bioMérieux, France). For routine susceptibility testing, the BD Phoenix automated system with NMIC/ID Gram-negative identification and susceptibility combination panels was used.

Colistin susceptibility was additionally determined by the broth microdilution method, as recommended by the joint EUCAST/CLSI Polymyxin Breakpoints Working Group. Two quality control strains were included in each test series: *Escherichia coli* ATCC 25922 and *mcr-1* positive *E. coli* NCTC 13846.^[12] Breakpoint interpretation was not applied retrospectively with a single EUCAST table. Instead, each isolate was assessed according to the version in effect at the time of testing: version 12.0 for 2022 isolates, version 13.0 for 2023 isolates, and version 14.0 for 2024 isolates.^[13] No breakpoint changes between these three editions affected the drug-organism pairs in our study, so year-to-year resistance comparisons are valid. Because EUCAST tigecycline breakpoints are validated only for *E. coli* and *C. koseri* and no species-specific breakpoints exist for *K. pneumoniae*, tigecycline was interpreted according to US Food and Drug Administration (FDA) criteria (susceptible ≤ 2 mg/L, intermediate 4 mg/L, resistant ≥ 8 mg/L)^[14,15]; all other agents were interpreted with EUCAST breakpoints. Resistance rates were calculated using isolates in the R category only; isolates in the I (susceptible, increased exposure) category

were grouped with susceptible isolates, in accordance with EUCAST guidance.^[13] CRKP was defined as resistance to at least one of ertapenem, imipenem or meropenem.

Statistical Analysis

Statistical analyses were carried out using SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous data are presented as mean $\pm$ standard deviation or median (interquartile range, IQR), as appropriate, and categorical data as counts with percentages. The Shapiro-Wilk test was used to assess normality. Two-group comparisons relied on Student's t-test or Mann-Whitney U test for continuous variables and chi-square or Fisher's exact test for categorical variables. The Kruskal-Wallis test was used when comparing more than two groups. Year-to-year differences in resistance rates were assessed with the chi-square test, and linear trends across study years were evaluated with the Cochran-Armitage test for trend. Throughout this article, the term "trend" refers to the direction of change across study years together with the result of this test. Antibiotic-by-antibiotic comparisons between pediatric and adult isolates were considered exploratory. Unadjusted p-values are presented as the primary analyses; Holm correction was additionally applied to assess the robustness of individual associations to multiple testing. To identify factors associated with CRKP isolation, univariate and multivariate logistic regression models were constructed; calendar year and clinical unit (entered as a categorical block with adult ICU as reference) were included in the multivariate model together with age and sex, which were retained as clinically relevant covariates irrespective of univariate significance. Model discrimination and calibration were assessed with the area under the ROC curve (AUC) and the Hosmer-Lemeshow test, respectively. The significance threshold was set at $p < 0.05$ (two-sided) for all tests.

Results

Between October 2022 and November 2024, 625 unique *K. pneumoniae* blood culture isolates were analyzed in our

microbiology laboratory. Table 1 provides the distribution by clinical unit along with baseline patient characteristics. Of these, 556 (88.9%) fulfilled our definition for CRKP; 30 isolates (5.4% of CRKP isolates and 4.8% of all isolates) were resistant to ertapenem only, with imipenem and meropenem remaining susceptible. The year-by-year data are shown in Table 2. CRKP rates were 68.4% in 2022, 84.0% in 2023, and 93.2% in 2024 ($p < 0.001$; $p\text{-trend} < 0.001$). The 2022 figure is based on only 19 isolates (October-December) and should therefore be interpreted cautiously; the 2023 and 2024 groups, with 237 and 369 isolates respectively, provide more stable estimates. Colistin resistance differed significantly across study years and showed a significant increasing trend, from 10.5% in 2022 to 35.0% in 2024 ($p = 0.014$; $p\text{-trend} = 0.004$). Significant increases were observed in resistance against all three individual carbapenems, ertapenem, imipenem and meropenem (all $p < 0.001$; $p\text{-trend} < 0.001$). Amikacin, gentamicin and TMP/SMX resistance rates also differed significantly across study years (Table 2): the rates observed in 2024 were significantly lower than those in 2023 (amikacin 60.3% vs. 45.5%, gentamicin 57.8% vs. 42.5%, TMP/SMX 59.9% vs. 43.6%; all $p < 0.001$), whereas the 2022 estimates ($n = 19$) did not differ significantly from those of 2023 and carry wide confidence intervals; the Cochran-Armitage test indicated significant negative linear trends across ordered study years for all three agents despite the non-monotonic annual pattern for amikacin and gentamicin ($p = 0.002$, $p = 0.002$ and $p < 0.001$, respectively). Fluoroquinolone and tigecycline resistance remained relatively stable with no significant year-over-year changes.

When resistance metrics were organized by patient age (Table 3), overall CRKP rates were nearly identical in pediatric and adult cohorts: 89.8% versus 88.8%, respectively ($p = 0.862$). The principal differences were observed at the level of specific antimicrobial classes. Children had substantially lower ciprofloxacin resistance than adults (30.6% vs. 89.9%; $p < 0.001$), and a similar gap was observed for levofloxacin (30.6% vs. 87.3%; $p < 0.001$). Adult isolates also

Table 1. Demographic features and key resistance parameters by clinical group

Parameter	NICU (n=66)	PICU (n=22)	Ped. Ward (n=10)	Adult ICU (n=380)	Adult Ward (n=147)	p
Age, mean $\pm$ SD (yr)	0.0 $\pm$ 0.0	2.4 $\pm$ 2.0	5.9 $\pm$ 5.3	61.8 $\pm$ 16.8	62.7 $\pm$ 14.6	<0.001
Sex M/F, n	31/35	17/5	5/5	210/170	89/58	0.104
CRKP, n (%)	61 (92.4)	20 (90.9)	7 (70.0)	366 (96.3)	102 (69.4)	<0.001
Colistin R, n (%)	15 (22.7)	8 (36.4)	0 (0.0)	158 (41.6)	13 (8.8)	<0.001
Tigecycline R, n (%)	0 (0.0)	1 (4.5)	0 (0.0)	29 (7.6)	12 (8.2)	0.157

Age: Kruskal-Wallis test. Other parameters: chi-square test. NICU: Neonatal intensive care unit; PICU: Pediatric intensive care unit; Ped.: Pediatric; CRKP: Carbapenem-resistant *K. pneumoniae* (resistance to ≥ 1 tested carbapenem); M: Male; F: Female; SD: Standard deviation; R: Resistant.

Table 2. Annual antibiotic resistance rates among *K. pneumoniae* isolates [n (%)]

Antibiotic	Abbr.	2022 (n=19)*	2023 (n=237)	2024 (n=369)	p
CRKP	—	13 (68.4)	199 (84.0)	344 (93.2)	<0.001
Amikacin	AMK	10 (52.6)	143 (60.3)	168 (45.5)	0.002
Ertapenem	ERT	13 (68.4)	198 (83.5)	343 (93.0)	<0.001
Gentamicin	GEN	9 (47.4)	137 (57.8)	157 (42.5)	0.001
Imipenem	IPM	12 (63.2)	179 (75.5)	328 (88.9)	<0.001
Colistin	COL	2 (10.5)	63 (26.6)	129 (35.0)	0.014
Levofloxacin	LEV	13 (68.4)	180 (75.9)	297 (80.5)	0.234
Meropenem	MEM	12 (63.2)	178 (75.1)	330 (89.4)	<0.001
Ciprofloxacin	CIP	15 (78.9)	188 (79.3)	301 (81.6)	0.778
Tigecycline	TGC	2 (10.5)	20 (8.4)	20 (5.4)	0.279
TMP/SMX	SXT	14 (73.7)	142 (59.9)	161 (43.6)	<0.001

Chi-square test. CRKP: Carbapenem-resistant *K. pneumoniae*; TMP/SMX: Trimethoprim-sulfamethoxazole. *The 2022 column covers only October–December (the first three months of the study period); estimates based on 19 isolates carry wide confidence intervals. The identical tigecycline-resistant count in 2023 and 2024 (n=20 each) was verified against original laboratory records.

Table 3. Comparison of antibiotic resistance rates between pediatric and adult *K. pneumoniae* isolates [n (%)]

Antibiotic	Abbr.	Pediatric (n=98)	Adult (n=527)	p
CRKP	—	88 (89.8)	468 (88.8)	0.862
Amikacin	AMK	50 (51.0)	271 (51.4)	1.000
Amoxicillin/Clavulanate	AMC	92 (93.9)	486 (92.2)	0.717
Ampicillin/Sulbactam	SAM	93 (94.9)	490 (93.0)	0.633
Ceftolozane/Tazobactam	C/T	86 (87.8)	468 (88.8)	0.899
Ciprofloxacin	CIP	30 (30.6)	474 (89.9)	<0.001
Colistin	COL	23 (23.5)	171 (32.4)	0.100
Ertapenem	ERT	88 (89.8)	466 (88.4)	0.826
Gentamicin	GEN	67 (68.4)	236 (44.8)	<0.001
Imipenem	IPM	71 (72.4)	448 (85.0)	0.004
Levofloxacin	LEV	30 (30.6)	460 (87.3)	<0.001
Meropenem	MEM	70 (71.4)	450 (85.4)	0.001
Piperacillin/Tazobactam	TZP	88 (89.8)	473 (89.8)	1.000
Cefepime	FEP	88 (89.8)	487 (92.4)	0.501
Ceftazidime	CAZ	92 (93.9)	490 (93.0)	0.916
Ceftriaxone	CRO	92 (93.9)	490 (93.0)	0.916
Cefuroxime †	CXM	95 (96.9)	507 (96.2)	1.000
Tigecycline †	TGC	1 (1.0)	41 (7.8)	0.008
TMP/SMX	SXT	26 (26.5)	291 (55.2)	<0.001

Chi-square test. † Fisher's exact test (expected cell count <5). Ampicillin was excluded because *K. pneumoniae* is intrinsically resistant to this agent. All listed antibiotics were tested on every isolate using the same BD Phoenix panel; denominators are identical. CRKP: Carbapenem-resistant *K. pneumoniae*; TMP/SMX: Trimethoprim-sulfamethoxazole. Pediatric: NICU + PICU + Pediatric Ward (n=98); Adult: Adult ICU + Adult Ward (n=527).

showed higher resistance rates for imipenem and meropenem. In contrast, gentamicin resistance was higher in children than in adults (68.4% vs. 44.8%; $p<0.001$). TMP/

SMX resistance was approximately half as common in the pediatric group (26.5% vs. 55.2%; $p<0.001$), and tigecycline resistance was nearly absent among children (1.0% vs.

Table 4. Univariate and multivariate logistic regression analysis for factors associated with CRKP isolation

Variable	Univariate OR (95% CI)	p	Multivariate OR (95% CI)	p
Calendar year (per 1-yr increase)	2.572 (1.683–3.929)	<0.001	2.472 (1.541–3.966)	<0.001
Age (per 1-yr increase)	1.003 (0.993–1.013)	0.571	—	—
Male sex	0.874 (0.574–1.331)	0.530	—	—
Clinical unit (ref: Adult ICU)				
NICU	0.463 (0.175–1.224)	0.120	0.567 (0.198–1.621)	0.290
PICU	0.383 (0.085–1.726)	0.212	0.471 (0.098–2.261)	0.348
Pediatric Ward	0.089 (0.022–0.365)	0.001	0.117 (0.027–0.510)	0.004
Adult Ward	0.120 (0.070–0.206)	<0.001	0.087 (0.045–0.169)	<0.001

OR: Odds ratio; CI: Confidence interval; ref: Reference category; NICU: Neonatal ICU; PICU: Pediatric ICU. Age and sex were excluded from the multivariate model because they were not significant in univariate analysis. Clinical unit was entered as a categorical block with adult ICU as reference. Model AUC = 0.824.

7.8%; $p=0.008$). These antibiotic-specific comparisons were exploratory; unadjusted p -values are presented, with Holm correction applied as a sensitivity analysis (see Methods).

Logistic regression models evaluated calendar year, patient age, sex, and specific clinical units as factors potentially associated with CRKP isolation (Table 4). On univariate analysis, each advancing calendar year was associated with more than a twofold increase in the odds of CRKP isolation (OR=2.572; 95% CI 1.683–3.929; $p<0.001$). Patients managed on adult general wards showed substantially lower odds of CRKP compared with those in adult ICUs (OR=0.120; 95% CI 0.070–0.206; $p<0.001$). Patient age and sex did not reach statistical significance. Isolates from pediatric and adult general wards also displayed significantly reduced odds of carbapenem resistance relative to the adult ICU baseline, whereas NICU and PICU did not show distinct differences. The multivariate model, which retained age and sex as clinically relevant covariates, showed that both calendar year (adjusted OR=2.472; $p<0.001$) and adult general ward origin (adjusted OR=0.087; $p<0.001$) were independently associated with CRKP isolation, whereas age (adjusted OR=1.013; $p=0.178$) and male sex (adjusted OR=1.455; $p=0.191$) were not significant. The model's AUC was 0.824, and calibration was adequate (Hosmer-Lemeshow test, $p=0.471$).

Discussion

Our observed institutional CRKP rate of 88.9% exceeds the historical figures reported in contemporary literature from Türkiye, where typical resistance baselines span between 60% and 67%.^[3,5,6] However, these broader regional estimates frequently incorporate outpatient specimens and various non-blood isolates. Several factors distinguish our study population: we evaluated predominantly hospitalized patients, limited our focus strictly to blood cultures, and noted that approximately three-quarters of clinical isolates originated from intensive

care settings. These selection parameters are highly relevant because CRKP rates vary substantially according to clinical setting. For instance, Mermer and Çağlayan documented a cumulative CRKP rate of 66.8% at their institution; however, when stratified by care type, outpatient strains showed a 26.8% resistance rate while inpatient isolates reached 83.8%, with 62.5% of all CRKP episodes concentrated inside ICUs.^[6] Similarly, a Turkish study examining adult ICU blood cultures between 2021 and 2024 found carbapenem resistance in *K. pneumoniae* exceeded 60% and showed an upward trend over time.^[16] Another study covering 2022–2024 blood cultures reported that 67.67% of gram-negative isolates were ICU-derived, and imipenem resistance in *K. pneumoniae* ranged between 48.9% and 54.5%.^[17]

Infection-control practices, prescribing habits, and patient populations differ from hospital to hospital, which may account for some of this variation.^[6,18,19] The COVID-19 pandemic may have further affected infection-control conditions. Our data collection started in late 2022 and continued through 2024, a period during which many hospitals were still managing strained infection-prevention resources. In China, for example, one 20-bed respiratory ICU documented 42 CRKP cases during a single Omicron wave, largely because of staffing shortages and lapses in routine hygiene protocols.^[18] Other centers have reported similar post-pandemic CRKP surges.^[20]

Previous molecular data from Türkiye reported *bla*_{NDM-1} in 52.4% of CRKP strains, with 39.0% carrying both NDM-1 and OXA-48 simultaneously.^[21] In this study, our isolates' genotypes were not determined; therefore, we cannot precisely identify which resistance genes underlie our phenotypic findings. Still, the institutional molecular picture is consistent with our observations. This NDM-plus-OXA-48 pattern has also been observed elsewhere in ICU bloodstream CRKP isolates. On a broader scale, pooled data from

a systematic review placed CRKP colonization prevalence at 5.43% and incidence at 22.3%, mostly in ICU and transplant settings.^[22] The very high CRKP rates observed in several ICUs may reflect ongoing institutional transmission and/or sustained antimicrobial selective pressure; however, molecular typing would be required to confirm transmission dynamics. Aslan et al.^[23] reported 53.1% carbapenem resistance among *Klebsiella* spp. in a prospective Turkish ICU study, and ECDC data confirm that this phenomenon extends far beyond our institution.^[2]

Although the 2022 starting point (19 isolates, three months) provides an imprecise baseline, the trajectory from 68.4% to 84.0% to 93.2% shows a consistent upward direction, confirmed by the Cochran-Armitage test ($p < 0.001$). Significant increases were observed in resistance against all three individual carbapenems, a trend consistent with findings from other Turkish centers.^[16] The increase in colistin resistance is clinically concerning: rates increased from 10.5% to 35.0% ($p = 0.014$; $p\text{-trend} = 0.004$) over the study period, reducing the in vitro activity of an agent historically used as salvage therapy for CRKP infections. For context, Isler et al.^[24] found colistin resistance as high as 77% in a multicenter Turkish bacteremia cohort, and a 20-year national meta-analysis documented a clear post-pandemic spike.^[7]

In contrast, aminoglycoside and TMP/SMX resistance decreased between 2023 and 2024: amikacin rates fell from 60.3% to 45.5%, gentamicin from 57.8% to 42.5%, and TMP/SMX from 59.9% to 43.6% (all $p < 0.001$), whereas the 2022 rates, based on 19 isolates, did not differ significantly from those of 2023; the Cochran-Armitage test indicated significant negative linear trends across ordered study years for all three agents despite the non-monotonic annual pattern for amikacin and gentamicin. Comparable declines have been observed in other recent Turkish surveys.^[16,17] Reduced selective pressure may partly explain these observations, as none of these conventional antimicrobials are routinely used as empirical monotherapy for confirmed CRKP infections. However, institutional antibiotic consumption data were unavailable, so this hypothesis could not be directly tested; international surveillance systems have nevertheless demonstrated associations between antimicrobial consumption and resistance.^[25]

However, retained in vitro activity does not necessarily make tigecycline an appropriate clinical option for bloodstream infections. In Turkish studies evaluating Gram-negative blood culture isolates, tigecycline resistance rates have been reported as 17%^[26] and 4.8% in carbapenemase-positive CRKP bacteremia isolates^[27], consistent with our observed rate of 6.7%. It should be noted, however, that our tigecycline results were interpreted with FDA cri-

teria (resistant ≥ 8 mg/L), which are higher than the EUCAST breakpoint established for *E. coli*; our rate is therefore not directly comparable with rates from studies applying EUCAST-derived thresholds and may be lower than would be obtained with a 0.5 mg/L cut-off. Likewise, the pediatric-adult difference in tigecycline resistance (1.0% vs. 7.8%) should be interpreted cautiously, as it did not remain significant after correction for multiple comparisons. The IDSA's 2024 guidance on CRE infections recommends against tetracycline-class agents for bacteremia and urinary tract infections because serum and urine drug levels are insufficient.^[28] Tigecycline should therefore be regarded as an agent with retained in vitro activity rather than a preferred therapeutic option for bloodstream infections.

The fluoroquinolone data illustrate the age-group difference most clearly. Ciprofloxacin resistance was 30.6% in children and 89.9% in adults; a similar difference was observed for levofloxacin. Contrary to adult clinical settings, this difference may reflect the limited use of fluoroquinolones in pediatric practice, where the indications listed on the label are restricted and routine empirical use is not recommended.^[29] Other groups comparing CRKP isolates from pediatric and adult individuals have reported the same pattern.^[10]

The higher gentamicin resistance observed in children (68.4% vs. 44.8%; $p < 0.001$) may partly reflect the fact that neonatal ICU strains comprised approximately two-thirds of our pediatric sample (66/98, or 67.3%). Neonates worldwide are commonly started on ampicillin plus gentamicin for presumed serious bacterial infection, consistent with WHO recommendations; the BARNARDS study reported 70.3% gentamicin resistance among Gram-negative neonatal sepsis isolates, which is close to our observation.^[30,31] Because approximately two-thirds of pediatric isolates originated from the NICU, some antibiotic-specific differences between children and adults may reflect unit distribution and unit-specific empirical antibiotic exposure patterns rather than patient age per se. Despite these individual-antibiotic differences, overall CRKP rates were essentially identical in children and adults (89.8% vs. 88.8%; $p = 0.862$). In the multivariate model, each advancing calendar year was associated with more than a twofold increase in the odds of CRKP (adjusted OR=2.472; $p < 0.001$), consistent with the rising CRKP trends documented in other Turkish centers.^[16,32] The significantly lower odds of CRKP isolation in adult general wards compared with adult ICUs (adjusted OR=0.087; $p < 0.001$) align with the well-established role of ICU-specific factors in driving carbapenem resistance. In the literature, prior ICU admission, mechanical ventilation, indwelling catheter use, and broad-spectrum antibiotic exposure are among the most frequently reported independent risk factors for CRKP infection.^[33,34]

This study has several limitations that should be acknowledged. It is single-center and retrospective, so findings may not be generalizable. The 2022 group comprised only 19 isolates from three months, making that data point unreliable for precise estimates. Mortality data and detailed clinical information were not collected, so the impact of CRKP on patient outcomes cannot be assessed. Without institutional antibiotic consumption records, prescribing patterns could not be formally linked to resistance changes. Tigecycline was interpreted with FDA criteria in the absence of species-specific EUCAST breakpoints for *K. pneumoniae*, which limits comparability with EUCAST-based studies. The study also has notable strengths: a large sample (625 isolates), an observation period exceeding two years, a pediatric-adult comparison that is uncommon in the Turkish literature, uniform testing of all isolates on the same Phoenix panel, and colistin testing by the reference broth microdilution method.

Conclusion

This study documents a high and rising CRKP burden among blood-culture *K. pneumoniae* isolates at a tertiary university hospital, with a parallel increase in colistin resistance. The distinct resistance profiles in children versus adults, particularly for fluoroquinolones and gentamicin, may inform age-stratified interpretation of local antibiograms and empirical therapy decisions, pending confirmation in studies incorporating clinical variables and outcomes. These data can inform local stewardship and guideline decisions. Multicenter efforts incorporating carbapenemase genotyping, patient outcome tracking, and prescribing data are needed to confirm and extend these findings.

Disclosures

Ethics Committee Approval: The study was approved by the Necmettin Erbakan University Non-Interventional Research Ethics Committee (no: 2025/5975, date: 26.09.2025).

Informed Consent: Informed consent was waived due to the retrospective design of the study.

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