

Prevalence of ESBL-Producing *Klebsiella* Isolated from Burn Wound Infections in a Tertiary Care Burn Hospital in Peshawar

ZUBEDA IRSHAD¹, MAHNOOR KHAN², RABBIA MAHBOOB³

¹Assistant Professor Microbiology, Department of Pathology, Burns and Plastic Surgery Centre, MTI - HMC Hayatabad Peshawar, Pakistan

²Trainee Medical Officer, Department of General Surgery, Khyber Teaching Hospital - MTI Peshawar, Pakistan

³Microbiology Technician, Department of Pathology, Burns and Plastic Surgery Center, MTI - HMC Hayatabad Peshawar, Pakistan

Correspondence to: Dr Zubeda Irshad, Email: zubedasamar@yahoo.com

ABSTRACT

Background: Patients with burns and other skin wounds suffer from skin damage and often prolonged hospitalization which compromises their immunological protection by skin and increases the chance of infections. *Klebsiella* in particular, have become one of the leading causes of such infections. Of even greater concern is their ability to produce extended spectrum beta-lactamases (ESBLs), enzymes that render many antibiotics useless. This study aimed to determine the prevalence of ESBL-producing *Klebsiella*, among the isolates from burn wound infections and to analyze their antimicrobial susceptibility patterns.

Methods: A total of 363 *Klebsiella* isolates were obtained from wound swabs of burn patients over a one-year period from August 2021 to July 2022 were used for identification. The ESBL production was confirmed using the combination disc method. Antimicrobial sensitivity testing was performed following CLSI guidelines.

Results: Out of 363 isolates, 74% were confirmed ESBL producers. Most patients belonged to the age group of 21–30 years, and a slight male predominance was observed. ESBL-producing isolates showed very low sensitivity to third-generation cephalosporins (only 2% to cefotaxime and 4% to ceftazidime), as well as reduced susceptibility to fluoroquinolones. Carbapenems remained the most effective antibiotics, over 85% demonstrating sensitivity."

Conclusion: The high prevalence of ESBL-producing *Klebsiella* in burn wound infections is alarming and highlights the need for strict infection control measures, routine surveillance, and rational antibiotic use in burn units.

Keywords: ESBL, *Klebsiella*, burn wound infection, antimicrobial resistance, prevalence, carbapenem, multidrug resistance.

INTRODUCTION

Burn injuries stand among the most physiologically traumatic types of injuries that one can sustain, as multiple infections may arise afterward. These patients tend to develop nosocomial pneumonia and sepsis due to *Staphylococcus aureus* and *Pseudomonas aeruginosa*, the latter serving as opportunistic pathogens in immunocompromised individuals. Among the various organisms encountered, *Klebsiella* have emerged as key pathogen, *Klebsiella pneumoniae* frequently and *Klebsiella oxytoca* sometimes isolated from burn wounds across different hospital settings¹⁻³.

With regards to *Klebsiella* infections, there is a growing concern in the medical community over their resistance to prevalent antibiotics. This obsolescence is linked with one of the primary mechanisms that generates beta-lactam antibiotic resistance: the production of ESBLs or extended-spectrum beta-lactamases. These enzymes irreversibly hydrolyze beta-lactam antibiotics; penicillins third generation cephalosporins and monobactams leading to a scarce collection of remaining drugs which have bona fide efficacy against these pathogens. In addition, organisms or patients infected with ESBLs become very expensive due to the requirement for complicated treatment plans alongside longer hospital stays resulting in a higher associated healthcare burden and increased risk of death⁴⁻⁶.

The worldwide dissemination of ESBL-producing *Klebsiella* strains has garnered significant interest in the past few years. Nonetheless, there is a lack of regional information, particularly from burn care centers in developing nations. The prevalence and resistance profiles of such organisms must be known to ensure appropriate antimicrobial treatment and implementation of effective infection control measures⁷⁻⁹.

This study was conducted to determine the prevalence of ESBL-producing *Klebsiella* species in burn wound infections and to assess their resistance patterns to commonly used antimicrobial agents. The findings aim to support evidence-based strategies for managing infections in burn patients and controlling the spread of resistant pathogens.

METHODOLOGY

This was a descriptive cross-sectional study to assess the prevalence of extended-spectrum beta-lactamase (ESBL) producers among the *Klebsiella* isolated from burn wound infections. This study was conducted in the Department of Microbiology at Burns and Plastic Surgery Center, Hayatabad, Peshawar. The data was collected over one year, from August 2021 to July 2022.

In total, *Klebsiella* was isolated from 363 wound swab specimens obtained from patients with burns and suspected of having infected wounds during the study period. A non-probability convenience sampling approach was used to recruit all qualifying individuals who fulfilled the inclusion criteria.

Patients of any age and gender with clinically infected burn wounds and wound swabs yielding growth of *Klebsiella* species on culture were included.

The patients who had received antibiotic therapy for more than 72 hours before sample collection, mixed growths, or isolates other than *Klebsiella* were excluded from final analysis.

Wound swabs were collected aseptically using sterile cotton swabs from the burn site after cleansing with sterile saline. The samples were transported immediately to the microbiology laboratory for culture and sensitivity testing.

All specimens were cultured on MacConkey agar and blood agar. Plates were incubated at 37°C for 24 hours. *Klebsiella* species were identified based on colony morphology, Gram staining, and a series of biochemical tests, including citrate utilization, urease production, indole, and triple sugar iron (TSI) reactions.

Isolates confirmed as *Klebsiella* were subjected to antimicrobial susceptibility testing using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, following Clinical and Laboratory Standards Institute (CLSI) guidelines. Screening for ESBL production was done using ceftazidime (30 µg) and cefotaxime (30 µg) discs. Zones of inhibition below the CLSI cutoff values indicated possible ESBL production. Confirmatory testing was carried out using the combination disc method, comparing the zone of inhibition of ceftazidime (30 µg) alone with ceftazidime+clavulanic acid (30µg10+µg). An increase of ≥5 mm in the zone diameter for the combination disc was interpreted as ESBL-positive.

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Demographic information (age, gender, residence), clinical details (type and cause of burn), and microbiological data were recorded in a pre-designed proforma. All data were analyzed using SPSS version 25. Descriptive statistics were used to summarize the findings. Categorical variables were compared using the Chi-square test, and a p-value less than 0.05 was considered statistically significant.

RESULT

Among the 363 patients with *Klebsiella* isolated from burn wound infections, 74% of isolates were found to be ESBL producers. The largest proportion belonged to the 21–30 year age group (28.1%), followed by 11–20 years (21.5%) and 31–40 years (19.8%). Children under 10 years made up 11.6%, while those older than 40 years accounted for 19%. Male patients were more frequently affected than females, with 56.5% of cases occurring in males. Additionally, 62.5% of the patients were residents of urban areas, while 37.5% came from rural settings. This demographic profile suggests that young adults and urban populations are more frequently affected by burn wound infections involving *Klebsiella*.

Table 1: Demographic Characteristics of Patients with *Klebsiella* Isolates (n = 363)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	<10	42	11.6
	11–20	78	21.5
	21–30	102	28.1
	31–40	72	19.8
	>40	69	19.0
Gender	Male	205	56.5
	Female	158	43.5
Residence	Urban	227	62.5
	Rural	136	37.5

Flame burns were the predominant cause of injury among the patients (57.9%), followed by scald burns (22.3%). Electrical injuries accounted for 11.3%, and chemical burns made up the remaining 8.5%. These figures indicate that thermal injuries, especially from flame exposure, are the most common underlying cause of burn wound infections in this population.

Table 2: Burn Characteristics of Patients with *Klebsiella* Isolates (n = 363)

Variable	Category	Frequency (n)	Percentage (%)
Cause of Burn	Flame	210	57.9
	Scald	81	22.3
	Electrical	41	11.3
	Chemical	31	8.5

Out of the 363 *Klebsiella* isolates, 269 (74%) were identified as ESBL producers. A statistically significant relationship was found between age and ESBL production (p = 0.001), with patients aged 20 years or older showing a higher frequency of ESBL-producing strains. Although males had a slightly higher number of ESBL isolates, the difference was not statistically significant (p = 0.09). No significant association was observed between place of residence and ESBL production. These findings suggest that age, particularly being over 20 years, may be associated with an increased risk of harbouring ESBL-producing organisms.

Table 3: Prevalence of ESBL-producing *Klebsiella* Isolates and Association with Demographics (n = 363)

Variable	Category	ESBL (n=269)	Non-ESBL (n=94)	p-value
Age Group	<20	72 (26.8%)	48 (51.1%)	0.001**
	≥20	197 (73.2%)	46 (48.9%)	
Gender	Male	145 (53.9%)	60 (63.8%)	0.09
	Female	124 (46.1%)	34 (36.2%)	
Residence	Urban	169 (62.8%)	58 (61.7%)	0.85
	Rural	100 (37.2%)	36 (38.3%)	

The proportion of ESBL-producing *Klebsiella* strains was highest among patients with flame burns (60.6%), followed by

those with scalds (19.3%), electrical injuries (10.8%), and chemical burns (9.3%). However, this association between type of burn and ESBL production was not statistically significant (p = 0.49). This indicates that while flame burns are more common overall, the type of burn may not independently predict ESBL presence.

Table 4: Association between Burn Type and ESBL Production (n = 363)

Burn Cause	ESBL (n=269)	Non-ESBL (n=94)	p-value
Flame	163 (60.6%)	47 (50.0%)	0.49
Scald	52 (19.3%)	29 (30.9%)	
Electrical	29 (10.8%)	12 (12.8%)	
Chemical	25 (9.3%)	6 (6.3%)	

The antibiotic susceptibility pattern presented in Table 5 highlights a concerning resistance trend among ESBL-producing *Klebsiella* isolates from burn wound infections. Notably, only 2% of ESBL-producing strains were sensitive to cefotaxime, and 4% to ceftazidime, compared to 75.5% and 72.3% sensitivity, respectively, among non-ESBL producers—indicating a statistically significant reduction in efficacy (p < 0.001). This stark difference confirms the ineffectiveness of third-generation cephalosporins in treating infections caused by ESBL-producing strains.

Carbapenems (imipenem and meropenem) remained the most effective treatment options, with high sensitivity rates observed in both ESBL and non-ESBL groups (89.6% vs. 97.9% for imipenem; 86.6% vs. 95.7% for meropenem). Aminoglycosides such as amikacin and gentamicin showed moderate activity, though significantly lower in ESBL producers. Fluoroquinolone (ciprofloxacin) sensitivity was also substantially reduced in the ESBL group (30.5% vs. 59.6%, p < 0.001).

These results underscore the limited therapeutic choices for ESBL infections and emphasize the urgent need for rational antibiotic use, active surveillance, and consideration of alternative treatments in burn care settings.

Table 5: Antibiotic Susceptibility Pattern of *Klebsiella* Isolates (n = 363)

Antibiotic	ESBL Producers (n = 269)	Non-ESBL Producers (n = 94)	p-value
Imipenem	241 (89.6%)	92 (97.9%)	0.02*
Meropenem	233 (86.6%)	90 (95.7%)	0.01*
Cefotaxime	7 (02.0%)	71 (75.5%)	<0.001**
Ceftazidime	11 (04.0%)	68 (72.3%)	<0.001**
Ciprofloxacin	82 (30.5%)	56 (59.6%)	<0.001**
Amikacin	147 (54.6%)	77 (81.9%)	<0.001**
Gentamicin	124 (46.1%)	63 (67.0%)	0.002**

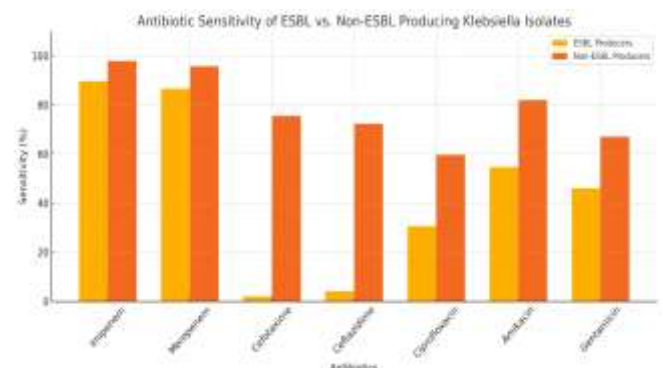


Figure 1: Bar graph comparing the antibiotic sensitivity of ESBL-producing and non-ESBL-producing *Klebsiella* isolates across different antibiotics. Imipenem and Meropenem have the highest sensitivity in both groups. Cefotaxime and Ceftazidime show dramatically low sensitivity in ESBL producers. Non-ESBL isolates show consistently higher sensitivity across all antibiotics.

DISCUSSION

In this study of 363 *Klebsiella* isolates from burn wounds, a notably high 74% were ESBL producers, indicating a critical antimicrobial

resistance burden. This aligns closely with similar studies that reported a 72.6% overall ESBL rate among wound pathogens, with *Klebsiella* showing an even higher rate (88.9%)¹⁰⁻¹². Although their sample size was smaller, the trend is consistent, highlighting that burn environments foster ESBL emergence.

Our local data also echoes regional hospital surveillance: a tertiary-care center in Pakistan reported 60% ESBL prevalence among *K. pneumoniae* and *E. coli*, with CTX-M genes being most common¹³⁻¹⁵. These patterns reflect a high ESBL burden across Pakistan^{16,17}. Hence, our findings both corroborate and extend the growing evidence that ESBL-producing *Klebsiella* are widespread in South Asia¹⁸, especially among burn injuries, where selective antibiotic pressure and prolonged hospitalization create ideal conditions for resistance development.

The antimicrobial susceptibility profile in our study reveals a critical therapeutic challenge. Even though carbapenems (imipenem and meropenem) maintained good efficacy (>85% sensitivity), third-generation cephalosporins and fluoroquinolones showed drastically reduced activity against ESBL strains. For instance, only 2% of ESBL-producing isolates were sensitive to cefotaxime and 4% to ceftazidime, compared to over 70% sensitivity in non-ESBL strains. This mirrors earlier studies from other regions: in Iran, ESBL-producing *K. pneumoniae* remained largely sensitive to carbapenems, but showed over 50% resistance to gentamicin and cephalosporins^{19,20}. Similarly, studies from Saudi Arabia reported high carbapenem responsiveness (~92%) among ESBL strains, while noting substantial resistance to cephalosporins and gentamicin²¹. These findings reinforce the role of carbapenems as the most reliable treatment option in ESBL-associated burn infections, while also highlighting the urgency for disciplined antibiotic stewardship to preserve their efficacy.

Interestingly, we observed a significant correlation between ESBL production and patient age ≥ 20 years ($p=0.001$), suggesting that older individuals may face higher risk possibly due to greater antibiotic exposure, co-morbidities, or environmental factors. Although gender and residence did not show strong associations, the overall high urban case load suggests that hospital-related pressures may be central. Notably, flame burns being the most common injury type showed high absolute numbers of ESBL isolation, though this did not reach statistical significance once adjusted for sample distribution.

Given the extensive ESBL prevalence and dwindling antibiotic options, alternative therapies merit consideration. Research into bacteriophage treatments has shown a study in Iran isolated potent phages against ESBL-producing *K. pneumoniae* from burn wound infections²². Integrating phage therapy into burn care, alongside robust infection control, may offer a viable strategy to curb multidrug-resistant pathogens.

Limitations of our work include its single-centre, cross-sectional design and lack of molecular typing to identify specific ESBL genes. Future studies should explore genetic mechanisms (CTX-M, TEM, SHV variants), include larger multicenter samples, and evaluate advanced interventions like phage therapy.

CONCLUSION

In conclusion, the prevalence of ESBL-producing *Klebsiella* in burn wound infections in our setting is alarmingly high (74%). The remaining effectiveness of carbapenems underscores their importance, but also the urgency for disciplined antimicrobial stewardship to slow down the appearance of carbapenem resistance. Given the rising resistance to all other antibiotics besides carbapenems, hospitals should enforce active microbiological surveillance, optimize antibiotic use, and explore alternative measures such as bacteriophage therapy in future to manage and prevent these challenging infections

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