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Determination of Antimicrobial Susceptibility Profiling Of ESBL-Producing *K. Pneumoniae* Isolated From Pediatric Patients Attending State Specialist Hospital, Maiduguri, Borno State

Mohammed Mohammed Usman¹, Ibrahim Musa Moi¹, Ismail Habib², Bashir Mohammed Abubakar^{2*} and Nathaniel Luka Kwarau^{1,3}

¹Department of Microbiology, Sa'adu Zungur University, Bauchi, PMB 065, Bauchi, Nigeria

²Department of Biological Sciences, Sa'adu Zungur University, Bauchi, PMB 065, Bauchi, Nigeria.

³Department of Plant Biology, Federal University Dutse, Jigawa State, Nigeria.

Abstract

The emergence and increasing prevalence of extended-spectrum β -lactamase (ESBL)-producing *Klebsiella pneumoniae* represent a significant challenge in pediatric healthcare because of resistance to commonly prescribed antibiotics, resulting in infections that are increasingly difficult and costly to treat. This study determined the prevalence and antimicrobial susceptibility patterns of ESBL-producing *K. pneumoniae* isolated from pediatric clinical samples at the State Specialist Hospital, Maiduguri, Borno State. A cross-sectional study was conducted over four months, from October 2024 to January 2025, among 256 children. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method. Of the 256 clinical samples analyzed, *K. pneumoniae* was the predominant isolate, accounting for 44.1% (113/256), followed by *Escherichia coli* (68; 26.6%), *Enterobacter* spp. (42; 16.4%), and *Pseudomonas aeruginosa* (32; 12.9%). Fourteen isolates were tested against selected antibiotics to determine their resistance profiles. Amoxicillin demonstrated the highest activity, with 12 (85.7%) isolates susceptible and 2 (14.3%) resistant. High susceptibility was also recorded for gentamicin (78.6%) and ciprofloxacin (71.4%), while nitrofurantoin, cefixime, and streptomycin each showed 64.3% susceptibility. Moderate susceptibility was observed for doxycycline and augmentin (57.1% each), whereas co-trimoxazole exhibited the highest resistance (78.6%). These findings demonstrate a considerable prevalence of ESBL-producing *K. pneumoniae* among pediatric patients and substantial antimicrobial resistance. The results provide evidence for appropriate antibiotic selection, antimicrobial stewardship, strengthened infection prevention and control, and continuous antimicrobial resistance surveillance within the hospital and region.

Keywords

Klebsiella pneumoniae,
ESBL, Prevalence,
Antimicrobial,
Susceptibility



Introduction

Antimicrobial resistance (AMR) has emerged as one of the most significant global public health threats of the 21st century, undermining the effective prevention and treatment of a wide range of infectious diseases (Murray et al., 2019). It is estimated that AMR was directly responsible for approximately 4.95 million deaths globally in 2019, with nearly 1.27 million deaths associated with bacterial resistance, highlighting its growing burden on healthcare systems worldwide (Murray et al., 2019). The increasing misuse and overuse of antibiotics in human medicine, agriculture, and animal husbandry have accelerated the development and spread of resistant pathogens (Collignon, 2016). In response, the World Health Organization (WHO) has emphasized the urgent need to strengthen surveillance systems, optimize antimicrobial use, and promote research into new therapeutic strategies as outlined in its Global Action Plan on AMR (Collignon, 2016). A major contributor to AMR is the emergence of multidrug-resistant (MDR) bacteria, which are defined as organisms resistant to at least one agent in three or more antimicrobial classes (Amati et al., 2023). MDR pathogens significantly limit treatment options, increase healthcare costs, prolong hospital stays, and are associated with higher morbidity and mortality rates (Budhram et al., 2020). Among these, members of the order Enterobacterales have gained particular attention due to their ability to acquire and disseminate resistance genes rapidly through horizontal gene transfer (Chao et al., 2023).

The resistance often leads to treatment failure, prolonged hospitalization, increased healthcare costs and higher morbidity and mortality among pediatric patients. Children are particularly vulnerable due to their immature immune systems and frequent exposure to antibiotics during hospitalization. Despite global recognition of the threat posed by ESBL-producing organisms, there remains limited data on

antimicrobial susceptibility patterns in many resource-limited settings, including parts of Nigeria. Pediatric populations are particularly vulnerable due to immature immune systems and frequent exposure to healthcare environment. Therefore, this study aims to determine the prevalence and antimicrobial susceptibility patterns of ESBL-producing *K. pneumoniae* isolated from pediatric clinical samples at State Specialist Hospital, Maiduguri, Borno State.

Materials and methods

This study was conducted in Maiduguri metropolitan, Borno state. It is situated at latitude and longitude of 11.8846°N, 13.1520°E. Maiduguri shares borders with Konduga Local Government Area to the North-East and Jere Local Government Area to the south and North-West. It occupies an area of 50,778km². The climate of Maiduguri has a mean annual rainfall of about 650 mm and a mean annual temperature of about 32 degrees. The study was conducted to determine the prevalence and antimicrobial susceptibility patterns of ESBL-producing *K. pneumoniae* isolated from pediatric clinical samples at State Specialist Hospital, Maiduguri, Borno State. Clinical samples, including urine, blood, sputum, and wound swabs, were aseptically collected from children with suspected bacterial infections following standard clinical procedures. All collected samples were transported promptly to the microbiology laboratory for analysis. A minimum sample size of 246 was established. Nonetheless, the determined sample size was adjusted to 256 thereby establishing it as the foundational sample size for the study, thus mitigating any skew in the selection of participants and to increasing accuracy and precision. The research project was approved and ethically cleared by the Department of Microbiology, Sa'adu Zungur University, Bauchi State, Nigeria. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar following CLSI (2021) guidelines. Data obtained from laboratory

investigations were entered into IBM SPSS version 27 for analysis. Descriptive statistics such as frequencies and percentages were used to summarize the data. The prevalence of ESBL-producing *Klebsiella pneumoniae* was calculated accordingly. Inferential statistics, including the Chi-square test, were used. At p-value of < 0.05 was considered statistically significant.

Results and discussion

Frequency Distribution of Bacterial Isolates

The study was undertaken to isolate, identify, and characterize ESBL-producing *K. pneumoniae* from children attending the State Specialist Hospital, Maiduguri, and to evaluate the prevalence, risk factors, and antimicrobial susceptibility patterns of these isolates. A total of 256 clinical samples were analyzed, comprising urine (12.5%), sputum (2%), blood (9.8%), pus (0.4%), nasal swab (36.3%), and throat swab (39.1%). Morphological and biochemical tests revealed the presence of four Gram-negative bacteria: *K. pneumoniae*, *P. aeruginosa*, *E. coli*, and *Enterobacter* species. *K. pneumoniae*, the primary focus of interest, was detected in 113 clinical samples, yielding a prevalence of 44.1%. This bacterium has been reported among the major pathogenic bacteria that cause hospital and community-acquired infections in humans, and its resistance to antibiotics has complicated treatment (Loaiza et al., 2023).

The distribution of bacterial isolates in this study revealed that *K. pneumonia* was the predominant organism, accounting for 113 (44.1%) of the 256 isolates recovered (Table 1). This findings indicates that *K. pneumonia* is a major pathogen among pediatric patients attending the State Specialist Hospital, Maiduguri, Borno State. The predominant *K. pneumonia* may be attributed to its ability to colonize hospital environment, survives on medical equipment and acquire multiple antimicrobial resistance genes, particularly extended-spectrum β -lactamase (ESBL) genes (Podschun and Ullman, 2018; Pitout and Laupad,

2019). Studies conducted in Kano reported a high prevalence of *K. pneumonia* among clinical isolates, particularly from urine and blood specimens, which was attributed to prolonged hospitalization, invasive procedures and increasing antimicrobial resistance (Baciu et al., 2024). Similarly, investigation in Abuja found *K. pneumonia* to be leading causes of hospital-acquired infections and highlights its association with ESBL production and multidrug resistance (Iregbu et al., 2016).

The high isolation rate underscores its growing importance as a cause of healthcare-associated and community-acquired infections.

Escherichia coli was the second most frequently isolated organism, representing 68 (26.6%) of the isolates. This findings is consistent with the well-established role of *E. coli* as one of the leading causes of urinary tract infections, septicemia, neonatal infections and gastro-intestinal diseases in children (Kaper et al., 2014).

Enterobacter spp accounted for 42 (16.4%) of the isolates. Although less prevalent than *K. pneumonia* and *Escherichia coli*, *Enterobacter spp* are recognized opportunistic pathogens frequently associated with hospital-acquired infections. Their ability to develop resistance to multiple antimicrobial agents poses significant therapeutic challenges (Mezzatesta et al., 2017). The least frequently isolated organism was *Pseudomonas aeruginosa*, with 33 (12.9%) isolates. Despite its lower prevalence, *P. aeruginosa* remains clinically important because of its intrinsic resistance to many antibiotics and its association with severe infections in hospitalized and immunocompromised patients (Lister et al., 2017). Its lower frequency in this study may reflect differences in specimen types, patient characteristics or local epidemiological patterns.

The predominance of Gram-negative bacteria, particularly *K. pneumoniae* and *E. coli*, highlights the importance of continuous microbiological surveillance and antimicrobial resistance monitoring in pediatric healthcare settings, antimicrobial stewardship programmes and routine screening for ESBL-producing isolates to reduce the burden of multidrug-resistant infections.

Table 1: Frequency Distribution of the Isolates

Isolates	Frequency	Percentage
<i>K. pneumoniae</i>	113	44.1%
<i>Pseudomonas aeruginosa</i>	33	12.9%
<i>Escherichia coli</i>	68	26.6%
<i>Enterobacter spp</i>	42	16.4%
Total	256	100%

Antibiotic Susceptibility Testing of ESBL *K. pneumoniae* Isolated from Children Attending State Specialist Hospital, Maiduguri, Borno State

The antibiotic susceptibility profile of extended-spectrum beta-lactamase (ESBL)-producing *K. pneumoniae* isolates from pediatric patients at the State Specialist Hospital, Maiduguri, Borno State, was evaluated. A total of 14 isolates were tested against various antibiotics to determine their resistance patterns. The highest susceptibility was observed with amoxicillin, with 12 (85.7%) isolates being sensitive and only 2 (14.3%) resistant. Gentamicin also showed high effectiveness, with 11 (78.6%) sensitive isolates, followed by ciprofloxacin (71.4%) and nitrofurantoin (64.3%). Moderate susceptibility was noted with doxycycline (57.1%), augmentin (57.1%), cefixime (64.3%), and streptomycin (64.3%) as shown in Table 2.

The antimicrobial susceptibility profile of the 14 ESBL-producing *K. pneumoniae* isolates revealed varying levels of sensitivity and resistance to the tested antibiotics. Among the antibiotics evaluated, amoxicillin exhibited the heightened sensitivity rate (85.7%), followed by gentamicin (78.6%) and ciprofloxacin (71.4). Nitrofurantoin, streptomycin and cefixime each demonstrated moderate sensitivity of (64.3%), while doxycycline and augmentin showed sensitivity rates of 57.1%. In contrast, the low sensitivity was observed with Co-trimoxazole (21.4%) indicating poor effectiveness against the isolates. In contrast, the highest resistance was observed with co-trimoxazole, where 11 (78.6%) isolates were resistant, and with nalidixic acid, where 8 (57.1%) isolates were resistant (Table 2).

The high susceptibility observed for gentamicin (78.6%) suggests that aminoglycosides may still retain considerable therapeutic value against ESBL-producing *K. pneumonia* infections in the study area. Antibiotic susceptibility patterns showed high sensitivity to amoxicillin (85.7%), gentamicin (78.6%),

and ciprofloxacin (71.4%), with high resistance to co-trimoxazole (78.6%) and nalidixic acid (57.1%). These results reflect regional trends reported by Ullah et al. (2022), Odewale et al. (2023), and Abdullah et al., (2024).

Table 2: Antibiotic Susceptibility Testing of ESBL *K. pneumoniae* Isolated from Children Attending the State Specialist Hospital, Maiduguri, Borno State

Antibiotic	ESBL <i>K. pneumoniae</i> (n = 14)			
	Sensitive		Resistant	
	No of Isolates`	%	No of Isolates`	%
Ciprofloxacin	10	71.4	4	28.6
Co-trimoxazole	3	21.4	11	78.6
Amoxicillin	12	85.7	2	14.3
Nitrofurantoin	9	64.3	5	35.7
Doxycycline	8	57.1	6	42.9
Gentamicin	11	78.6	3	21.4
Streptomycin	9	64.3	5	35.7
Cefixime	9	64.3	5	35.7
Nalidixic acid	6	42.9	8	57.1
Augmentin	8	57.1	6	42.9

Conclusion

These findings indicate that ESBL-producing *K. pneumonia* isolates from pediatric patients exhibit substantial resistance to several commonly prescribed antibiotics. This highlights the importance of routine antimicrobial susceptibility testing before initiating therapy and emphasizes the need for antimicrobial stewardship programs to minimize the emergence and spread of resistant strain. The antimicrobial susceptibility profile revealed varying levels of effectiveness among the antibodies tested against ESBL-producing *K. pneumonia*.

The relatively high susceptibility observed for gentamycin and ciprofloxacin suggest that these antibiotics remain useful therapeutic options for treating infections caused by ESBL-producing *K. pneumonia* in the study area. It is hereby recommended that there should be routine antimicrobial susceptibility test, continuous surveillance of antimicrobial resistance and enhance infection prevention and control measures.

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