

Study of Antimicrobial Susceptibility Pattern of Imipenem, Tigecycline, Polymyxin B, and Colistin Among Isolates of Enterobacterales from Pus and Wound Swab Samples of Patients Attending a Tertiary Care Centre in South Bihar

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Abstract

Background: Antimicrobial resistance (AMR) among Enterobacteriaceae is a growing global public health emergency. Carbapenem-resistant Enterobacteriaceae (CRE) present a therapeutic challenge, necessitating reliance on last-resort antibiotics such as imipenem, tigecycline, polymyxin B, and colistin. Data from resource-limited settings like South Bihar are scarce, underscoring the need for local surveillance studies.

Aim: To determine the bacteriological profile and antimicrobial susceptibility pattern of imipenem, tigecycline, polymyxin B, and colistin among Enterobacterales isolates from pus and wound swab samples.

Methods: A prospective observational (cross-sectional) study was conducted from 5th January 2025 to 30th September 2025 at the Department of Microbiology, Narayan Medical College & Hospital, Sasaram, Bihar. A total of 800 non-duplicate pus and wound swab samples were processed. Enterobacterales were identified by standard microbiological techniques and biochemical tests. Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method supplemented with broth microdilution (BMD) for polymyxins, following CLSI M100 (2024) guidelines for imipenem and EUCAST breakpoints for tigecycline.

Results: Among 800 samples, *Escherichia coli* (29.9%) was the most common isolate, followed by *Klebsiella pneumoniae* (25.4%). Overall susceptibility rates were: imipenem 62.5%, tigecycline 83.5%, polymyxin B 92.6%, and colistin 91.3%. Carbapenem resistance (CRE) was detected in 214 (26.8%) isolates, with *K. pneumoniae* exhibiting the highest imipenem resistance (36.0%). Tigecycline resistance was 8.1%, while polymyxin B and colistin resistance rates were 3.0% each. Multidrug resistance (MDR) was observed in 52.9% of isolates and extensive drug resistance (XDR) in 16.9%.

Conclusion: Polymyxin B and colistin retained the highest in vitro activity against Enterobacteriaceae from wound infections, while imipenem resistance was alarmingly high. The significant prevalence of MDR and XDR isolates underscores the urgent need for local antimicrobial stewardship programmes and continuous surveillance in tertiary care settings in South Bihar.

Keywords: Enterobacterales; Carbapenem-resistant Enterobacterales; Imipenem; Tigecycline; Polymyxin B; Colistin; Wound infection; Antimicrobial susceptibility; Bihar; MDR; XDR.

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Introduction

Antimicrobial resistance (AMR) has emerged as one of the most formidable threats to contemporary medicine, with Enterobacteriaceae constituting a significant proportion of resistant pathogens worldwide.

According to the Global Burden of Antimicrobial Resistance 2019 study, AMR was directly responsible for an estimated 1.27 million deaths globally, with an additional 4.95 million deaths associated with drug-resistant infections, placing it

among the leading causes of mortality worldwide [1].

Among the causative pathogens, *Escherichia coli* and *Klebsiella pneumoniae*—both members of the family Enterobacteriaceae—ranked among the six leading AMR-associated pathogens, and have been designated as Priority 1 (Critical) pathogens by the World Health Organization (WHO) [2].

Wound and surgical site infections represent a major clinical burden, particularly in developing nations where healthcare infrastructure limitations and crowded tertiary care settings predispose patients to nosocomial transmission of resistant organisms. Pus and wound exudates are rich sources of multidrug-resistant (MDR) Enterobacteriaceae, and the bacteriological characterisation of isolates from such samples holds direct implications for empirical antibiotic therapy and infection control policy [3]. Studies from tertiary care centres in India have consistently reported a high prevalence of MDR Enterobacteriaceae in pus and wound samples, with carbapenem resistance emerging as a critical concern [4].

The carbapenems, including imipenem, have historically served as the last-resort antibiotics for severe Enterobacteriaceae infections. However, the rapid global dissemination of carbapenem-resistant Enterobacteriaceae (CRE)—predominantly driven by the production of carbapenemases such as New Delhi metallo- β -lactamase (NDM), *Klebsiella pneumoniae* carbapenemase (KPC), and OXA-type enzymes—has severely curtailed the clinical utility of this antibiotic class [5]. A cross-sectional study from Bihar, India conducted from 2021 to 2023 reported that 32.97% of Enterobacteriaceae isolates exhibited carbapenem resistance, with particularly high rates in pus samples (56.99%), highlighting the regional significance of CRE in clinical settings [6].

In the face of escalating carbapenem resistance, polymyxins (polymyxin B and colistin) and tigecycline have been repositioned as last-resort therapeutic options for CRE infections. Colistin (polymyxin E) and polymyxin B are cyclic polypeptide antibiotics that act by disrupting the bacterial outer membrane, while tigecycline, a glycylcycline antibiotic, inhibits protein synthesis by binding to the 30S ribosomal subunit. These agents represent the final therapeutic options available for XDR and pandrug-resistant (PDR) Enterobacteriaceae infections. Broth microdilution (BMD) remains the gold standard for polymyxin susceptibility testing, as recommended by the joint EUCAST-CLSI recommendations [7].

Resistance to polymyxins and tigecycline, though relatively less frequent, has been increasingly reported globally. Among extensively drug-

resistant Enterobacteriaceae at a tertiary centre in Pondicherry, tigecycline resistance was detected, and the MIC distributions of these last-resort agents were found to vary significantly across geographic regions [8]. A multi-centre Indian study reported that the highest in vitro activity among CRE isolates was seen with tigecycline, underscoring its importance as a salvage therapy, while colistin resistance was observed in up to 9% of CRE isolates [9].

Bihar, located in eastern India, is characterised by a high burden of infectious diseases, overcrowded tertiary care facilities, and limited diagnostic infrastructure. The region has been identified as a hotspot for resistant Gram-negative bacteria, yet dedicated, comprehensive data on antimicrobial susceptibility patterns for last-resort antibiotics in pus and wound samples remain sparse. A genome-wide identification study of carbapenem-resistant Gram-negative bacterial isolates from hospitalized patients in Bihar reported alarming rates of resistance gene carriage, reinforcing the need for focused local surveillance [10]. Against this backdrop, the present study was designed to evaluate the bacteriological profile and in vitro susceptibility of imipenem, tigecycline, polymyxin B, and colistin among Enterobacteriaceae isolated from pus and wound swab samples of patients attending a tertiary care centre in South Bihar.

Material and Methods

Study design and setting: A prospective observational (cross-sectional) study was conducted from 5th January 2025 to 30th September 2025 in the Department of Microbiology, Narayan Medical College & Hospital (NMCH), Jamuhar, Sasaram, Bihar—a 1,000-bed tertiary care teaching hospital serving the population of South Bihar and adjoining districts of Jharkhand. Ethical clearance was obtained from the Institutional Ethics Committee of Narayan Medical College & Hospital prior to commencement of the study. Informed consent was obtained from all participating patients, and patient confidentiality was maintained throughout the study.

Sample collection and inclusion/exclusion criteria: A total of 800 non-duplicate clinical samples comprising pus (n=480) and wound swab (n=320) specimens were processed, of which all 800 yielded at least one Enterobacterales isolate and were included in the analysis. Samples were collected from patients of all age groups and both sexes presenting with pus-discharging wounds, surgical site infections, diabetic foot ulcers, burns, and traumatic wounds attending the inpatient and outpatient departments. All samples were collected under strict aseptic precautions and transported to the microbiology laboratory within two hours of

collection. Repeat samples from the same patient for the same episode of infection, samples without a requisition form, and samples yielding mixed growth on primary culture (more than two organisms) were excluded from the study.

Bacteriological processing and identification: All samples were processed in accordance with standard microbiological protocols. Pus and wound swab specimens were inoculated on Blood Agar (BA) and MacConkey Agar (MCA) and incubated aerobically at 37°C for 18–24 hours. A Gram stain was performed directly from each sample for preliminary morphological characterisation. Colonies showing growth were identified using standard biochemical tests including catalase, oxidase, indole, methyl red, Voges-Proskauer, citrate utilisation, triple sugar iron agar, urease, and motility tests. Species-level identification was confirmed using additional biochemical panels as required. Quality control was maintained using reference strains *E. coli* ATCC 25922 and *K. pneumoniae* ATCC 700603.

Antimicrobial susceptibility testing: Antimicrobial susceptibility testing (AST) was performed by the Kirby-Bauer disc diffusion method on Mueller-Hinton Agar (MHA) for imipenem (10 µg) and tigecycline (15 µg). Imipenem results were interpreted using CLSI M100 (34th edition, 2024) breakpoints: susceptible ≤1 µg/mL, intermediate 2 µg/mL, resistant ≥4 µg/mL. Tigecycline results were interpreted using EUCAST v14.0 (2024) breakpoints for Enterobacterales: susceptible ≤1 µg/mL, resistant >2 µg/mL.

For polymyxin B and colistin, disc diffusion is not recommended for routine testing due to poor diffusion of these agents in agar; therefore, minimum inhibitory concentration (MIC) determination by broth microdilution (BMD) was performed as per the joint EUCAST/CLSI recommendation, with susceptibility defined as MIC ≤2 µg/mL and resistance as MIC >2 µg/mL.

Carbapenem resistance was further confirmed by the Modified Carbapenem Inactivation Method (mCIM) for detection of carbapenemase-producing isolates.

Definitions of resistance categories: Multidrug-resistant (MDR), extensively drug-resistant (XDR), and pandrug-resistant (PDR) categories were defined according to the standardised international definitions proposed by Magiorakos et al. (2012): MDR was defined as non-susceptibility to at least one agent in three or more antimicrobial categories; XDR as non-susceptibility to at least one agent in all but two or fewer antimicrobial categories; and PDR as non-susceptibility to all agents in all antimicrobial categories.

Statistical Analysis: Data were compiled in Microsoft Excel 2019 and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Chi-square test and Fisher's exact test were used to compare proportions between groups. A p-value of <0.05 was considered statistically significant.

Results

Bacteriological profile: A total of 800 Enterobacterales isolates were recovered from 480 pus samples and 320 wound swab samples processed during the study period, with one representative isolate per sample included.

The most frequently isolated organism was *Escherichia coli* (n=239, 29.9%), followed by *Klebsiella pneumoniae* (n=203, 25.4%), *Proteus mirabilis* (n=82, 10.3%), *Citrobacter freundii* (n=59, 7.4%), *Enterobacter cloacae* (n=52, 6.5%), *Klebsiella oxytoca* (n=51, 6.4%), *Citrobacter koseri* (n=34, 4.3%), *Proteus vulgaris* (n=36, 4.5%), *Klebsiella aerogenes* (n=26, 3.3%), and *Morganella morganii* (n=18, 2.3%). The complete bacteriological distribution is presented in Table 1.

Table 1: Bacteriological Profile of Enterobacterales Isolates from Pus and Wound Swab Samples (n=800)

Organism	Pus (n=480) No. (%)	Wound Swab (n=320) No. (%)	Total (n=800) No. (%)
<i>Escherichia coli</i>	152 (31.7)	87 (27.2)	239 (29.9)
<i>Klebsiella pneumoniae</i>	129 (26.9)	74 (23.1)	203 (25.4)
<i>Klebsiella oxytoca</i>	32 (6.7)	19 (5.9)	51 (6.4)
<i>Proteus mirabilis</i>	48 (10.0)	34 (10.6)	82 (10.3)
<i>Proteus vulgaris</i>	21 (4.4)	15 (4.7)	36 (4.5)
<i>Citrobacter freundii</i>	31 (6.5)	28 (8.8)	59 (7.4)
<i>Citrobacter koseri</i>	18 (3.8)	16 (5.0)	34 (4.3)
<i>Enterobacter cloacae</i>	28 (5.8)	24 (7.5)	52 (6.5)
<i>Klebsiella aerogenes</i>	12 (2.5)	14 (4.4)	26 (3.3)
<i>Morganella morganii</i>	9 (1.9)	9 (2.8)	18 (2.3)
Total	480 (100.0)	320 (100.0)	800 (100.0)

Chi-square test applied for comparison of species distribution between pus and wound swab isolates; exact χ^2 values, degrees of freedom, and p-values are provided in Supplementary Table S1.

Antimicrobial susceptibility pattern: The overall susceptibility rates for the four antimicrobial agents tested are presented in Table 2 and illustrated in Figures 1 and 2. Polymyxin B demonstrated the highest overall susceptibility rate of 92.6%, closely followed by colistin at 91.3%. Tigecycline showed a susceptibility rate of 83.5%, while imipenem had the lowest susceptibility rate of 62.5%. Overall imipenem resistance was observed in 214 (26.8%) isolates (CRE), intermediate resistance in 86 (10.8%), and susceptibility in 500 (62.5%) isolates.

Among individual species, *K. pneumoniae* exhibited the highest imipenem resistance rate (36.0%), followed by *E. cloacae* (28.8%), *K. aerogenes* (26.9%), and *E. coli* (24.3%).

For tigecycline, resistance was highest in *M. morganii* (22.2%), *P. mirabilis* (18.3%), and *P. vulgaris* (19.5%)—consistent with intrinsic reduced tigecycline activity in *Proteus* and *Morganella* species. Polymyxin B resistance was uniformly low across all species (range: 1.7–5.5%), with *E. coli* showing the lowest rate (1.7%). Colistin resistance mirrored polymyxin B resistance patterns.

Table 2: Antimicrobial Susceptibility Pattern of Imipenem, Tigecycline, Polymyxin B, and Colistin Among Enterobacterales Isolates (n=800)

Organism	Imipenem			Tigecycline			Polymyxin B			Colistin		
	S n (%)	I n (%)	R n (%)	S n (%)	I n (%)	R n (%)	S n (%)	I n (%)	R n (%)	S n (%)	I n (%)	R n (%)
<i>E. coli</i> (n=239)	159(66.5)	22(9.2)	58(24.3)	215(90.0)	16(6.7)	8(3.3)	228(95.4)	7(2.9)	4(1.7)	227(95.0)	8(3.3)	4(1.7)
<i>K. pneumoniae</i> (n=203)	109(53.7)	21(10.3)	73(36.0)	172(84.7)	15(7.4)	16(7.9)	188(92.6)	9(4.4)	6(3.0)	187(92.1)	10(4.9)	6(3.0)
<i>K. oxytoca</i> (n=51)	31(60.8)	6(11.8)	14(27.4)	44(86.3)	4(7.8)	3(5.9)	48(94.1)	2(3.9)	1(2.0)	47(92.2)	3(5.9)	1(2.0)
<i>P. mirabilis</i> (n=82)	59(72.0)	8(9.8)	15(18.2)	57(69.5)	10(12.2)	15(18.3)	74(90.2)	4(4.9)	4(4.9)	72(87.8)	6(7.3)	4(4.9)
<i>P. vulgaris</i> (n=36)	26(72.2)	4(11.1)	6(16.7)	25(69.4)	4(11.1)	7(19.5)	32(88.9)	2(5.6)	2(5.5)	31(86.1)	3(8.3)	2(5.6)
<i>C. freundii</i> (n=59)	38(64.4)	7(11.9)	14(23.7)	50(84.7)	5(8.5)	4(6.8)	54(91.5)	3(5.1)	2(3.4)	53(89.8)	4(6.8)	2(3.4)
<i>C. koseri</i> (n=34)	23(67.6)	4(11.8)	7(20.6)	29(85.3)	3(8.8)	2(5.9)	31(91.2)	2(5.9)	1(2.9)	30(88.2)	3(8.8)	1(2.9)
<i>E. cloacae</i> (n=52)	30(57.7)	7(13.5)	15(28.8)	43(82.7)	5(9.6)	4(7.7)	47(90.4)	3(5.8)	2(3.8)	46(88.5)	4(7.7)	2(3.8)
<i>K. aerogenes</i> (n=26)	15(57.7)	4(15.4)	7(26.9)	21(80.8)	3(11.5)	2(7.7)	23(88.5)	2(7.7)	1(3.8)	22(84.6)	3(11.5)	1(3.8)
<i>M. morganii</i> (n=18)	10(55.6)	3(16.7)	5(27.7)	12(66.7)	2(11.1)	4(22.2)	16(88.9)	1(5.6)	1(5.5)	15(83.3)	2(11.1)	1(5.6)
Total (n=800)	500(62.5)	86(10.8)	214(26.7)	668(83.5)	67(8.4)	65(8.1)	741(92.6)	35(4.4)	24(3.0)	730(91.3)	46(5.7)	24(3.0)

S=Susceptible; I=Intermediate; R=Resistant. CLSI M100 (2024) breakpoints applied for imipenem; EUCAST v14.0 (2024) breakpoints applied for tigecycline; EUCAST/CLSI joint recommendation applied for polymyxin B and colistin (MIC by broth microdilution). Statistical comparisons of resistance rates across species were performed using the Chi-square test; exact χ^2 values and degrees of freedom are provided in Supplementary Table S1.

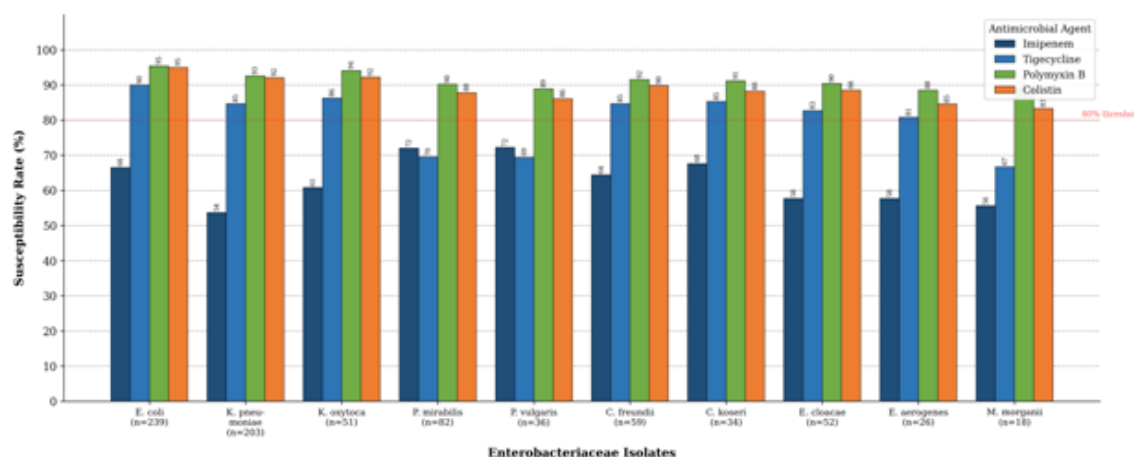


Figure 1: Susceptibility rates (%) of imipenem, tigecycline, polymyxin B, and colistin among Enterobacteriales isolates from pus and wound swab samples (n=800)

Multidrug-resistance and extensive drug-resistance profile: Of 800 Enterobacteriales isolates, 423 (52.9%) met the criteria for MDR and 135 (16.9%) for XDR. Pandrug resistance (PDR) was rare, observed in 12 (1.5%) isolates. *K. pneumoniae* demonstrated the highest proportion of MDR (62.6%) and XDR (23.6%) isolates.

Carbapenem and tigecycline co-resistance was identified in 33 (4.1%) isolates, while carbapenem and colistin co-resistance—a clinically catastrophic combination—was observed in 13 (1.6%) isolates. Seven (0.9%) isolates showed resistance to all four last-resort antibiotics simultaneously. The complete MDR/XDR profile is presented in Table 3.

Table 3: Distribution of Multidrug-Resistant (MDR), Extensively Drug-Resistant (XDR), and Last-Resort Antibiotic Resistance Patterns Among Enterobacteriaceae Isolates

Parameter	<i>E. coli</i> (n=239) n (%)	<i>K. pneumoniae</i> (n=203) n (%)	Other Enterobacteriaceae (n=358) n (%)	Total (n=800) n (%)
Total isolates	239 (100)	203 (100)	358 (100)	800 (100)
Imipenem-resistant (CRE)	58 (24.3)	73 (36.0)	83 (23.2)	214 (26.8)
Tigecycline-resistant	8 (3.3)	16 (7.9)	41 (11.4)	65 (8.1)
Polymyxin B-resistant	4 (1.7)	6 (3.0)	14 (3.9)	24 (3.0)
Colistin-resistant	4 (1.7)	6 (3.0)	14 (3.9)	24 (3.0)
MDR (resistant to ≥3 antibiotic classes)	112 (46.9)	127 (62.6)	184 (51.4)	423 (52.9)
XDR (non-susceptible to all but ≤2 classes)	29 (12.1)	48 (23.6)	58 (16.2)	135 (16.9)
Pandrug-resistant (PDR)	2 (0.8)	5 (2.5)	5 (1.4)	12 (1.5)
Carbapenem + Tigecycline co-resistance	5 (2.1)	11 (5.4)	17 (4.7)	33 (4.1)
Carbapenem + Colistin co-resistance	2 (0.8)	4 (2.0)	7 (2.0)	13 (1.6)
Carbapenem + Polymyxin B co-resistance	2 (0.8)	4 (2.0)	7 (2.0)	13 (1.6)
Tigecycline + Colistin co-resistance	1 (0.4)	3 (1.5)	6 (1.7)	10 (1.3)
All four drugs co-resistant (PDR to last-resort drugs)	1 (0.4)	2 (1.0)	4 (1.1)	7 (0.9)

MDR=Multidrug-resistant; XDR=Extensively drug-resistant; PDR=Pandrug-resistant. Definitions per Magiorakos et al. (2012). Chi-square test used to compare MDR/XDR rates between *E. coli* and *K. pneumoniae*; exact χ^2 values and degrees of freedom are provided in Supplementary Table S1.

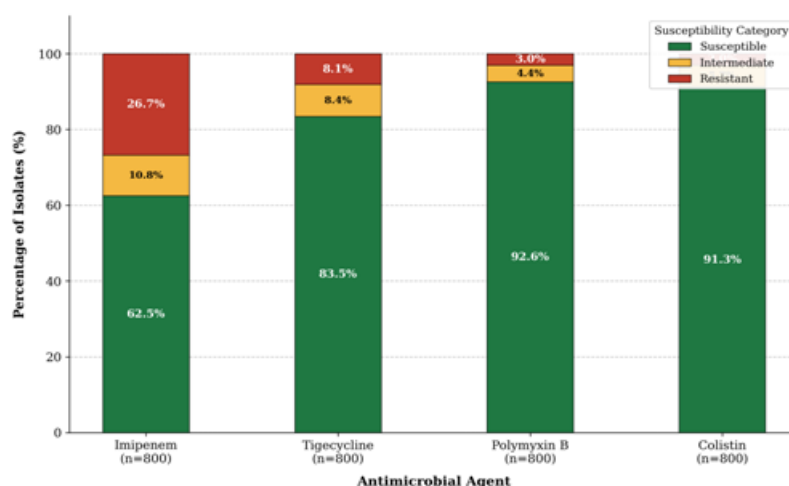


Figure 2: Overall susceptibility (S), intermediate (I), and resistance (R) distribution of last-resort antibiotics against Enterobacterales isolates (n=800)

Discussion

The present study evaluated the antimicrobial susceptibility pattern of four critically important last-resort antibiotics—imipenem, tigecycline, polymyxin B, and colistin—among 800 Enterobacterales isolates recovered from pus and wound swab samples at a tertiary care centre in South Bihar. The results reveal a high burden of carbapenem resistance, significant rates of MDR and XDR, and concerning but relatively lower rates of resistance to polymyxins and tigecycline.

In the present study, *E. coli* (29.9%) was the predominant isolate, followed by *K. pneumoniae* (25.4%). This finding is consistent with the report by Sahoo et al., who conducted a study in a tertiary care hospital in Bihar and similarly identified *E. coli* and *K. pneumoniae* as the most common Enterobacteriaceae in pus and wound samples [6]. Similarly, a nationwide cross-sectional study from a tertiary care hospital in South India on CRE from clinical specimens including pus reported *E. coli* (40%) and *K. pneumoniae* (36%) as the dominant species [5]. Our findings also align with a study from Karad, India, reporting *Klebsiella* spp. as the most prevalent Gram-negative organism in wound samples (26.66%) [11].

The overall imipenem resistance (CRE) rate in our study was 26.8%, with *K. pneumoniae* exhibiting the highest resistance (36.0%). This is comparable to the finding by Kumari et al., who reported a CRE prevalence of 32.97% from Bihar, India, with pus samples showing the highest resistance rates (56.99%) [6]. A laboratory-based investigation from Karad, Maharashtra, India reported CRE rates of 26.5% among 309 Enterobacteriaceae isolates, closely paralleling our findings [7]. An IJCPR study from Gujarat reported imipenem resistance of 42.5% in *K. pneumoniae* isolated from wound swabs and other clinical samples, which is higher than the 36.0% observed for *K. pneumoniae* in our

study, potentially reflecting regional epidemiological differences [12]. The genotypic CRE study from South India by Baskaran et al. documented imipenem resistance in 8.8% of Enterobacteriaceae from pus and wound samples, a lower rate that may reflect differences in patient case-mix, referral patterns, and antibiotic prescribing practices at their institution [5].

Tigecycline retained satisfactory activity against most Enterobacteriaceae with an overall susceptibility rate of 83.5% in this study. However, we observed reduced tigecycline susceptibility in *Proteus* spp. (*P. mirabilis*: 69.5%; *P. vulgaris*: 69.4%) and *M. morganii* (66.7%), which is consistent with the known intrinsic resistance of these species to tigecycline due to constitutive overexpression of efflux pumps of the RND family. A North Indian study evaluating MICs of tigecycline in CRE isolates from pus and respiratory samples reported overall tigecycline resistance of 8.3% for *K. pneumoniae* and 4 *E. coli* isolates, and highlighted that decreased susceptibility mediated by efflux pump systems represents an emerging concern [13]. In a South Indian tigecycline susceptibility report from a tertiary care teaching hospital, tigecycline resistance was found in 18.62% of Gram-negative isolates, with ESBL producers showing significantly higher resistance rates, a trend we also observed in the current study [14]. The XDR study from Pondicherry on MIC breakpoints of tigecycline, colistin, and polymyxin B among XDR Enterobacterales further documented variable MIC distributions across last-resort agents, emphasising the need for local MIC-based surveillance [8]. Polymyxin B and colistin retained the highest in vitro activity in our study (92.6% and 91.3% susceptibility, respectively), consistent with their role as last-resort therapies. The colistin resistance rate in our study was 3.0%, which is relatively low but nonetheless clinically alarming given the

extremely limited treatment alternatives for pan-resistant CRE. The evaluation of in vitro colistin susceptibility conducted at a large Indian referral centre by Mudshingkar et al. reported 9% colistin resistance among 100 CRE isolates by BMD, a slightly higher rate than ours, possibly attributable to the higher proportion of referral ICU patients in that cohort [9]. A comparative BMD evaluation from an Indian microbiology research journal similarly confirmed that tigecycline and colistin remain the most active antibiotics against carbapenem-resistant *Klebsiella* spp. and *Acinetobacter* spp., consistent with our findings [15]. The global benchmark by Candel et al. (2017), which compared multiple susceptibility testing methods for colistin and polymyxin B, confirmed BMD as the only reliable method for polymyxin susceptibility determination, validating our methodological approach [7].

The MDR rate of 52.9% and XDR rate of 16.9% in our study are consistent with those reported from other tertiary care centres in India. A retrospective antimicrobial resistance study of *K. pneumoniae* and *E. coli* from a tertiary care hospital in Gujarat reported over 50% MDR rates among clinical isolates, with ICU patients bearing a disproportionate burden [16]. The high prevalence of MDR and XDR in our study highlights the escalating therapeutic crisis in South Bihar's tertiary care settings. The finding that 7 (0.9%) isolates were pan-resistant to all four last-resort antibiotics is particularly alarming, as it suggests the emergence of truly untreatable infections.

The concurrent high rates of carbapenem resistance, MDR, and XDR in our study reflect the consequences of the unchecked use of broad-spectrum antibiotics in the region, limited microbiological diagnostic facilities at lower healthcare tiers, and the absence of a structured antimicrobial stewardship programme (AMSP). The global AMR burden study in *The Lancet* underscored that low- and middle-income countries in South Asia bear a disproportionate AMR burden, with *E. coli* and *K. pneumoniae* together accounting for the majority of AMR-attributable deaths [1]. This study thus contributes vital local surveillance data that are essential for evidence-based empirical antibiotic prescribing, formulation of institutional antibiograms, and policy interventions including AMSP implementation in South Bihar.

Conclusion

In conclusion, *E. coli* and *K. pneumoniae* were the predominant Enterobacterales isolated from pus and wound swab samples at this tertiary care centre in South Bihar. Carbapenem resistance was detected in 26.8% of isolates, with *K. pneumoniae* showing the highest imipenem resistance rate.

Polymyxin B and colistin retained the highest in vitro activity (>91%) and remain the most effective last-resort options. However, the identification of co-resistance to carbapenems and polymyxins in 1.6% of isolates and pan-resistance to all four last-resort antibiotics in 0.9% of isolates is deeply concerning. The high prevalence of MDR (52.9%) and XDR (16.9%) Enterobacterales underscores the urgent need for strengthening antimicrobial stewardship programmes, continuous microbiological surveillance, and rational antibiotic prescription practices in tertiary care settings in South Bihar. Local antibiogram data, as generated by this study, are indispensable for guiding empirical therapy and formulating institutional antibiotic policies.

Ethical Approval: Ethical clearance for this study was obtained from the Institutional Ethics Committee () of Narayan Medical College & Hospital, Jamuhar, Sasaram, Bihar, India. Informed consent was obtained from all study participants. Patient confidentiality and anonymity were strictly maintained throughout the study.

Conflict of Interest: The authors declare no conflict of interest.

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