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PREVALENCE, IDENTIFICATION, AND ANTIMICROBIAL SUSCEPTIBILITY TESTING OF *Acinetobacter baumannii* COMPLEX & PSEUDOMONAS SPECIES IN A TERTIARY CARE CENTRE IN THE EASTERN PART OF BIHAR.

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ABSTRACT

Background

Acinetobacter baumannii and Pseudomonas species have emerged as significant pathogens in healthcare-associated infections, showing resistance to multiple antibiotics, which complicates treatment options. Both organisms exhibit inherent and acquired resistance, making infections difficult to manage.

Aim

The study aimed to isolate, identify, and determine the antimicrobial susceptibility patterns of Acinetobacter baumannii and Pseudomonas species from clinical samples in a tertiary care center.

Materials & Methods

This hospital-based cross-sectional study was conducted between November 2023 and September 2024 at a tertiary care center in Northern Bihar. A total of 60 isolates of Acinetobacter baumannii and Pseudomonas species were identified using VITEK 2. Antibiotic susceptibility testing was performed using the MIC microbroth dilution technique.

Results

Out of 1058 clinical samples, 186 were positive for bacterial growth. Acinetobacter baumannii complex was isolated from 36 samples, and Pseudomonas species from 23. The sociodemographic results revealed that the majority of patients were in the 21-30 age group, with a higher prevalence of males (59.3%) compared to females (40.6%). The majority of Acinetobacter baumannii isolates (44.4%) were from sputum, followed by blood (30.5%). Resistance to multiple antibiotics, including piperacillin/tazobactam and meropenem, was observed in Acinetobacter baumannii, with strains isolated from urine showing 100% resistance to several antibiotics. Pseudomonas aeruginosa from sputum samples showed sensitivity to piperacillin/tazobactam and meropenem, while those from pus samples exhibited resistance to ceftazidime and imipenem.

Conclusion

Nitrofurantoin is an effective option for urinary tract infections caused by Acinetobacter baumannii, while piperacillin/tazobactam and meropenem are recommended for empirical treatment of Pseudomonas aeruginosa. Resistance patterns highlight the need for stringent infection control measures to prevent the spread of multidrug-resistant organisms.

Recommendation

Enhanced infection control and cautious use of antibiotics are essential to combat multidrug-resistant infections in healthcare settings.

Keywords: *Acinetobacter baumannii, Pseudomonas species, antibiotic resistance, antimicrobial susceptibility, healthcare-associated infections, empirical treatment, infection control.*
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INTRODUCTION

Acinetobacter baumannii, previously regarded as a low-virulence pathogen, has now emerged as a significant cause of both healthcare-associated and community-acquired infections. It exhibits antibiotic resistance, which is chromosomally encoded, and at the same time can survive for prolonged periods in stringent environments (as on/in walls, surfaces, and medical devices) in hospital settings. (1)

Acinetobacter baumannii has become a progressively more relevant and significant human pathogen because of the infections caused by this organism and the emergence of multidrug-resistant (MDR) strains. The majority of infections caused by this bacterium are often seen in the intensive care setting in critically sick patients. In addition, *Acinetobacter baumannii* has come up as a cause of infections acquired in long-term care facilities, among inhabitants of villages and cities, and in injured military personnel. (2,3,4)

The most common infections encountered with these organisms are pneumonia (both hospital and community-acquired), bacteremia, endocarditis, skin and soft tissue infections, urinary tract infections, and meningitis. The ability of this organism to contaminate the healthcare facility environment for prolonged periods is associated with hospital breakouts. Acinetobacter baumannii, once hospital-associated, now infects both hospitalized and general populations, with a 26% mortality rate in hospitals and up to 43% in ICUs. (5)

Acinetobacter baumannii has remarkable genetic plasticity as it shows antibiotic resistance either through a horizontal gene transfer mechanism that causes alteration in the cell wall of bacteria, development of efflux pumps, or via expression of Class D oxacillinase genes like *OXA-23*, *OXA-40,* and *OXA-58*, or through chromosomally encoded *OXA-51* gene. It has been noted that the bacteria also elaborate metallo-β-lactamases (IMP, VIM, and NDM). Clonal transmission of drug-resistant *A. baumannii* is reported globally. OXA-type enzymes or oxacillinases have a reduced capacity to break down carbapenems as compared to metallo-β-lactamases (MBLs). This group of OXA genes is located near the insertion sequence or IS, which in turn, can increase their expression under the influence of their strong promoters and includes *blaOXA-23, blaOXA-24, blaOXA-51, blaOXA-58, and blaOXA-143,* and many MBLs implicated in CRAB encompassing *bla* genes (*bla SIM, bla NDM, bla VIM, bla IMP,* and *bla SPM*), the prevalence of which varies depending upon the various geographical locations. The multidrug-resistant *Acinetobacter baumannii* is of medical concern as it has an immense capacity to disseminate quickly among hospitalized patients, leaving clinicians with nephrotoxic drugs like colistin as the only treatment option. Hence, surveillance should be done on a timely basis to know the true picture of these oxacillinase and metalo-β-lactamase producing enzymes present in Acinetobacter species so that hospital infection control committees can reinforce strict environmental cleaning, disinfection, and isolation practices in vulnerable sites inside the hospital premises. [6]

The present hospital-based cross-sectional study was conducted to isolate and characterize *Acinetobacter baumannii* & Pseudomonas species from clinical samples along with their antibiotic susceptibility pattern in various clinical samples that were submitted for culture and sensitivity testing from outdoor as well as indoor patients from November 2023 to August 2024 in the Microbiology Section the of Clinical Laboratory, Katihar Medical College, Katihar. The study aimed to isolate, identify, and determine the antimicrobial susceptibility patterns of Acinetobacter baumannii and Pseudomonas species from clinical samples in a tertiary care center.

MATERIALS AND METHODS

Study Design

This was a hospital-based cross-sectional study aimed at isolating, identifying, and determining the antimicrobial susceptibility patterns of Acinetobacter baumannii and Pseudomonas species from various clinical samples. The study was conducted from November 2023 to September 2024.

Study Area and Setting

The study was carried out at the Clinical Laboratory of Katihar Medical College and Hospital, located in Katihar, Bihar, India. The laboratory is a tertiary care center providing specialized microbiological diagnostics to both indoor and outdoor patients.

Sampling Technique

Clinical samples, including urine, blood, pus, and other body fluids, were collected from patients presenting at Katihar Medical College Hospital. These samples were processed and analyzed for bacterial identification and antimicrobial susceptibility testing. A total of 60 consecutive isolates of Acinetobacter baumannii and Pseudomonas species were included in the study.

Eligibility Criteria

- **Inclusion Criteria**

All clinical samples (urine, blood, pus, body fluids) from patients admitted or visiting Katihar Medical College Hospital were included for analysis in the study.

- **Exclusion Criteria**

Samples with insufficient quantities that were only used for diagnostic purposes were excluded from the study.

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Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC) of Katihar Medical College and Hospital, as per ethical standards. The approval was granted under Memo No. KMC / IEC / Ph. D. /001 / 2024 (Microbiology) on [approval date].

Ethical Approval

Ethical approval for this study was obtained from the Institutional Ethics Committee of Katihar Medical College, Katihar (Approval No: KMC/IEC/Ph.D./001/2024). The study was conducted by ethical standards set out by the Declaration of Helsinki.

Informed Consent

Informed consent was obtained from all individual participants included in the study. All procedures were explained to the patients, and their consent was documented before inclusion in the study.

Data Collection and Microbiological Procedures

Clinical samples were collected and cultured using standard protocols. Blood agar (BA), MacConkey agar (MA), and CLED agar (for urine samples) were used for bacterial isolation. Bacterial growth on these media was processed for identification and characterization at the species level. Identification was performed using the VITEK 2 Compact system, which is an automated system for organism identification and antimicrobial susceptibility testing.

- **VITEK 2 Gram-Negative (GN) Identification**

The VITEK 2 Compact system was used for identifying non-fermenting Gram-negative bacilli. It utilizes a fluorogenic methodology for identification and a turbidimetric method for antimicrobial susceptibility testing. The VITEK 2 Gram-negative identification card (GN) contains 47 biochemical tests, and results are available in approximately 10 hours.

- **Antimicrobial Susceptibility Testing (AST)**

The antimicrobial susceptibility testing was performed using the double dilution method to determine the Minimum Inhibitory Concentration (MIC). A bacterial suspension was prepared and adjusted to a McFarland standard of 0.5–0.63. A 280 µL aliquot of the diluted test organism was transferred into a tube containing a susceptibility card. This card contains antimicrobial agents in varying concentrations. The results were read after incubation, and susceptibility patterns were recorded.

Data Analysis

The data collected from the VITEK 2 system, including organism identification and susceptibility patterns, were analyzed using appropriate statistical methods. Descriptive statistics were used to summarize the findings, including the proportion of isolates exhibiting resistance to different antibiotics. Statistical software was used for data analysis, and significance testing was performed as needed.

RESULTS

A total of 1058 clinical samples were processed in the Microbiology section of the Clinical Laboratory at Katihar Medical College and Hospital. Out of these, 186 samples yielded positive culture results from both the outdoor and indoor patient departments. Among the 186 culture-positive cases, 142 samples exhibited microbial growth from single organisms, while 22 samples showed growth of two types of organisms (Table 1). The predominant sample type from which isolates were recovered was urine (59/186), followed by pus (46/186), blood (44/186), and sputum (37/186).

However, during the study, some samples were excluded from the final analysis due to various reasons. A few samples were insufficient in quantity, making them unsuitable for further testing or diagnostic purposes. Additionally, certain samples were contaminated, leading to mixed cultures that were discarded from the study. After considering these exclusions, a final total of 186 samples was analyzed.

A total of 1058 clinical samples were processed in the Microbiology section of the Clinical Laboratory, out of which 186 yielded positive culture results from the outdoor and indoor patient departments. Of these 186 culture-positive results, un-microbial growth was detected in 142 samples, whereas growth of two types of organisms was detected in 22 samples. (Table 1). The predominant sample from which isolates were recovered was urine (59/186), followed by a pus sample (46/186) blood sample (44/186), and a sputum sample (37/186). Out of the 46-plus samples that yielded growth, un-microbial growth was seen in 24 samples, and growth of two types of organisms was seen in 22 samples.

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Table 1: Isolation of different organisms from clinical samples:

Total number of isolates	Total number	Percentage
	1058	100
Growth detected	186	17.5
Culture negative	872	82.0
Unimicrobial growth	142	13.0
Two types of organisms	22	2.0
Isolates taken from the study	59	5.0

A total of 56/186 Gram-positive organisms and 130/186 Gram-negative organisms were recovered from the culture-positive cases. Amongst the 130/186 Gram-negative bacteria, Acinetobacter baumannii complex was isolated in 36 samples and Pseudomonas species in 23 samples. The predominant age group showing infection was 21-30 years, being 54.1% in females, followed by 20.0% in males, respectively. Another 20.0% of the elderly males in the 61-70 age group were predominantly infected. The overall male-to-female ratio was 1.5:1. (Table 2)

Table 2: Age and gender-wise distribution of patients

Age group (yrs)	Male (%)	Female (%)	Total (%)
0-10	0	0	0(0)
11-20	2(5.7)	2(8.3)	4(6.7)
21-30	7(20.0)	13 (54.1)	20(33.8)
31-40	3(8.7)	01(4.1)	4(6.7)
41-50	4(11.4)	5(20.8)	9(15.2)
51-60	6(17.1)	3(12.5)	9(15.2)
61-70	7(20.0)	0(0)	7(11.8)
71-80	02(5.7)	0(0)	2(3.4)
81-90	04(11.4)	0(0)	4(6.7)
Total	35(59.3)	24(40.6)	59(100)

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The majority of the isolates were obtained from Medicine (30.8%), followed by Surgery (27.6%), Casualty (12.0%), Paediatrics (11.5%), and Neurosurgery (7.4%) departments. (Table 3).

Table 3: Outdoor and indoor department-wise distribution:

Department	OPD (%)	IPD (%)	TOTAL (%)
Paediatrics	7(11.8)	17	11.5%
Gynaecology	6(10.0)	04	2.6%
Surgery	7(11.8)	41	27.6%
General medicine	11(18.6)	46	30.8%
Neurosurgery	5(8.4)	11	7.4%
Orthopaedics	2(3.3)	7	4.6%
Causality	13(22.0)	18	12%
Chest & TB	8(13.5)	05	3.7%
Total	59	149	100%

Acinetobacter baumannii complex was mainly isolated from sputum samples (44.4%; 16/36), followed by 30.5% (11/36) from blood, and 11.1% (4/36) from pus samples. On the other hand, 39.1% (9/23) of Pseudomonas aeruginosa were isolated from sputum samples, followed by 43.4% (10/23) from wound swabs, and 17.3% (4/23) from urine samples.

Acinetobacter baumannii complex isolated from urine showed 100% (3/3) resistance to piperacillin/tazobactam, ceftazidime, cefoperazone/sulbactam, meropenem, amikacin, ciprofloxacin, levofloxacin, and minocycline. Another 82.0% (9/11) strains isolated from blood were resistant to piperacillin/tazobactam, amikacin, and gentamicin, respectively. 73.0% (8/11) strains were resistant to imipenem and ciprofloxacin, whereas 82% (9/11) strains were sensitive to ceftazidime, followed by minocycline. Out of the 16 strains isolated from sputum samples, 100% resistance was shown towards ceftazidime and ciprofloxacin. 94% (15/16) strains were resistant to gentamicin and levofloxacin, respectively, whereas 88% (14/16) strains were sensitive to minocycline. All the pus isolates 100% (4/4) were resistant to trimethoprim/ sulfamethoxazole and meropenem, whereas 50.0% (2/4) were sensitive to cefepime. All the strains isolated from CVP tips were multidrug-resistant, being resistant to 11 drugs (Table 4).

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Original Article

Table 4: Antibiotic susceptibility pattern of Acinetobacter baumannii complex

Sample	Antibiotics	Sensitive	Intermediate	resistance	Sample	Antibiotics	Sensitive	Intermediate	resistance	Sample	Antibiotics	Sensitive	Intermediate	resistance
Urine	Piperacillin / tazobactam	0 (0%)	0 (0%)	03 (100%)	Pus	Piperacillin / tazobactam	02 (18%)	00 (0%)	09 (82%)	Blood/Wound	Piperacillin / tazobactam	01 (25%)	00 (0%)	03 (75%)
	Ceftazidime	0 (0%)	0 (0%)	03 (100%)		Ceftazidime	09 (82%)	00 (0%)	02 (18%)		Cefoperazone / sulbactam	01 (25%)	00 (0%)	03 (75%)
	Cefoperazone / sulbactam	0 (0%)	0 (0%)	03 (100%)		Cefoperazone / sulbactam	03 (27%)	01 (9%)	07 (64%)		Cefepime	02 (50%)	00 (0%)	02 (50%)
	Cefepime	0 (0%)	1 (50%)	02 (50%)		Cefepime	01 (9%)	00 (0%)	10 (91%)		Imipenem	01 (25%)	00 (0%)	03 (75%)
	Imipenem	0 (0%)	3 (100%)	00 (0%)		Imipenem	02 (18%)	01 (9%)	08 (73%)		Meropenem	00 (0%)	00 (0%)	04 (100%)
	Meropenem	0 (0%)	0 (0%)	03 (100%)		Meropenem	03 (27%)	01 (9%)	07 (64%)		Amikacin	01 (25%)	01 (25%)	02 (50%)
	Amikacin	0 (0%)	1 (100%)	02 (100%)		Amikacin	01 (9%)	01 (9%)	09 (82%)		Gentamicin	01 (25%)	00 (0%)	03 (75%)
	Gentamicin	0 (0%)	2 (50%)	01 (50%)		Gentamicin	02 (28%)	00 (0%)	09 (82%)		Ciprofloxacin	01 (25%)	00 (0%)	03 (75%)
	Ciprofloxacin	0 (0%)	0 (0%)	03(100%)		Ciprofloxacin	03 (27%)	00 (0%)	08 (73%)		Colistin	00 (0%)	04 (100%)	00 (0%)
	Levofloxacin	0 (0%)	0 (0%)	03(100%)		Levofloxacin	04 (36%)	01 (9%)	06 (55%)		Trimethoprim/sulfamethoxazole	00 (0%)	00 (0%)	04 (100%)
	Minocycline	0 (0%)	00 (0%)	03(100%)		Minocycline	06 (55%)	00(0%)	05 (45%)					
	Nitrofurantoin	3 (100%)	00 (0%)	00(0%)		Colistin	00 (0%)	11 (100%)	00 (0%)					
						Trimethoprim/ sulfamethoxazole	04 (36%)	00 (0%)	07 (64%)					

On the other hand, 78% of strains of Pseudomonas aeruginosa isolated from sputum samples were sensitive to piperacillin/tazobactam, cefepime, meropenem, amikacin, and ciprofloxacin, respectively. Another 89% of strains were sensitive to imipenem. 100% of the strains isolated from the pus sample were resistant to ceftazidime and cefepime, and

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Original Article

90% were resistant to imipenem. Maximum sensitivity was shown towards piperacillin/tazobactam (70%), followed by meropenem (44.0%). Out of the urinary isolates, 100% of the strains were resistant to ceftazidime and cefepime, and 90% of the strains were resistant to imipenem and amikacin. Another 70.0% of strains were sensitive to piperacillin/tazobactam (Table 5).

Table 5: Antibiotic susceptibility pattern of Pseudomonas aeruginosa

Sample	Antibiotics	Sensitive	Intermediate	resistance	Sample	Antibiotics	Sensitive	Intermediate	resistance	Sample	Antibiotics	Sensitive	Intermediate	resistance
URINE	Piperacillin / tazobactam	07(70%)	01(10%)	02(22%)	SPUTUM	Piperacillin / tazobactam	07(78%)	01(11%)	01(11%)	PUS	Piperacillin / tazobactam	07(70%)	01(10%)	02(20%)
	Ceftazidime	00(0%)	00(0%)	10(100%)		Ceftazidime	05(56%)	01(11%)	03(33%)		Ceftazidime	00(0%)	00(0%)	10(100%)
	Cefoperazone/sulbactam	01(10%)	01(10%)	08(80%)		Cefoperazone / sulbactam	6(67%)	02(22%)	01(11%)		Cefoperazone /sulbactam	01(10%)	01(10%)	08(80%)
	Cefepime	00(0%)	00(0%)	10(100%)		Cefepime	07(78%)	01(11%)	01(11%)		Cefepime	00(0%)	00(0%)	10(100%)
	Imipenem	01(10%)	00(0%)	09(90%)		Imipenem	08(89%)	00(0%)	01(11%)		Imipenem	01(10%)	00(0%)	09(90%)
	Meropenem	04(40%)	00(0%)	06(60%)		Meropenem	07(78%)	01(7%)	01(11%)		Meropenem	04(44%)	00(0%)	06(60%)
	Amikacin	01(10%)	00(0%)	09(90%)		Amikacin	07(78%)	01(14%)	01(11%)		Amikacin	01(10%)	00(0%)	09(90%)
	Ciprofloxacin	02(20%)	00(0%)	08(80%)		Ciprofloxacin	07(78%)	01(7%)	01(11%)		Ciprofloxacin	02(20%)	00(0%)	08(68%)
	Colistin	00(0%)	10(100%)	00(0%)		Levofloxacin	08(89%)	00(0%)	01(11%)		Colistin	00(0%)	10(100%)	00(0%)
	Nitrofurantoin	07(70%)	01(10%)	02(22%)		Colistin	00(0%)	09(100%)	00(0%)					
						Aztreonam	07(78%)	01(11%)	01(11%)					

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Both the organisms were predominantly isolated from the sputum sample (30.2%) followed by blood (19.5%), and pus (15.4%), while 10.1% isolates were obtained from CVP tips respectively.

DISCUSSION

A. baumannii and *P. aeruginosa* are the two most important healthcare-associated pathogens in humans, and increasingly resistant strains are being recognized all over the world.[9] Both bacteria have immense properties to acquire resistance to commonly used antibiotics, survive in variable environmental conditions, and have the unique ability to adhere and grow inside biofilms.[10] Both bacteria show acquired drug resistance either by mutation or by the acquisition of extrachromosomal genes in patients admitted, especially in the ICU.[11,12]

In our study, a total of 1058 clinical samples were processed out of which 186 yielded positive culture results from the outdoor and indoor patient departments. The predominant sample from which isolates were recovered was urine (59/186), followed by a pus sample (46/186) blood sample (44/186), and a sputum sample (37/186). Out of the 46 pus samples that yielded growth, unimicrobial growth was seen in 24 samples, and growth of two types of organisms was seen in 22 samples. Amongst the 130/186 Gram-negative bacteria, *Acinetobacter baumannii* complex was isolated in 36 samples, and Pseudomonas species in 23 samples, including various species.

Studies conducted by other authors showed that *Pseudomonas aeruginosa* was maximally isolated from the samples of patients admitted to the neurosurgery wards followed by neurosurgery & surgery ICUs, surgery wards, and orthopedic wards, suggesting the fact that nosocomial infections due to *Pseudomonas aeruginosa* were seen more in the postoperative patients and those who are in the hospital for a long time.[13]

Furthermore, it was seen that *P. aeruginosa* mostly colonizes in the patient vicinity and on/in instruments, thus spreading to the patients; hence, simple cleaning was able to minimize the infection rate considerably.[14]

Studies from other northeastern parts of India reported that 572 samples were processed for culture and sensitivity, among which showed the growth of 276 bacterial isolates obtained, and the prevalence rate was 48.25%. The incidence rate of Pseudomonas species was only 20.28%. 35/56 isolates, i.e., 62.5% and (21/56), i.e., 37.5%, were reported from males and females, respectively. Various specimens included in this investigation included urine, pus, sputum, blood, endotracheal secretions (ET), semen, catheter tip (CT), stool, body fluids, and body tissues.[15] In our study, the predominant age group showing infection was 21-30 years, being 54.1% in females, followed by 20.0% in males, respectively. Another 20.0% of the elderly males in the 61-70 age group were predominantly infected. The overall male-to-female ratio was 1.5:1 in our study.

Results from our study show that *Acinetobacter baumannii* complex was mainly isolated from sputum samples, 44.4% (16/36), followed by 30.5% (11/36) & 11.1% (4/36) from blood and pus samples. Contrary to this, 39.1% (9/23) *of Pseudomonas* species were found in the sputum sample, although a higher percentage of 43.4% (10/23) was taken from the wound swab.

Other authors reported on the isolation pattern of *Acinetobacter baumannii* isolates which were derived from specimens of deep tracheal aspirates (57; 51.4%), sputum (27; 24.3%), skin wound/exudates (15; 13.5%), blood (11; 9.9%), and urine (1; 0.9%). The main source of infection was the respiratory tract (89; 80.2%), followed by the soft and skin tissues (15; 13.5%), the bloodstream (6; 5.4%), and the urinary tract (1; 0.9%).[16]

Our study isolates, i.e., *Acinetobacter baumannii* complex isolated from urine, showed 100% (3/3) resistance to piperacillin/tazobactam, ceftazidime, cefoperazone/sulbactam, meropenem, amikacin, ciprofloxacin, levofloxacin, and minocycline. On the other hand, all the strains of *Pseudomonas aeruginosa* were resistant to ceftazidime and cefepime, and 90% of the strains were resistant to imipenem and amikacin. The present study showed that neither the fluoroquinolones nor the cephalosporin group retained susceptibility against *Acinetobacter baumannii* complex.

However, findings of other studies show that combination therapy of ampicillin and amoxicillin with sulbactam and clavulanic acid demonstrated significantly higher antibacterial activity against *Pseudomonas aeruginosa* when compared to their respective monotherapies (R=98.21% in both cases). The strains also showed 67.8% and 94.6% resistance to ceftazidime and cephalexin. However, extended-spectrum penicillins and the third-generation cephalosporins, in combination with sulbactam, tazobactam, and clavulanic acid, showed a significant decrease in resistance to *Pseudomonas aeruginosa*.[15]*Pseudomonas aeruginosa* was highly sensitive to the carbapenem group of antibiotics like imipenem (78.57%) and meropenem (69.64%), while aztreonam showed 71.43% resistance ($P<0.001$).

Blood isolates in our study showed that 82.0% (9/11) *Acinetobacter baumannii* strains were resistant to piperacillin/tazobactam, amikacin, and gentamicin, respectively. Another 73.0% (8/11) strains were resistant to imipenem and ciprofloxacin, whereas 82% (9/11) strains were sensitive to ceftazidime, followed by minocycline. Authors reported resistance rates for piperacillin/tazobactam, followed by ceftazidime, and cefepime, to be 85.1%, 77.6%, and 82.3%. Other antibiotics with significant resistance rates included cefoperazone/sulbactam 69.2%, gentamicin 78.5%, and

ciprofloxacin 74.8%. On the other hand, the highest sensitivity was observed for colistin 94.4% and tigecycline 75.7%, indicating these antibiotics as potential therapeutic options. Amikacin demonstrated intermediate effectiveness, with 40.2% of isolates responding, while minocycline was effective against 38.3% of the strains.[17]

Out of the 16 *Acinetobacter baumannii* strains isolated from sputum samples, 100% resistance was shown towards ceftazidime and ciprofloxacin. 94% (15/16) strains were resistant to gentamicin and levofloxacin, respectively, whereas 88% (14/16) strains were sensitive to minocycline. Irrational and inadequate use of antibiotics is responsible for the development of resistance of Pseudomonas species to antibiotic monotherapy. Hence, there is a need to lay stress on the rational use of antimicrobials and strictly abide by the concept of "reserve drugs" to minimize the misuse of available antimicrobials.

On the other hand, 78% of strains of *Pseudomonas aeruginosa* isolated from sputum samples were sensitive to piperacillin/tazobactam, cefepime, meropenem, amikacin, and ciprofloxacin, respectively. In other studies, 19.6% of strains of *Pseudomonas aeruginosa* showed resistance to carbapenems, and the authors explained the reason to be due to reduced levels of drug accumulation and increased expression of efflux pumps. Amikacin showed the highest sensitivity against *Pseudomonas aeruginosa* in our study, which is in corroboration with earlier reports published from India. [18.19]

Critically ill patients in ICUs are much more susceptible to A. baumannii infection since ICUs are prone to contamination, thereby spreading pathogens to patients. [11, 12]

The scrutiny of patients infected with *A. baumannii* revealed that the majority of the strains were recovered from patients in the ICU, presenting with respiratory tract infections. This finding highlights the true impact of *A. baumannii* multidrug-resistant (MDR) strains in ICU patients, consistent with reports of *A. baumannii* and *P. aeruginosa* causing infections in individuals undergoing invasive operations [20, 21].

This study investigated the prevalence and antibiotic susceptibility patterns of healthcare-associated pathogens, including *A. baumannii* and *P. aeruginosa*, isolated from patients admitted to hospital wards in a tertiary care center in Bihar. Both of these organisms exhibit a remarkable ability to survive in the hospital environment under various conditions, including both dry and wet surfaces, as well as on animate and inanimate objects. They are particularly adept at colonizing patients on supported respiration. Studies have shown that these hardy organisms can gain access to the respiratory tract through the endotracheal tube, often facilitated by tightly fitting masks [22].

The appropriate use of antibiotics is a critical factor in controlling the development of bacterial multidrug resistance. The increasing prevalence of extended-spectrum beta-lactamase (ESBL)-producing bacteria has led to the use of carbapenems as a preferred treatment, which in turn has contributed to the emergence of MDR strains [23]. Monitoring the local *A. baumannii* susceptibility profile is essential, as is regulating antibiotic dosages to prevent the further development of resistance. Moreover, it is crucial to implement effective measures to halt the spread of MDR strains within the hospital environment, especially among vulnerable patients, to reduce the overall burden of healthcare-associated infections. These findings align with global concerns about the spread of MDR pathogens in healthcare settings and emphasize the importance of continued surveillance and antimicrobial stewardship.

CONCLUSION

In our study settings, nitrofurantoin is considered to be the best drug for treatment of patients suffering from urinary tract infections whereas in case of *Pseudomonas aeruginosa*, piperacillin/tazobactam followed by meropenem and nitrofurantoin can be used for empirical treatment.

A low number of isolates i.e. 55.5% and 82.0% of the blood isolates retained susceptibility to minocycline and ceftazidime which can be used for the treatment in patients suffering from *Acinetobacter baumannii* complex blood stream infections. The major limitation is that none of the drugs can be used to treat outdoor patients.

Empirical treatment of UTI patients suffering from *Pseudomonas aeruginosa* infection can be done with piperacillin/tazobactam or nitrofurantoin, which is a good option. On the other hand, 89.0% of the strains isolated from the sputum sample were sensitive to levofloxacin and imipenem, respectively. Another 70.0% of isolates from wound infection were also sensitive to piperacillin/tazobactam.

Furthermore 90.0% of the *Pseudomonas aeruginosa* isolated from urine and pus sample were resistant to imipenem. 100% of the strains of *Acinetobacter baumannii* complex from wound infection were found resistant to meropenem.

Recommendation

This finding is alarming. Hence, strict infection control measures should be taken to prevent the spread of multidrug-resistant organisms from patient to patient or from health care workers to patients.

Study limitations

The study's limitations include its single-center design, which limits the generalizability of findings to other regions or settings. The sample size, though significant, may not fully represent the diversity of healthcare-associated infections, and the study's cross-sectional nature

restricts insights into long-term resistance trends. Additionally, the focus on resistant strains may have excluded broader clinical data and factors influencing resistance.

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List of Abbreviations

- A. baumannii: *Acinetobacter baumannii*
- P. aeruginosa: *Pseudomonas aeruginosa*
- ICU: Intensive Care Unit
- MDR: Multi-Drug Resistant
- ESBL: Extended-Spectrum Beta-Lactamase
- MIC: Minimum Inhibitory Concentration
- VITEK: Automated Identification System
- UTI: Urinary Tract Infection

Source of Funding

None

Conflict of Interest

The authors declare that there are no conflicts of interest regarding this study.

Availability of Data

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Authors' Contributions

All authors contributed equally to this study.

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