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PATTERNS OF INFECTIONS AND ANTIMICROBIAL RESISTANCE AMONG GRAM-NEGATIVE ORGANISMS IN A TERTIARY CARE HOSPITAL: AN OBSERVATIONAL DESCRIPTIVE STUDY

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ABSTRACT

Introduction

Regional variation in the distribution of various organisms is noted. Monitoring the use of antimicrobials and constant review of sensitivity patterns is imperative. The main aim of this study was to determine the species prevalence of Gram-negative isolates, including antibiotic resistance patterns from various clinical specimens.

Materials and methods

A hospital-based observational descriptive study was conducted to identify and perform an antibiotic susceptibility test of Gram-negative bacilli from clinical samples. The VITEK 2 Compact (30 card capacity) system was used where a fluorogenic methodology for organism identification and a turbidimetric method for susceptibility testing was performed. The method used for antimicrobial susceptibility testing was the doubling dilution technique for MIC based on the microdilution method.

Results

A total of 970 clinical samples were received, of which culture positivity was seen in 391(40.3%) cases. The most common specimen was urine at 35.1% (45/128), followed by a blood sample at 27.3% (35/128). The most common isolate was *Escherichia coli* 36.0% (47/128), followed by *Klebsiella pneumoniae* 16.4% (21/128) and *Burkholderia cepacia* 11.7% (15/128). Among the IPD patients, *Escherichia coli* showed maximum sensitivity to amikacin 67.7% and gentamicin 61.2%; 55.5% of the strains of *Acinetobacter baumannii* were sensitive to ceftazidime. *Pseudomonas aeruginosa* was sensitive to cefepime, cefoperazone/sulbactam, and levofloxacin, 70.0% each respectively. 86.6% of strains of *Burkholderia cepacia* retained susceptibility to meropenem.

Conclusion

This study isolates (lactose fermenting bacteria) were sensitive to trimethoprim sulfamethoxazole, levofloxacin, and amoxicillin/clavulanic acid. On the other hand, the non-lactose fermenting bacteria were susceptible to imipenem, meropenem, and levofloxacin.

Recommendation

Recommendations include strongly preferred alternative drugs for active or combination treatments.

Keywords: multidrug resistance (MDR), indoor patient department (IPD), outdoor patient department (OPD)
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INTRODUCTION

Recent years have witnessed the emergence of various drug-resistant organisms within the hospital itself, which has subsequently raised treatment concerns as they have been left with few treatment options. This, in turn, has not only increased the length of hospital stays of patients but has also increased the financial burden upon them.[1] Our tertiary care setting is well equipped with modern infrastructural facilities, advanced technology, and technical experts, which helps to cater to the bulk of patients in the north and eastern part of Bihar, primarily including the Kosi region. Any hospital is expected to be a hallmark of sterility and cleanliness. However, as literature, concerned with the reality reveals, most hospitals are also the places of the day-to-day proliferation of multidrug-resistant organisms that grow in dry as well as in moist environments and tend to colonize critically ill patients as opportunistic pathogens when they gain access to unusual anatomical sites through intravenous catheter lines, ventilators, prosthetics or other invasive medical procedures and devices.

Patients in ICU are at increased risk of acquiring healthcare-associated infections such as sepsis, pneumonia, urinary tract infections, post-surgical infections caused by carbapenem-ase-producing gram-

negative bacilli, vancomycin-resistant Enterococci (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), and several others, many of which are likely to be still evolving.[2]

To address these issues effectively, comprehensive surveillance and research on patterns of infection, the associated etiological agents, and antimicrobial resistance in tertiary care hospitals are crucial. The main aim of this study was to determine the species prevalence of Gram-negative isolates, including antibiotic resistance patterns from various clinical specimens.

MATERIALS AND METHODS

Study Design and Location

The present hospital-based observational descriptive study was conducted from December 2022 to August 2023 in the Microbiology Laboratory of Central Laboratory, Katihar Medical College, Katihar.

Sample selection, collection, and processing

A total of 970 clinical samples, viz urine, blood, pus, sputum, pleural fluid, CVP tips, drain tips, and CSF, were collected from patients admitted to various wards of the hospital. Pus samples were collected from undrained abscesses. Aspirates were collected in a sterile syringe. BacT/ALERT BPA disposable culture bottles [Organon Teknika Corp., Durham, NC] were used to collect blood samples and were introduced into the BacT/ALERT machine for incubation until a growth signal was detected.[3] The presence of the microorganisms in the blood culture bottle was indicated by the presence of CO2 produced during the metabolism of the bacteria, as indicated by the change in the color of the sensor attached to the bottom of each tube to yellow. Subcultures were done from the bottles on Chocolate agar, Blood agar [BA], and MacConkey agar [MA] plates and examined for any growth. All culture plates were incubated at 370C for 18 to 24 hrs. Bacterial growth on BA, CLED, and MA was processed for their identification and characterization up to the species level.[4]

Identification of Gram-negative (GN) isolates by Vitek 2 system

The GN card in the VITEK2 Compact system is based on established biochemical methods and newly developed substrates measuring carbon source utilization and enzymatic activities. There are 47 biochemical tests and one negative control well.

A doubling dilution technique for all antibiotics in the GN AST panel was done, which was based on the microdilution method. An inoculum was prepared by making a suspension of the organism in 3 ml of 0.45% sterile saline and standardized by adjusting with MacFarland in Densicheck Plus to get a reading between 0.5 – 0.63. The diluted test organism (280 µl) was transferred to another tube containing 3 ml of saline. Then, this tube was placed in the cassette with a susceptibility card. Each GN-AST card contains selected antimicrobials in varying concentrations, dried with a microbiological culture medium.[5]

Ethical Clearance

Institutional Ethical Committee Clearance for the study was obtained before the study vide Memo No IEC/IRB No: KMC/ IEC/MSc/001/2021 (Microbiology), dated 21/08/2021 from the Ethical Committee of Katihar Medical College.

RESULTS

Of the 970 clinical samples received in the Department laboratory, only 391(40.3%) showed growth of various microorganisms isolated from the outdoor and indoor patient departments. 347/391(88.7%) showed uni-microbial growth, and 22 showed growth of two organisms. A total of 128 isolates were randomly taken up for further study. Out of the 128 isolates, 122 (95.3%) were isolated in pure culture, while 04(3.1%) were in combination with Gram-positive or Gram-negative bacteria. The predominant age group infected was 0-10 years (32.0%), followed by 21-30 years (21.6%). The overall male-to-female ratio was 1.7:1.

32.0% (41/128) isolates were recovered from the Paediatrics department followed by 21.8%(28/128) isolates from gynaecology and 17.9%(23/128) from the General Medicine department.

Among the IPD patients, the maximum number of isolates was obtained from the Neurosurgery 100% followed by the Paediatrics 87.8% and Surgery 75.0% departments. Among the OPD patients, maximum isolates were obtained from ENT (100%), followed by Orthopaedics (50.0%) and Casualty (40.0%).

The most common specimen was urine (5.1%; 45/128) followed by a blood sample (27.3%; 35/128) and a pus sample (17.2%; 22/128). The most common isolates were *Escherichia coli* (36.0%; 47/128), followed by *Klebsiella pneumoniae* (16.4%; 21/128), *Burkholderia cepacia* (11.7%; 15/128), and *Pseudomonas aeruginosa* (10.1%; 13/128).

Escherichia coli (62.2%) was the main isolate in the urine sample, followed by *Klebsiella pneumoniae* (17.8%), *Enterobacter cloacae complex* & *Proteus mirabilis* (6.7% each, respectively. Another (17.1%; 6/35) strains of *Escherichia coli* and *Klebsiella pneumoniae* were isolated from blood specimens. The predominant strain from the sputum sample was *Pseudomonas aeruginosa* (50.0%; 9/18) followed by *Acinetobacter baumannii* (27.8%; 05/18). 31.8% strains of *Escherichia coli* followed by 50.0% strains of *Klebsiella pneumoniae* were isolated from the pus sample and CVP tips [**Table 1**].

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Table 1: Specimen-wise isolation of various organisms:

Organism	Specimen type						
	Urine	Blood	Sputum	Pus	CVP tip	Pleural fluid	TOTAL
Escherichia coli	28(62.2%)	06(17.1%)	03(16.7%)	07(31.8%)	01(16.7%)	02(100%)	47
Klebsiella pnuemoniae	08(17.8%)	06(17.1%)	01(5.6&)	03(13.6%)	03(50.0%)	0(0%)	21
Enterobacter cloacae complex	03(6.7%)	0(0%)	0(0%)	03(13.6%)	0(0%)	0(0%)	06
Proteus mirabilis	03(6.7%)	0(0%)	0(0%)	03(13.6%)	0(0%)	0(0%)	06
Pseudomonas aeruginosa	01(2.2%)	0(0%)	09(50.0%)	03(13.6%)	0(0%)	0(0%)	13
Pseudomonas putida	01(2.2%)	0(0%)	0(0%)	02(9.0%)	01(16.7%)	0(0%)	04
Acinetobacter baumannii	01(2.2%)	04(11.4%)	05(27.8%)	01(4.5%)	01(16.7%)	0(0%)	12
Burkholderia cepacia	0(0%)	15(42.9%)	0(0%)	0	0(0%)	0(0%)	15
Stenotrophominas maltophila	0(0%)	04(11.4%)	0(0%)	0	0(0%)	0(0%)	04
TOTAL	45(35.2%)	35(37.3%)	18(14.0%)	22(17.2%)	06(4.7%)	02(1.6%)	128

Escherichia coli isolated from OPD showed maximum sensitivity to amoxicillin-clavulanic acid, followed by cefoperazone/sulbactam and amikacin 67.8% each, respectively. Among the IPD patients, *Escherichia coli* showed maximum sensitivity towards amikacin 67.7% and gentamicin 61.2%, respectively. All the OPD isolates were found to be moderately sensitive to colistin [**Table 2**].

Antibiotics	Isolates from OPD patients, N=06			Antibiotics	Isolates from IPD patients, N=15		
	Resistant	Intermediate	Sensitive		Resistant	Intermediate	Sensitive
Amoxicillin/clavulanic acid	04(66.6%)	0(0%)	02(33.3%)	Amoxicillin/clavulanic acid	09(60.0%)	03(20.0%)	03(20.0%)
Cefuroxime	03(33.3%)	01(16.6%)	02(33.3%)	Cefuroxime	11(73.3%)	03(20.0%)	02(13.3%)
Cefoperazone/sulbactam	03(33.3%)	01(16.6%)	02(33.3%)	Cefoperazone/sulbactam	10(66.6%)	03(20.0%)	02(13.3%)
Ciprofloxacin	05(83.3%)	0(0%)	01(16.6%)	Ciprofloxacin	09(60.0%)	03(20.0%)	03(20.0%)
Meropenem	04(66.6%)	0(0%)	02(33.3%)	Meropenem	08(53.3%)	04(26.6%)	03(20.0%)
Imipenem	03(33.3%)	0(0%)	03(33.3%)	Imipenem	08(53.3%)	04(26.6%)	03(20.0%)
Cefepime	02(33.3%)	0(0%)	06(100%)	Cefepime	09(60.0%)	0(0%)	04(26.6%)
Amikacin	01(16.6%)	0(0%)	05(83.3%)	Amikacin	06(40.0%)	06(40.0%)	03(20.0%)
Colistin	0	06(100%)	0	Colistin	01(6.6%)	14(93.3%)	0(0%)
Gentamicin	02(33.3%)	02(33.3%)	02(33.3%)	Gentamicin	06(40.0%)	04(26.6%)	05(33.3%)
Piperacillin/tazobactam	03(33.3%)	01(16.6%)	02(33.3%)	Piperacillin/tazobactam	09(60.0%)	06(40.0%)	0(0%)
Trimethoprim/sulfamethoxazole	03(33.3%)	0(0%)	03(33.3%)	Trimethoprim/sulfamethoxazole	06(40.0%)	0(0%)	09(60.0%)
Nitrofurantoin**	01(16.6%)	0(0%)	04(66.6%)	Nitrofurantoin	02(13.3%)	0(0%)	02(13.3%)

Table 2: Antibiotic susceptibility pattern of *Escherichia coli* among OPD and IPD patients:

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***** only for urinary isolates***

Antibiotics	Isolates from OPD patients, N=03			Antibiotics	Isolates from IPD patients, N=09		
	Resistant	Intermediate	Sensitive		Resistant	Intermediate	Sensitive
Levofloxacin	0(0%)	0(0%)	03(100%)	Levofloxacin	03(33.3%)	03(33.3%)	03(33.3%)
Ceftazidime	02(66.6%)	01(33.3%)	0(0%)	Ceftazidime	04(44.4%)	05(55.5%)	0(0%)
Cefoperazone/sulbactam	03(100%)	0(0%)	0(0%)	Cefoperazone/sulbactam	08(88.8%)	0(0%)	01(11.1%)
Cefepime	03(100%)	0(0%)	0(0%)	Cefepime	09(100%)	0(0%)	0(0%)
Imipenem	03(100%)	0(0%)	0(0%)	Imipenem	09(100%)	0(0%)	0(0%)
Meropenem	03(100%)	0(0%)	0(0%)	Meropenem	09(100%)	0(0%)	0(0%)
Ciprofloxacin	03(100%)	0(0%)	0(0%)	Ciprofloxacin	09(100%)	0(0%)	0(0%)
Gentamicin	01(33.3%)	01(33.3%)	01(33.3%)	Gentamicin	08(88.8%)	01(11.1%)	0(0%)
Amikacin	02(66.6%)	0(0%)	01(33.3%)	Amikacin	09(100%)	0(0%)	0(0%)
Piperacillin/tazobactam	03(100%)	0(0%)	0(0%)	Piperacillin/tazobactam	09(100%)	0(0%)	0(0%)
Trimethoprim/sulfamethoxazole	0(0%)	01(33.3%)	02(66.6%)	Trimethoprim/sulfamethoxazole	08(88.8%)	01(11.1%)	0(0%)
Colistin	0(0%)	03(100%)	0(0%)	Colistin	01(11.1%)	08(88.8%)	0(0%)

Table 3 shows the antibiotic susceptibility pattern of *Klebsiella pneumoniae* among OPD and IPD patients. Maximum sensitivity was shown to amoxicillin/clavulanic acid, cefuroxime, cefoperazone/sulbactam, gentamicin, and piperacillin/tazobactam, each being 33.3%, respectively. Resistance was shown to ciprofloxacin (83 3%). On the other hand, 60.0% of the IPD patients showed sensitivity to trimethoprim/sulfamethoxazole, followed by gentamicin (33.3%). Maximum resistance was shown to cefuroxime (73.3%).

Table 3: Antibiotic susceptibility pattern of *Klebsiella pneumoniae* among OPD and IPD patients:

***** only for urinary isolates***

The antibiotic susceptibility pattern of *Pseudomonas aeruginosa*, among OPD and IPD patients, was found to retain maximum sensitivity to piperacillin/tazobactam, ceftazidime, cefoperazone/sulbactam, meropenem, amikacin, and ciprofloxacin, being 66.6% each, respectively. 66.6% of the strains retained sensitivity to colistin. Resistance was shown to imipenem, gentamicin, and levofloxacin, each 66.6%, respectively.

The IPD patients showed maximum sensitivity to cefepime, cefoperazone/sulbactam, and levofloxacin (70.0% each). 70.0% of the strains retained intermediate susceptibility to colistin. Maximum resistance was shown to ceftazidime (70.0%).

Table 4 shows the antibiotic susceptibility pattern of *Acinetobacter baumannii* isolated from OPD & IPD patients. 100% of the OPD strains retained sensitivity to levofloxacin and 66.6% to trimethoprim/sulfamethoxazole. All the strains were sensitive to colistin. However, 100% of the strains showed resistance to cefoperazone/sulbactam, cefepime, imipenem, meropenem, ciprofloxacin, and meropenem.

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Antibiotics	Isolates from OPD patients, N=03			Antibiotics	Isolates from IPD patients, N=09		
	Resistant	Intermediate	Sensitive		Resistant	Intermediate	Sensitive
Levofloxacin	0(0%)	0(0%)	03(100%)	Levofloxacin	03(33.3%)	03(33.3%)	03(33.3%)
Ceftazidime	02(66.6%)	01(33.3%)	0(0%)	Ceftazidime	04(44.4%)	05(55.5%)	0(0%)
Cefoperazone/sulbactam	03(100%)	0(0%)	0(0%)	Cefoperazone/sulbactam	08(88.8%)	0(0%)	01(11.1%)
Cefepime	03(100%)	0(0%)	0(0%)	Cefepime	09(100%)	0(0%)	0(0%)
Imipenem	03(100%)	0(0%)	0(0%)	Imipenem	09(100%)	0(0%)	0(0%)
Meropenem	03(100%)	0(0%)	0(0%)	Meropenem	09(100%)	0(0%)	0(0%)
Ciprofloxacin	03(100%)	0(0%)	0(0%)	Ciprofloxacin	09(100%)	0(0%)	0(0%)
Gentamicin	01(33.3%)	01(33.3%)	01(33.3%)	Gentamicin	08(88.8%)	01(11.1%)	0(0%)
Amikacin	02(66.6%)	0(0%)	01(33.3%)	Amikacin	09(100%)	0(0%)	0(0%)
Piperacillin/tazobactam	03(100%)	0(0%)	0(0%)	Piperacillin/tazobactam	09(100%)	0(0%)	0(0%)
Trimethoprim/sulfamethoxazole	0(0%)	01(33.3%)	02(66.6%)	Trimethoprim/sulfamethoxazole	08(88.8%)	01(11.1%)	0(0%)
Colistin	0(0%)	03(100%)	0(0%)	Colistin	01(11.1%)	08(88.8%)	0(0%)

Table 4: Antibiotic susceptibility pattern of *Acinetobacter baumannii* among OPD and IPD patients

On the other hand, IPD patients showed maximum resistance to imipenem, meropenem, cefepime, ciprofloxacin, and piperacillin/tazobactam, each 100%, respectively. 55.5% of the strains were moderately sensitive to ceftazidime.

66.6% of the strains of *Proteus mirabilis* were sensitive to gentamicin and aztreonam. Another 66.6% of the *Proteus mirabilis* strains were resistant to piperacillin/tazobactam, ceftazidime, cefepime, and imipenem, respectively.

The antibiotic susceptibility pattern of *Burkholderia cepacia* showed that 86.6% of strains retained susceptibility to meropenem. 60.0% of the strains were sensitive to trimethoprim/sulfamethoxazole.

DISCUSSION

An increased rate of isolation of non-lactose fermenting bacteria with multi-drug resistance patterns is noted in this study, which highlights the importance of increasing the knowledge regarding the prevalence of local strains. This, in turn, raises awareness among the physicians to start appropriate empirical treatment on one hand and send appropriate sample(s) for culture and sensitivity, awaiting the results for necessary escalation and de-escalation of medication during the treatment.

Of the 970 clinical samples received in the departmental laboratory, only 391(40.3%) showed growth of various microorganisms isolated from the outdoor and indoor patient departments, whereas 579(59.6%) were culture-negative. 347 of the 391 culture-positive samples (347/391; 88.7%) showed antimicrobial growth, and 44 (11.3%) showed growth of two organisms. A total of 128 isolates were randomly taken up for further study. Out of the 128 isolates, 122 (95.3%) were isolated in pure culture, while 06 (4.7%) were in combination with Gram-positive or Gram-negative bacteria.

A study was conducted on 175 pus samples in a tertiary care hospital in Gwalior, Madhya Pradesh, from September 2021 to April 202. 102/175 (58.28%) wound samples showed growth of various organisms. Another 73/175 (41.71%) wound samples were culture negative. 92/102(90.10%) showed monomicrobial growth whereas 10/102(9.80%) showed polymicrobial growth. Hence, a total of 112/175(64.0%) isolates were obtained in total in their study. This study's results showed a higher rate of isolation of organisms in total (including monomicrobial and polymicrobial) growth, 391/970 (40.3%) in this geographical region.[6]

The age and gender-wise distribution of patients showing infections with various Gram-negative organisms

showed that the most predominant age group was 0-10 years (32.0%) followed by 21-30 years (21.6%). The overall male-to-female ratio was 1.7:1. A study was carried out in Shahjahanpur, Uttar Pradesh, to characterize and perform antibiotic susceptibility patterns of 100 non-lactose fermenting Gram-negative bacterial strains that were isolated from 1218 clinical samples. Most of the isolates were obtained from patients in the age group of 40–60 years (42%), followed by the age group of 20–39 years (34%).[7]

Department-wise isolation of organisms shows that 32.0% (41/128) isolates were recovered from the Paediatrics department, followed by 21.8% (28/128) isolates from gynecology and 17.9% (23/128) from the General Medicine department. The findings of S Prasanna et al. showed that the majority of the isolates were obtained from the Surgery ward (50%) followed by Medicine (14.5%), Orthopaedics ward (5.9%), and OBG ward (2.9%). [12]

This study results showed the most common isolates were from urine 35.1% (45/128) followed by blood 27.3% (35/128), pus sample being 17.2% (22/128), sputum 14.0$ (18/128), CVP tip 4.7% (06/128) and pleural fluid being 0.7% (02/128). The reason behind the increased isolation of Gram-negative organisms from UTI could be due to many factors like adherence and colonization of the uroepithelium due to the expression of virulence factors like adhesins and pili.

A study from Maharashtra reported the isolation of non-lactose fermenting organisms from various clinical samples, which included blood, pus/wound swabs, sputum, drain fluids, and urine. The majority of the isolates were recovered from pus 57 (51.81%), urine 19 (17.27%), blood 3 (2.72%), sputum 19 (17.27%), and drain fluid 13 (11.81%). [8]

The most common isolate in the clinical setup was *Escherichia coli* 36.0% (47/128), followed by *Klebsiella pneumoniae* 16.4% (21/128), *Burkholderia cepacia* 11.7% (15/128), and *Pseudomonas aeruginosa* 10.1% (13/128). Other studies showed the most prevalent isolates to be *E. coli* (32.89%), Acinetobacter species (28.94%), Klebsiella species (15.78%), and Pseudomonas species (15.78%). Other organisms isolated were Proteus species and Gram-negative non-fermenters.[9]

Escherichia coli 62.2% was the main isolate in the urine sample followed by *Klebsiella pneumoniae* 17.8%, *Enterobacter cloacae complex* & *Proteus mirabilis* each 6.7% respectively. Another 17.1% (6/35) strains of *Escherichia coli* and *Klebsiella pneumoniae* were isolated from blood specimens. The predominant strain from the sputum sample was *Pseudomonas aeruginosa* 50.0% (9/18) followed by *Acinetobacter baumannii* 27.8% (05/18). 31.8% strains of *Escherichia coli* followed by 50.0% strains of *Klebsiella pneumoniae* were isolated from the pus sample and CVP tip.

Findings of other studies show that *Escherichia coli* species isolated maximum from urine samples i.e. (40/62; 64.51%) followed by pus (12/62; 19.35%), blood (03/62; 4.83%), sputum (03/62; 4.83%), endotracheal tube (03/62; 4.83%) and minimum from a high vaginal swab.[10]

Maximum sensitivity was shown towards amoxicillin/clavulanic acid and meropenem, each being 46.8%, respectively. 68.0% (32/47) strains showed a moderate susceptibility pattern to amikacin.

Maximum resistance was shown to ciprofloxacin (41/47; 87.2%), followed by trimethoprim/sulfamethoxazole and ceftazidime (31/47; 65.9%).

Findings show that 64.0% of *Escherichia coli* isolates were resistant to aminoglycoside, followed by fluoroquinolones 68.0%, 3rd-generation cephalosporins 76.0%, piperacillin/tazobactam 28.0%, cefepime 52.0%, and imipenem 16.0%.[11]

Among the patients in the IPD, maximum sensitivity was shown towards amikacin (67.7%) and gentamicin (61.2%), respectively. All the OPD isolates were found to be moderately sensitive to colistin. Resistance was shown to ciprofloxacin (93.5%) followed by cefuroxime (80.6%) by the IPD strains.

In other studies, *Escherichia coli* among the OPD patients showed maximum sensitivity to tigecycline (95.2%) followed by nitrofurantoin (89.2%), Fosfomycin (86.3%), and carbapenem (82%). On the other hand, isolates from IPD showed 79.5% sensitivity to tigecycline, 75.9% to nitrofurantoin, and 52.4% to carbapenem.

Antibiotic susceptibility patterns in *Klebsiella pneumoniae* showed maximum susceptibility to trimethoprim/sulfamethoxazole (57.1%). Moderate susceptibility was shown by the strains to colistin (95.2%). Resistance was shown to cefuroxime (66.7%). On the other hand, 60.0% of the IPD patients showed sensitivity to trimethoprim/sulfamethoxazole, followed by 33.3% to gentamicin. Maximum resistance (73.3%) was shown to cefuroxime.

Findings of other studies show that 90.0% of *Klebsiella pneumoniae* strains were resistant to amoxicillin, followed by cefuroxime, cefotaxime, cefoperazone, and cefepime each, 65.0% respectively. On the other hand, 70.0% of the strains were sensitive to cotrimoxazole and 45.0% to imipenem.[9]

Overall antibiotic sensitivity pattern of *Pseudomonas aeruginosa* showed that 76.9% of strains were sensitive to cefepime, followed by 61.5% sensitivity to levofloxacin and cefoperazone/sulbactam each, respectively. Resistance was shown to gentamicin, 61.5%, and ciprofloxacin, meropenem, and aztreonam, each 53.8% respectively. The IPD patients showed maximum sensitivity to cefepime, cefoperazone/sulbactam, and levofloxacin, 70.0% each, respectively. 70.0% of the strains retained intermediate susceptibility to colistin. Maximum resistance was shown to ceftazidime 70.0%.

Studies conducted showed that 81.0 % of strains were sensitive to gentamicin, followed by 76.2% sensitivity to amikacin and 71.4% to tobramycin. The authors commented that susceptibility to imipenem and meropenem was very poor. 96.0% of the pathogens were multi-drug resistant, and the authors explained that

prolonged hospital stays and excessive use of drugs were responsible for such MDR cases. [13]

In this study, it is seen that 50.0% of strains of *Acinetobacter baumannii* were sensitive to levofloxacin, followed by Trimethoprim/sulfamethoxazole (16.6%). All the strains were resistant to cefepime, followed by imipenem, meropenem, and ciprofloxacin, followed by cefoperazone/sulbactam & amikacin, each 91.6% respectively. 91.6% of strains were moderately sensitive to colistin. On the other hand, IPD patients showed maximum resistance to imipenem, meropenem, cefepime, ciprofloxacin, and piperacillin/tazobactam, each 100% respectively. 55.5% of the strains were moderately sensitive to ceftazidime.

66.6% of strains of *Enterobacter cloacae* complex were sensitive to tigecycline, followed by piperacillin/tazobactam, amikacin, and levofloxacin (50.0% each). 83.3% of strains were moderately sensitive to colistin. 66.6% of strains were resistant to ceftazidime, imipenem, and meropenem. Reports show that *Enterobacter cloacae* complex mediated 60.0% resistance to cefixime, whereas maximum susceptibility was shown to amikacin, meropenem, and imipenem, respectively.[10] The difference in the production of ESBL in *the Enterobacter cloacae* complex was statistically significant (P=0.03) as compared to *Klebsiella aerogenes*. [10]

66.6% of the strains of *Proteus mirabilis* were found to be sensitive to gentamicin and aztreonam. Another 66.6% of the strains were resistant to piperacillin/tazobactam, ceftazidime, cefepime, and imipenem, respectively. Reports show *Proteus mirabilis* showed 66.7% resistance to amoxicillin and 33.3% each to amoxicillin-clavulanate, ceftriaxone, cefuroxime, and cefepime.[11]

The antibiotic susceptibility pattern of *Burkholderia cepacia* showed that 86.6% of strains retained susceptibility to meropenem. 60.0% of the strains were resistant to trimethoprim/sulfamethoxazole. Resistance to trimethoprim/sulfamethoxazole is alarming in this study as it narrows down the treatment options because combination therapy of trimethoprim/sulfamethoxazole along with meropenem or ceftazidime is used for the treatment of infections caused by this pathogen.

CONCLUSION

The isolation pattern and antibiogram of the Gram-negative pathogen from different infectious sites varies not only between hospitals but also among patients. It is an important responsibility of Clinical microbiologists to perform culture sensitivity of the bacterial pathogens isolated from various clinical samples and put forward the true picture before the physicians for wise and judicious selection of antibiotics. It is a matter of vital importance to carry out surveillance from time to time to monitor the hospital antibiogram as the sensitivity pattern of organisms changes from time to time in every hospital.

This study isolates (lactose fermenting bacteria) were sensitive to trimethoprim sulfamethoxazole, levofloxacin, and amoxicillin/clavulanic acid. On the other hand, the non-lactose fermenting bacteria were susceptible to imipenem, meropenem, and levofloxacin.

Limitations

The limitations of this study include the small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation to this study's findings.

Recommendation

Recommendations include strongly preferred alternative drugs for active or combination treatments.

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Data Availability

Data is available upon request.

Author contributions

All authors contributed to the design of the research. AS and PPB collected and analyzed the data. PK and AS wrote the manuscript. AS and PK edited the paper. All authors read and approved the paper.

List of abbreviations:

MDR- multidrug resistance
IPD- Indoor patient department
OPD- outdoor patient department
ICU- Intensive Care Unit
VRE- Vancomycin-resistant Enterococci
MRSA- Methicillin-resistant *Staphylococcus aureus*
BA- Blood agar
MA- MacConkey agar
GN- Gram-negative
ENT- Ear, Nose, and Throat
UTI- Urinary Tract Infection

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Conflict of interest

The authors have no conflicting interests to declare.

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