

Rising Threat Of Multidrug-Resistant Pathogens In Icu Pus Specimens: Insights From A North Indian Tertiary Hospital

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ABSTRACT

Background: Infections acquired in intensive care units (ICUs) are often severe and caused by multidrug-resistant (MDR) organisms, making early identification and targeted therapy critical. This study aimed to analyze the bacteriological profile and antibiotic susceptibility patterns of clinical isolates from ICU patients at Sharda Hospital, Greater Noida.

Materials and Methods: A total of 2,125 clinical specimens including blood (46%), urine (30%), respiratory (20%), and pus (4%) were processed over the study period. Identification of pathogens and antimicrobial susceptibility testing were performed using standard microbiological techniques and CLSI guidelines.

Results: Out of 2,125 samples, 285 bacterial isolates were obtained. Respiratory specimens had the highest positivity (46%), followed by blood (23%), urine (20%), and pus (11%). The most frequently isolated organism was *Escherichia coli* (24%), followed by *Acinetobacter* spp. (23%), *Klebsiella* spp. (13%), *Pseudomonas aeruginosa* (10%), *Staphylococcus aureus* (10%), *Enterococcus* spp. (10%), Coagulase-negative *Staphylococci* (6%), *Citrobacter* spp. (3%), and *Proteus* spp. (1%). Among Gram-negative organisms, carbapenems and tigecycline showed moderate sensitivity, while resistance was high to cephalosporins and fluoroquinolones. For *Acinetobacter* spp., minocycline (68%) and tigecycline (45%) were the most effective. *Pseudomonas* isolates were mostly susceptible to amikacin, gentamicin, and carbapenems (75–79%). Among Gram-positive organisms, linezolid and vancomycin were highly effective against *Staphylococcus aureus* and *Enterococcus* spp. Alarming, resistance to commonly used antibiotics such as penicillin, fluoroquinolones, and erythromycin was widespread.

Conclusion: The study highlights the prevalence of multidrug-resistant organisms, especially *Acinetobacter* spp. and *E. coli*, in ICU settings. Regular surveillance and stringent antibiotic stewardship are vital for improving patient outcomes and combating antimicrobial resistance.

Keywords: ICU infections, antimicrobial resistance, *Acinetobacter*, *E. coli*, multidrug-resistant organisms, antibiotic susceptibility, tertiary care hospital

INTRODUCTION

Infections acquired in the intensive care unit (ICU) setting are among the leading causes of morbidity and mortality worldwide, primarily due to the emergence and spread of multidrug-resistant (MDR) pathogens. Critically ill patients in ICUs are vulnerable to infections because of their underlying illnesses, frequent exposure to invasive procedures, prolonged hospital stays, and immune suppression, all of which create a conducive environment for colonization and infection by resistant microorganisms [1] .

The global healthcare community is increasingly alarmed by the surge in antimicrobial resistance (AMR), particularly among Gram-negative bacilli such as *Escherichia coli*, *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*, which are often implicated in ICU-acquired infections [2] . Gram-positive cocci such as *Staphylococcus aureus* (including MRSA) and *Enterococcus* spp. have also demonstrated resistance to commonly used antibiotics, complicating treatment protocols and increasing patient mortality [3] .

India, with its high burden of infectious diseases and widespread antibiotic misuse, has become a hotspot for antimicrobial resistance [4] . A recent national surveillance report highlighted the increasing prevalence of carbapenem-resistant *Enterobacteriaceae* and colistin-resistant isolates in both community and hospital settings [5] . Studies from North India have shown that infections in ICU patients are often caused by highly resistant strains, making empirical therapy challenging and often ineffective [6] .

Urinary tract infections (UTIs), bloodstream infections (BSIs), ventilator-associated pneumonia (VAP), and surgical site infections (SSIs) are the most common types of healthcare-associated infections (HAIs) in ICUs [7] . These infections are frequently polymicrobial and difficult to treat due to the limited therapeutic options available for MDR organisms [8] . Notably, *Acinetobacter* spp. and *Pseudomonas* spp. have shown resistance even to carbapenems and aminoglycosides in several recent studies from tertiary care hospitals [9] .

The scenario is particularly dire in respiratory and bloodstream infections. In mechanically ventilated patients, *Acinetobacter* and *Pseudomonas* are the predominant pathogens associated with VAP, and often exhibit resistance to first-line agents [10] . Similarly, Gram-negative bacteremia in ICU settings is increasingly being caused by extended-spectrum beta-lactamase (ESBL) and metallo-beta-lactamase (MBL) producers [11] .

Antibiotic stewardship programs (ASPs), stringent infection control policies, and regular microbiological surveillance are essential to curb this growing menace [12] Clinical microbiology plays a pivotal role in guiding appropriate empirical and definitive therapy through culture and susceptibility data, reducing the spread of resistance and improving clinical outcomes [13] .

This study was conducted to assess the bacteriological profile and antimicrobial susceptibility patterns of isolates from ICU patients at a tertiary care hospital in North India. The goal was to determine the predominant pathogens, their resistance patterns, and to provide updated local data to inform empiric therapy decisions. Additionally, the study focuses on the pattern of resistance in respiratory, urinary, blood, and pus samples, offering a comprehensive view of MDR trends in critical care settings.

Such local epidemiological data are crucial for tailoring empirical treatment regimens and updating hospital formularies in accordance with prevailing resistance patterns [14] . With increasing resistance even to last-resort antibiotics like colistin and tigecycline in some regions, this study underscores the urgency of revisiting antimicrobial policies at the institutional level [15] .

MATERIAL AND METHODS

This prospective study was conducted in the Department of Microbiology at Sharda Hospital, a tertiary care hospital in Greater Noida, Uttar Pradesh, India. The study duration spanned over a defined period (exact dates to be specified), during which a total of 2,125 clinical specimens were collected from various ICUs, including Medical ICU (MICU), Surgical ICU (SICU), Pediatric ICU (PICU), Respiratory ICU (RICU), and Intensive Coronary Care Unit (ICCU).

Sample Collection and Processing

The clinical specimens processed in the bacteriology laboratory included:

Blood samples: 988 (46%)

Urine samples: 627 (30%)

Respiratory samples: 420 (20%)

Pus samples: 90 (4%)

All specimens were collected using sterile techniques following standard aseptic precautions and were transported to the laboratory without delay for processing.

Isolation and Identification of Bacteria

Each specimen was cultured on appropriate media such as Blood agar, MacConkey agar, CLED agar, and Chocolate agar, depending on the sample type. The plates were incubated aerobically at 37°C for 18–24 hours and examined for bacterial growth. Identification of bacterial isolates was carried out based on:

Colony morphology

Gram staining

Biochemical tests (e.g., catalase, coagulase, oxidase, TSI, SIM, citrate, urease, indole tests)

For Gram-negative bacilli, further differentiation was done using conventional biochemical reactions or commercial identification systems, as required.

Antimicrobial Susceptibility Testing

Antibiotic susceptibility of all isolates ($n = 285$) was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, and results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

For Enterobacteriaceae and non-fermenters (e.g., *Acinetobacter* spp. and *Pseudomonas* spp.), commonly tested antibiotics included:

Beta-lactams (ampicillin, ceftriaxone, cefotaxime, cefepime)

Aminoglycosides (amikacin, gentamicin, tobramycin)

Carbapenems (imipenem, meropenem)

Fluoroquinolones (ciprofloxacin, levofloxacin)

Others: tigecycline, minocycline, cotrimoxazole, piperacillin/tazobactam, aztreonam, tetracycline, nitrofurantoin, and fosfomycin

For Gram-positive organisms (*Staphylococcus aureus*, *Enterococcus* spp., Coagulase-negative *Staphylococci*), tested antibiotics included:

Penicillin, ceftiofur, vancomycin, teicoplanin, linezolid, gentamicin, tetracycline, erythromycin, azithromycin, clindamycin, cotrimoxazole, and fosfomycin

High-level aminoglycoside resistance was also tested for *Enterococcus* spp. using high-concentration gentamicin and streptomycin disks.

Antibiotic disks were procured from HiMedia Laboratories Pvt. Ltd., Mumbai, India. Control strains such as Escherichia coli ATCC 25922, Staphylococcus aureus ATCC 25923, and Pseudomonas aeruginosa ATCC 27853 were used to ensure quality control in susceptibility testing.

Data Analysis

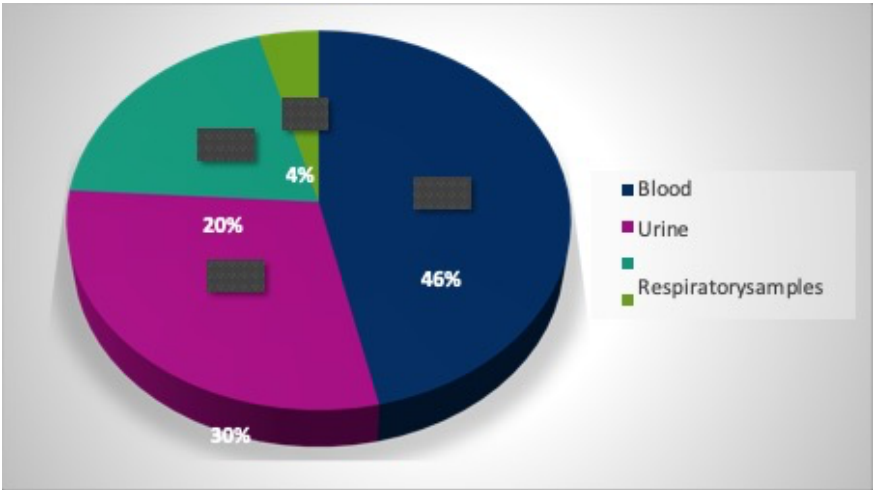
The data collected were tabulated and analyzed using descriptive statistics. Results were expressed in percentages. The susceptibility profile of each isolate was categorized as sensitive or resistant based on CLSI breakpoints.

RESULTS

During the study period, a total of 2,125 samples were received from various ICUs and analyzed in the Bacteriology Lab at Sharda Hospital, Greater Noida. The distribution of these samples were as follows- 988 blood samples (46%), 627 urine samples (30%), 420 Respiratory samples (20%), and 90 pus samples (4%). (Table 1)

Table 1

Sample Type	No. of samples (Percentage)
Blood	988 (46%)
Urine	627 (30%)
Respiratory samples	420 (20%)
Pus	90 (4%)

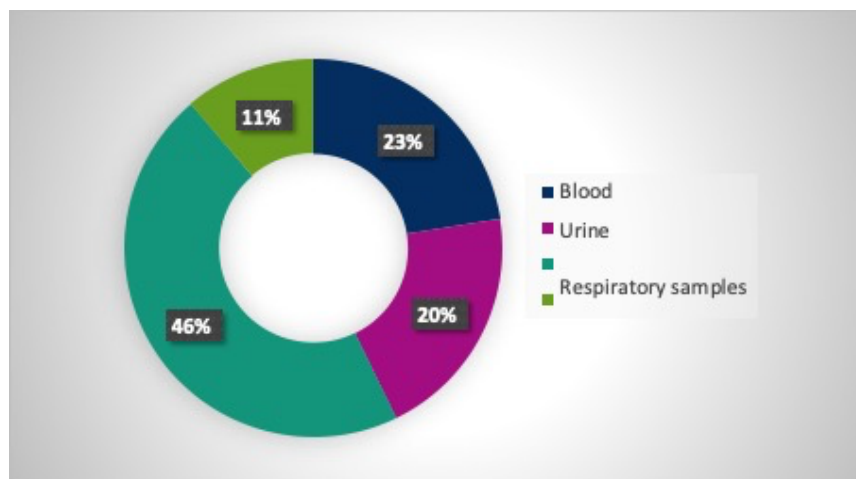


Graph 1-Total Samples Collected from ICUs

A total of 285 clinical isolates have been obtained from various samples collected across different ICUs. Respiratory samples showed the highest isolation rate, with 131 isolates (46%), followed by blood samples with 64 isolates (23%), urine samples with 58 isolates (20%), and pus samples with 32 isolates (11%). (Table 2)

Table 2

Sample Type	No.of isolates(Percentage)
Blood	64 (23%)
Urine	58 (20%)
Respiratory samples	131 (46%)
Pus	32 (11%)

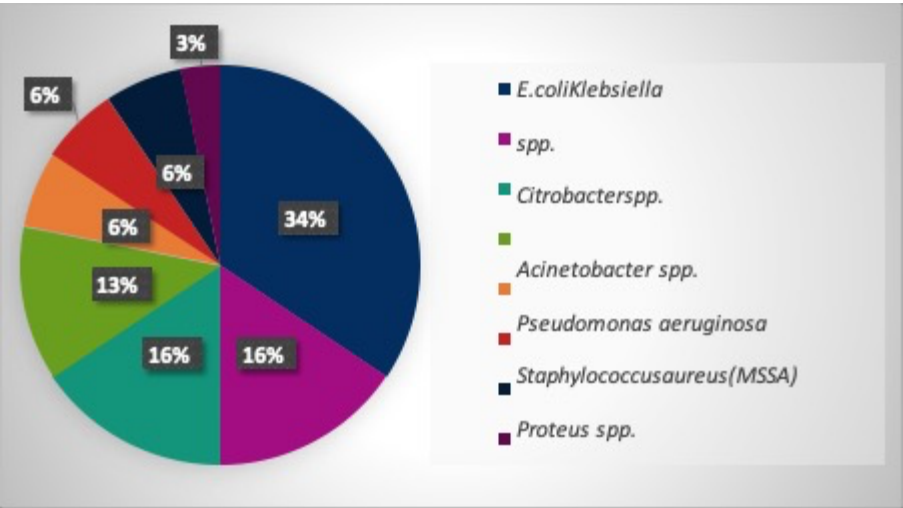


Graph 2-Samplewise distribution of isolates

The most frequently isolated organisms were *Staphylococcus aureus* (including both MRSA and MSSA) and Coagulase-negative staphylococci (CONS) with 17 isolates (27%), followed by *Klebsiella* spp. with 10 isolates (16%), *E. coli* with 8 isolates (12%), *Acinetobacter* spp. with 6 isolates (9%), and *Enterococcus* spp. with 4 isolates (6%). *Pseudomonas* spp. was the least isolated organism, with only 2 isolates (3%) in bloodstream infections. (Table 3)

Table 3: Pus samples (n= 32)

Causative Organisms	Numbers(Percentage)
<i>E. coli</i>	11(35%)
<i>Klebsiella</i> spp.	5 (16%)
<i>Citrobacter</i> spp.	5 (16%)
<i>Acinetobacter</i> spp.	4 (12%)
<i>Pseudomonas</i> spp.	2 (6%)
<i>Staphylococcus aureus</i> (MSSA)	2 (6%)
<i>Proteus</i> spp.	2 (6%)
<i>Enterococcus</i> spp.	1 (3%)



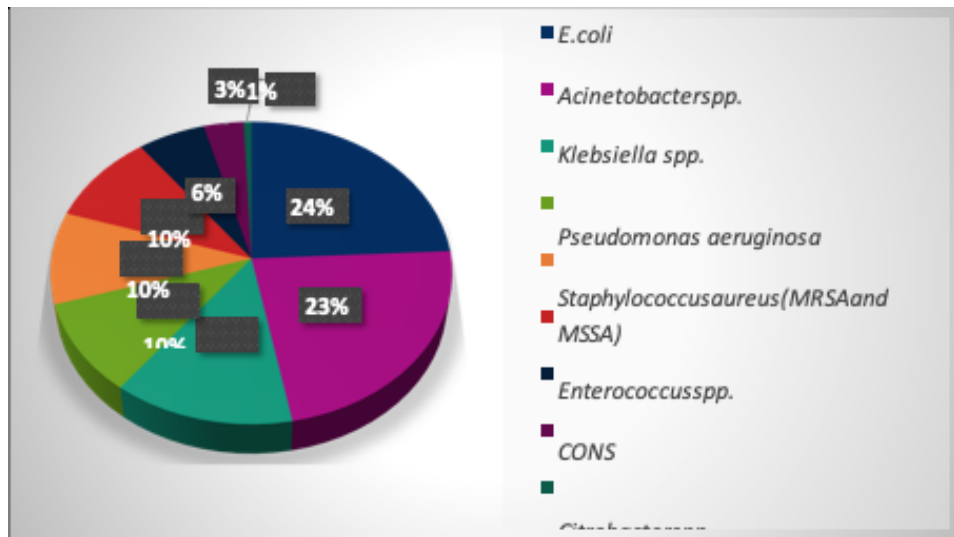
Graph 3 Etiological distribution of skin and soft tissue infections

E.coli was the most frequently isolated organism,with 69 isolates(24%),followed by Acinetobacterspp.with 65 isolates(23%),Klebsiellaspp.with38isolates(13%), Pseudomonasspp.with28isolates(10%),Staphylococcusaureus(MRSAandMSSA)with28 isolates (10%), Enterococcus spp. with 28 isolates (10%), CONS with 17 isolates (6%), and Citrobacter spp. with 10 isolates (3%). Proteus spp. was the least isolated organism, with only 2 isolates (1%) among various ICU infections.

Table 4 : InTotal samples(n=285)

Causative organisms	Numbers(Percentage)
<i>E.coli</i>	69 (24%)
<i>Acinetobacterspp.</i>	65 (23%)
<i>Klebsiellaspp.</i>	38 (13%)
<i>Pseudomonasspp.</i>	28 (10%)
<i>Staphylococcus aureus(MRSAandMSSA)</i>	28 (10%)
<i>Enterococcusspp.</i>	28 (10%)
<i>CONS</i>	17 (6%)
<i>Citrobacterspp.</i>	10 (3%)
<i>Proteus spp.</i>	2 (1%)

Overall distribution of microorganisms causing infections in ICUs



Graph 4-Overall distribution of microorganisms causing infections in ICUs

Table 5: Table In Pus

Ward wise distribution	No. of cases
ICCU-	7
MICU-	7
PICU-	1
RICU-	5
SICU-	12

Antimicrobial susceptibility profiles

Theantimicrobialsusceptibilityprofiles ofallGram-negativeandGram-positivebacteria (GNB and GPC) isolates (n = 285) were determined using the Clinical and Laboratory Standards Institute (CLSI) disk diffusion method.

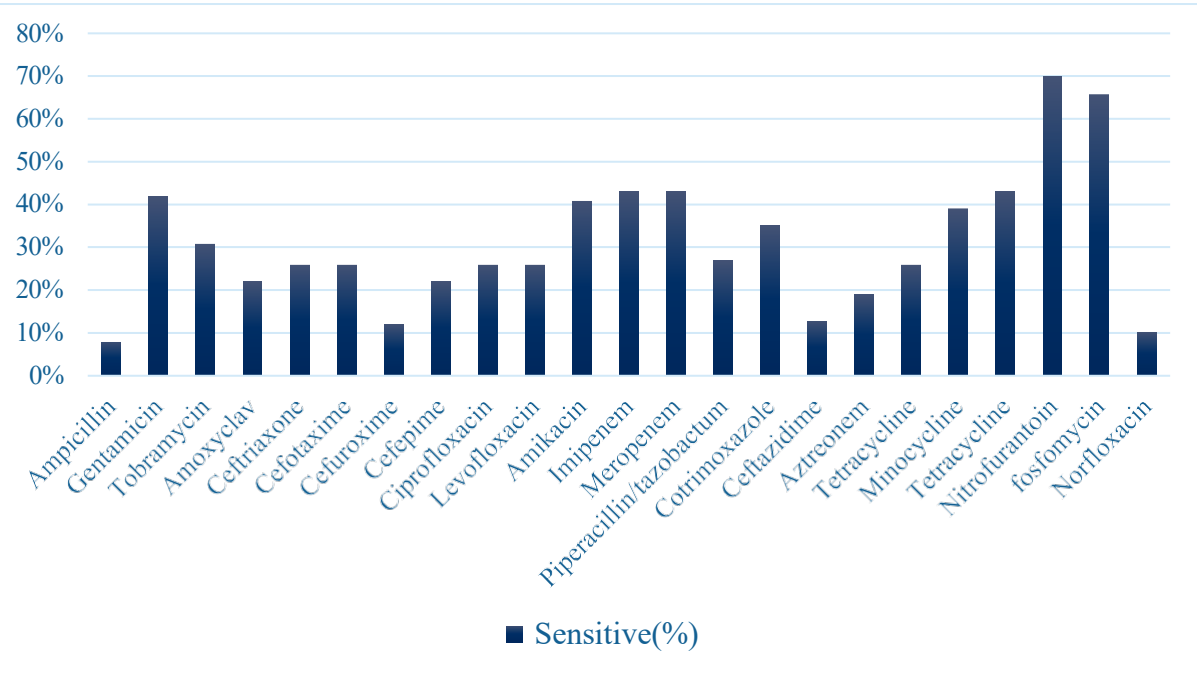
Enterobacteriaceae

- Carbapenems (meropenem, imipenem) and tigecycline were the most effective antibiotics,showinga43%efficacy,followedbygentamicin(42%),amikacin(41%), minocycline(39%),cotrimoxazole(35%),andtoframycin(31%).Ampicillinwasthe least effective, with an efficacy of only 8%.
- Inurinarytractinfections,nitrofurantoinshowedthehighestefficacy(70%),while norfloxacin was the least effective (10%).
- Fosfomycin demonstrated higheffectiveness,with66%efficacyinbothurinaryand respiratory tract infections. (Table-5)

Table 6

Antibiotics	Sensitivity(%)	Resistance(%)
Ampicillin	8%	92%
Gentamicin	42%	58%
Tobramycin	31%	69%
Amoxyclav	22%	78%
Ceftriaxone	26%	74%
Cefotaxime	26%	74%
Cefuroxime	12%	88%
Cefepime	22%	78%
Ciprofloxacin	26%	74%
Levofloxacin	26%	74%
Amikacin	41%	59%
Imipenem	43%	57%
Meropenem	43%	57%
Piperacillin/tazobactam	27%	73%
Cotrimoxazole	35%	65%
Ceftazidime	13%	87%
Aztreonam	19%	81%
Tetracycline	26%	74%
Minocycline	39%	61%
Tigecycline	43%	57%
Nitrofurantoin	70%	30%
Fosfomycin	66%	34%
Norfloxacin	10%	90%

Antibiotic susceptibility profile of Enterobacteriaceae(n=119)



Graph 5-Antibiotic sensitive profile of Enterobacteriaceae(n=119)

Non-Enterobacteriaceae-Amongthe 285isolates,65 wereas Acinetobacterspp.,and28 as Pseudomonasspp.

1- Acinetobacter spp.

□ Atotal of 65 Acinetobacter species were isolated from 285 isolates. Acinetobacter spp. were found to be highly effective for Minocycline (68%) followed byTigecycline (45%), Cotrimoxazole (15%), Ceftriaxone and Cefotaxime (14%) whereas,Meropenem,Imipenem,CefepimeandCefuroximewereleasteffective(1%) among all the antibiotic agents tested.

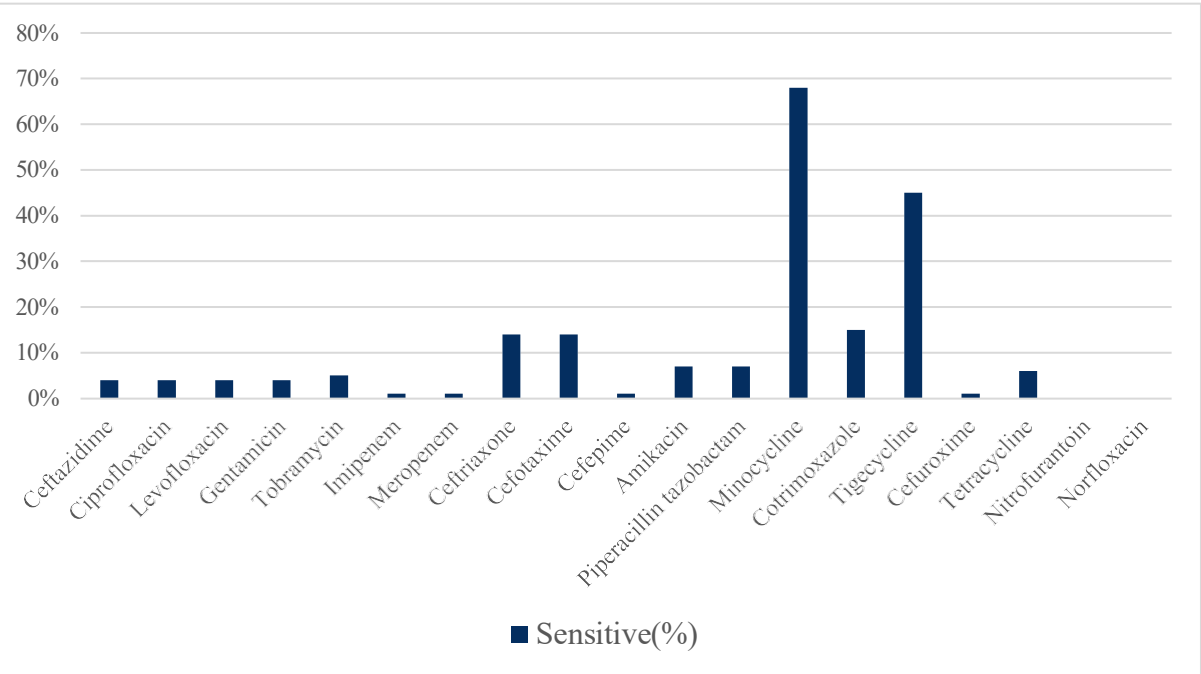
□ NitrofurantoinandNorfloxacinshowedresistanttoalltheisolatesofAcinetobacter spp. in urinary tract infection.

Table 7

Antibiotics	Sensitivity(%)	Resistance(%)
Ceftazidime	4%	96%
Ciprofloxacin	4%	96%
Levofloxacin	4%	96%
Gentamicin	4%	96%
Tobramycin	5%	95%
Imipenem	1%	99%
Meropenem	1%	99%
Ceftriaxone	14%	86%

Cefotaxime	14%	86%
Cefepime	1%	99%
Amikacin	7%	93%
Piperacillin/tazobactam	7%	93%
Minocycline	68%	32%
Cotrimoxazole	15%	85%
Tigecycline	45%	55%
Cefuroxime	1%	99%
Tetracycline	6%	94%
Nitrofurantoin	0%	100%
Norfloxacin	0%	100%

Antibiotic susceptibility pattern of Acinetobacterspp.(n=65)



Graph 6-Antibiotic sensitive pattern of Acinetobacterspp.(n=65) 2-Pseudomonas aeruginosa

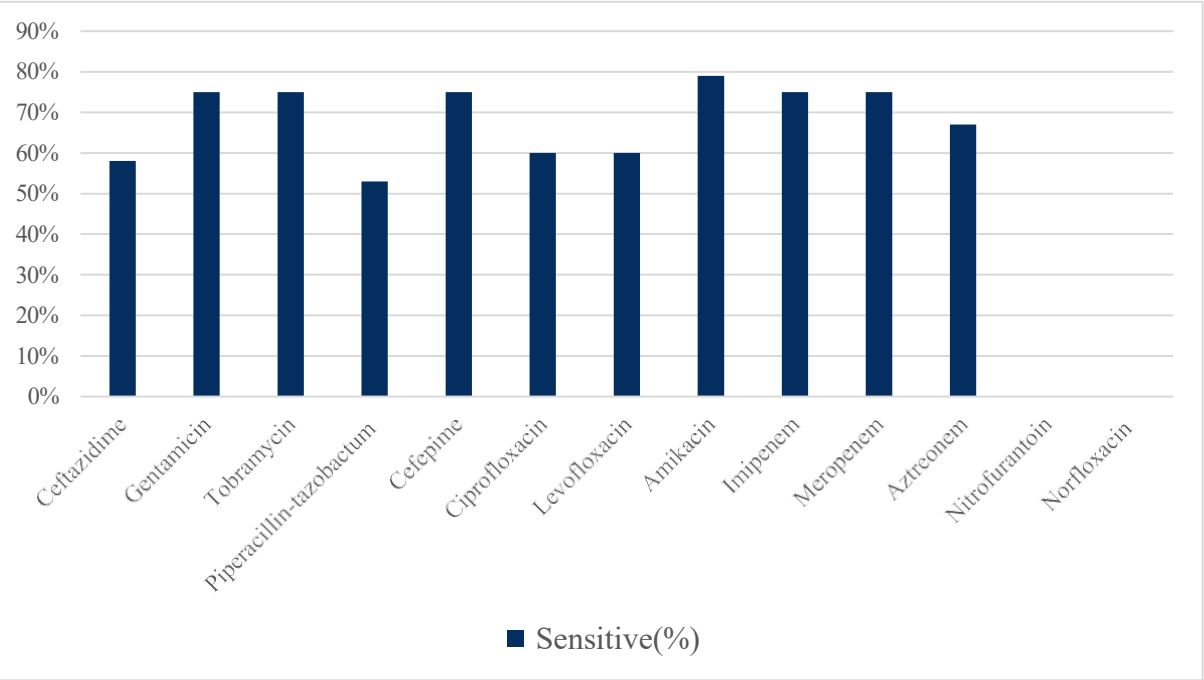
- Aminoglycosides (Amikacin, Gentamicin, Tobramycin) were found to be highly effective(79%,75%,75%)followedbyCarbapenems(meropenem,imipenem)(75%) Cefepime (75%) and flouroquinolones (Ciprofloxacin, Levofloxacin) (60%) respectively. whereas, Piperacillin-tazobactum was least effective (53%).
- NitrofurantoinandNorfloxacinshowedresistanttoalltheisolatesofPseudomonas aeruginosa in urinary tract infection.

Table 8

Antibiotics	Sensitivity(%)	Resistance(%)
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Ceftazidime	58%	42%
Gentamicin	75%	25%
Tobramycin	75%	25%
Piperacillin-tazobactam	53%	47%
Cefepime	75%	25%
Ciprofloxacin	60%	40%
Levofloxacin	60%	40%
Amikacin	79%	21%
Imipenem	75%	25%
Meropenem	75%	25%
Aztreonem	67%	33%
Nitrofurantoin	0%	100%
Norfloxacin	0%	100%

Antibiotic susceptibility pattern of Pseudomonas aeruginosa(n=28)



Graph 7-Antibiotic sensitive pattern of Pseudomonas aeruginosa (n=28)

Among the 285 isolates, 28 were *Staphylococcus aureus*, 28 *Enterococcus* spp. and 17 *Coagulase negative Staphylococci* (CoNS).

1- *Staphylococcus aureus* and CoNS

□ Linezolid was found to be highly effective (95%) followed by Vancomycin (86%), Tetracycline(81%),Cotrimaxazole(68%),Gentamicin(63%)andTeicoplanin(46%) whereas, Penicillin was least effective (15%) respectively.

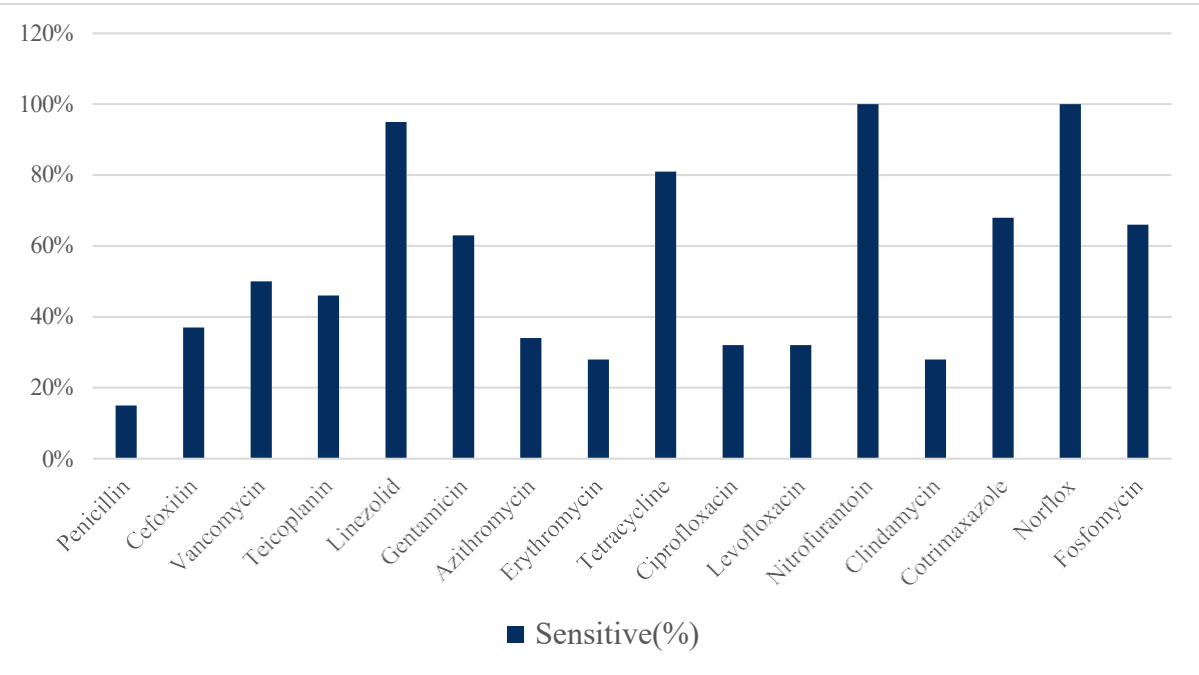
□ NitrofurantoinandNorfloxacinwasfoundtobehighlyeffective(100%)inurinary tract infections.

□ Fosfomycinwasfoundtobehighlyeffective(66%)inurinarytractinfectionsand respiratory tract infections.

Table 9

Antibiotics	Sensitivity(%)	Resistance(%)
Penicillin	15%	85%
Cefoxitin	37%	63%
Vancomycin	50%	50%
Teicoplanin	46%	54%
Linezolid	95%	5%
Gentamicin	63%	37%
Azithromycin	34%	66%
Erythromycin	28%	72%
Tetracycline	81%	19%
Ciprofloxacin	32%	68%
Levofloxacin	32%	68%
Nitrofurantoin	100%	0%
Clindamycin	28%	72%
Cotrimaxazole	68%	32%
Norflox	100%	0%
Fosfomycin	66%	34%

Antibiotic susceptibility pattern of Staphylococcus aureus and CoNS(n=45)



Graph 8-Antibiotic sensitive pattern of Staphylococcus aureus and CoNS(n=45) 2-Enterococcus spp.

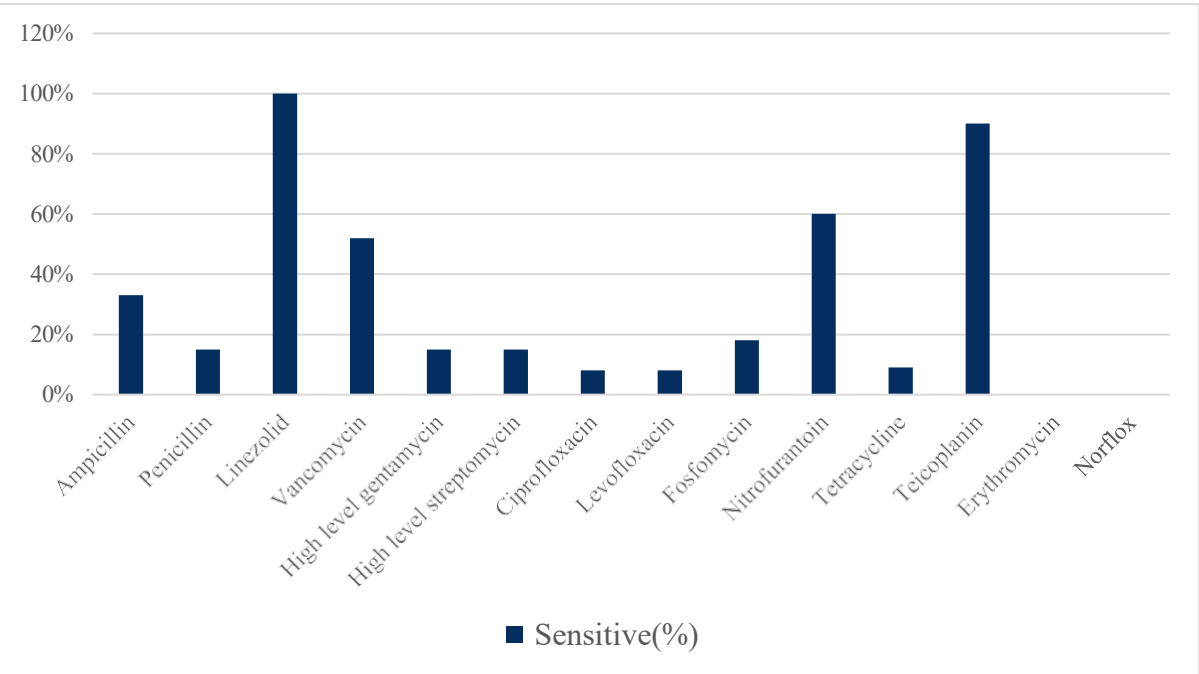
- Linezolid was found to be highly effective (100%) followed by Teicoplanin (90%), Vancomycin (78%), Ampicillin (33%), High level gentamycin (15%) and High level streptomycin (15%) respectively. Erythromycin showed resistant to all the isolates of Enterococcus spp.
- Nitrofurantoin was found to be highly effective (60%) whereas, Fosfomycin was least effective (18%) respectively and Norfloxacin showed resistant to all the isolates of Enterococcus spp. in urinary tract infections.

Table 10

Antibiotics	Sensitivity(%)	Resistance(%)
Ampicillin	33%	67%
Penicillin	15%	85%
Linezolid	100%	0%
Vancomycin	52%	48%
Highlevel gentamycin	15%	85%
Highlevel streptomycin	15%	85%
Ciprofloxacin	8%	92%
Levofloxacin	8%	92%
Fosfomycin	18%	82%
Nitrofurantoin	60%	40%

Tetracycline	9%	91%
Teicoplanin	90%	10%
Erythromycin	0%	100%
Norflox	0%	100%

Antibiotic susceptibility pattern of Enterococcusspp.(n=28)



Graph 9 –Antibiotic sensitive pattern of Enterococcusspp.(n=28)

DISCUSSION

This study underscores the critical concern of rising multidrug resistance (MDR) in ICU settings, with *E. coli* and *Acinetobacter* spp. being the most frequently isolated organisms. A similar trend has been reported in recent studies from India and other developing countries, where *E. coli* has emerged as the dominant pathogen in both bloodstream and urinary infections [6,11] . The high prevalence of *Acinetobacter* spp., particularly in respiratory samples, aligns with its known association with ventilator-associated pneumonia and its notorious capacity to develop resistance to multiple antibiotic classes [9,10] .

The antimicrobial susceptibility profile in our study revealed high resistance to commonly used beta-lactams, fluoroquinolones, and even carbapenems in Gram-negative organisms, echoing the findings of Taneja et al. (2022) and Veeraraghavan et al. (2016) [6,9] . *Acinetobacter* spp. showed resistance to almost all antibiotics except minocycline and tigecycline, which reflects the limited treatment options remaining for such infections [9,15] . *Pseudomonas aeruginosa*, although less frequent, retained moderate susceptibility to aminoglycosides and carbapenems, which is consistent with studies reporting variable resistance patterns in ICU settings [10,14] .

Gram-positive isolates, including *Staphylococcus aureus* and *Enterococcus* spp., were also significantly resistant to beta-lactams and macrolides, while linezolid and vancomycin remained effective. This matches global and national trends showing persistent MRSA and VRE concerns in ICUs [3,12]. Alarmingly, resistance to high-level aminoglycosides in *Enterococcus* spp. and reduced susceptibility to teicoplanin point toward narrowing therapeutic choices.

The respiratory specimens demonstrated the highest positivity rate (46%), highlighting the vulnerability of intubated ICU patients to nosocomial pneumonia. These findings mirror those reported by Choudhuri et al. (2021), who emphasized the risk posed by prolonged ventilation in promoting colonization and infection by resistant Gram-negatives [10]. Furthermore, urine and pus samples revealed notable rates of *E. coli* and *Klebsiella* isolates, supporting the role of urinary catheters and poor wound care as predisposing factors [7,8].

The study's findings reinforce the urgent need for robust antimicrobial stewardship programs (ASPs) and continuous local antibiogram updates. Empirical therapy should be guided by local resistance data, and definitive therapy should be rapidly adjusted based on culture and sensitivity results. In addition, stringent infection control practices including hand hygiene, isolation protocols, and decontamination measures must be enforced to prevent the horizontal transfer of MDR organisms.

Microbial infections and antimicrobial resistance have been recognized as a critical issue worldwide, affecting public health, therefore considering the most important causes of mortality and morbidity [16].

Surveillance of AMR is the first and foremost essential step towards curtailing the spread of antimicrobial resistance, forming policies, and for infection prevention and control interventions. AMR surveillance helps to generate baseline data on the pattern of microorganisms in the hospital and their susceptibility profile, which in turn helps in deciding effective and rational empirical treatment [16,17].

CONCLUSION

The emergence of multidrug-resistant bacteria, particularly *E. coli*, *Acinetobacter* spp., and MRSA in ICU settings, presents a formidable challenge in the management of critically ill patients. Our findings underscore the necessity of regular microbiological surveillance, tailored empiric therapy, and strict adherence to infection control protocols. The study highlights that while some last-resort antibiotics like minocycline, tigecycline, and linezolid retain efficacy, the window for effective antibiotic treatment is narrowing. Hospitals must prioritize the implementation of antimicrobial stewardship and infection control programs to combat the spread of resistance and improve patient outcomes.

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: Author equally contributed the work.

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