Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1859
Original Article

Antibiogram of uropathogens from cases of urinary tract infections in a tertiary care hospital: A cross-sectional study.

Dr.Nazia Begum Mohammed[1*], Cherukuri Richa Choudary[2], Dr.Jyothi pendyala[3], Dr.K. Parameswari[4]
[1]*Assistant Professor, Department of Microbiology, Guntur Medical College, Guntur, Andhra Pradesh, India.*
[2] *Phase III MBBS Student, Guntur Medical College, Guntur, Andhra Pradesh, India.*
[3]*Associate Professor, Department of Microbiology, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.*
[4]*Professor, Department of Microbiology, Nimra Institute of Medical Sciences, Ibrahimpatnam, Andhra Pradesh, India.*

Abstract

Background
Urinary tract infections (UTIs) are among the most common bacterial infections affecting people of all ages. The increasing prevalence of antimicrobial resistance among uropathogens presents a major clinical challenge, particularly in empirical treatment. This study aimed to identify the prevalence of uropathogens and evaluate their antibiotic susceptibility patterns in a tertiary care setting.

Methods
A cross-sectional study was conducted at a government tertiary care hospital in Guntur district, Andhra Pradesh, India. A total of 100 urine samples from patients suspected of UTIs were collected and cultured using standard microbiological techniques. Isolated bacterial pathogens were identified, and their antibiotic susceptibility profiles were determined using the Kirby-Bauer disk diffusion method. Data were recorded and analyzed using Microsoft Excel, and results were expressed in percentages and graphically represented.

Results
Out of 100 urine samples analyzed, 34% showed significant bacteriuria. Among the 34 positive isolates, 91.2% (31/34) were Gram-negative bacteria. *Escherichia coli* was the most prevalent uropathogen, accounting for 48.4% (15/31) of Gram-negative isolates, followed by *Klebsiella* species at 22.6% (7/31). Antibiotic susceptibility testing revealed the highest sensitivity to Nitrofurantoin (79.4%, 27/34), followed by Carbapenems (64.7%, 22/34). Resistance was notably high against commonly used antibiotics such as Ampicillin and third-generation Cephalosporins.

Conclusion
The findings underscore the dominance of Gram-negative bacteria, particularly *E. coli*, in UTIs and the growing resistance to frequently prescribed antibiotics. Nitrofurantoin and Carbapenems demonstrated relatively high effectiveness against the isolated strains, suggesting their continued role in empirical therapy. Regular surveillance and antibiogram development are essential to guide appropriate antibiotic use and combat rising antimicrobial resistance.

Recommendations
Promote local antibiogram usage, restrict empirical antibiotic misuse, encourage stewardship programs, update treatment guidelines periodically, and educate healthcare professionals continuously.

Keywords: *Urinary tract infections, Significant bacteriuria, Escherichia coli, Nitrofurantoin, Klebsiella sps*
Submitted: *2025-03-05* ***Accepted:*** *2025-05-07* ***Published:*** *2025-06-30*

Corresponding author: *Dr. Nazia Begum Mohammed**
Email: ***naziamohammed786@gmail.com***
Assistant Professor, Department of Microbiology, Guntur Medical College, Guntur, Andhra Pradesh, India.

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Introduction

Urinary tract infections (UTIs) are diseases resulting from microbial invasion of the urinary tract (kidneys, bladder, ureters, and urethra) and are the most common healthcare-associated infections.[1] Bacteria, especially Gram-negative organisms like *Escherichia coli*, are the primary cause; other pathogens such as *Klebsiella*, *Proteus*, *Pseudomonas*, *Staphylococcus aureus*, and *Enterococcus* can also be commonly involved.[1] Fungi, viruses, and parasites may also contribute to UTIs.[1] Clinical presentations vary from mild dysuria to severe complications like bacteremia and sepsis.[1] UTIs significantly impact women of all ages and older men, presenting as either uncomplicated (without structural abnormalities or comorbidities) or complicated infections.[2] UTIs have a significant impact worldwide, affecting 150 million or more patients every year, with women having a greater annual incidence.[3] Reinfections are more common in women, likely due to the shorter length of the urethra, which makes it easier for bacteria to reach the bladder[4]. There has been an increased burden of UTIs caused by bacteria with variable sensitivity to antimicrobials that precludes their use as an empirical treatment of urinary tract infections[5]. The resistance is particularly greater if the patient has been exposed to antibiotics recently or is at risk of infections with ESBLs (Extended-Spectrum β-lactamases)[6]. Antibiotic susceptibility testing improves treatment accuracy by identifying species-specific variations in microbial sensitivity. [7]Therefore, the objective of this study was to determine the prevalence of uropathogens and evaluate their antibiotic susceptibility patterns in patients with urinary tract infections in a tertiary care hospital setting.

Materials and methods

Study design and setting

This was a cross-sectional observational study conducted in the Department of Microbiology in association with the Government General Hospital, Guntur, a tertiary care teaching hospital in Guntur, Andhra Pradesh, India. The hospital is a major referral center catering to a large urban and rural population in the Guntur district and surrounding regions, offering comprehensive diagnostic and treatment services across various specialties. The study was conducted over two months (November to December 2023).

Study Population and Sample Size

A total of 100 urine samples were collected from patients aged 15 to 65 years attending the General Medicine Department (both inpatients and outpatients).

Inclusion criteria

Patients aged between 15 to 65 years attending the General Medicine Department (both inpatients and outpatients) with clinical symptoms suggestive of urinary tract infection (such as dysuria, frequency, urgency, suprapubic pain, or fever) were included in the study.

Exclusion criteria

- Patients from other departments
- Children below 15 years
- Elderly above 65 years
- Females aged 15–30 years (to avoid confounding due to high asymptomatic bacteriuria prevalence)

Specimen collection and transport

Midstream "clean catch" urine samples were collected in sterile, wide-mouth, screw-capped containers and promptly transported to the microbiology laboratory for processing.

Bias

To minimize selection bias, urine samples were consecutively collected from all eligible patients meeting the inclusion criteria during the study period. Standardized procedures for sample collection, culture, bacterial identification, and antibiotic susceptibility testing were strictly followed to reduce measurement and classification biases. Laboratory personnel were blinded to the clinical details of the patients to avoid potential observer bias in interpreting culture results.

Microscopic and preliminary screening

Wet mount microscopy for pyuria (>8 pus cells/mm³)
Leukocyte esterase test
Griess nitrate test for detecting nitrate-reducing bacteria

Culture and bacterial identification

Samples were inoculated on CLED agar and incubated at 37°C for 24 hours. Significant bacteriuria was defined as

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>10^5 CFU/mL. Colony characteristics, Gram staining, and biochemical tests such as catalase, oxidase, indole, methyl red, citrate, urease, TSI, and coagulase (for staphylococci) were used for identification. Quality control: *E. coli* ATCC 25922 and *S. aureus* ATCC 25923 reference strains.

Antibiotic Susceptibility Testing (AST)

The Kirby-Bauer disk diffusion method was performed on Mueller-Hinton agar following CLSI 2023 guidelines. Bacterial suspension was adjusted to 0.5 McFarland standard. Discs were placed aseptically and plates incubated at 37°C for 24 hours. Zones of inhibition were measured and interpreted against CLSI-defined breakpoints.

Antibiotics tested

Gram-positive isolates: Cefoxitin, Gentamicin, Erythromycin, Doxycycline, Clindamycin, Imipenem, Nitrofurantoin, Ciprofloxacin, Ampicillin, Cefotaxime, Amikacin

Gram-negative isolates: Nitrofurantoin, Ciprofloxacin, Cefepime, Amoxicillin-Clavulanic Acid, Piperacillin-Tazobactam, Ceftriaxone, Imipenem, Meropenem, Gentamicin, Amikacin, Ampicillin, Cefotaxime

Statistical analysis

Data were entered and analyzed using Microsoft Excel. Descriptive statistics such as frequencies and percentages were used to summarize the prevalence of bacterial isolates and their antibiotic sensitivity patterns. Bar graphs and pie charts were used for the visual representation of results. No inferential statistics were applied due to the descriptive nature of the study and sample size limitations.

Ethical considerations

The study received approval from the Institutional Ethics Committee of Guntur Medical College, Guntur (Approval No: GMC/IEC/13/2023, dated 21-11-2023). Informed written consent was obtained from all participants before their inclusion in the study.

Results

Participant flow

During the study period, a total of 120 patients presenting with symptoms suggestive of urinary tract infections were screened for eligibility. Out of these, 20 patients were excluded: 8 were below 15 years of age, 5 were above 65 years, and 7 were females aged 15–30 years. Finally, 100 eligible patients who met the inclusion criteria were enrolled, and midstream urine samples were collected from all of them. All 100 samples were processed for culture and sensitivity testing, with no dropouts or missing data during the study process.

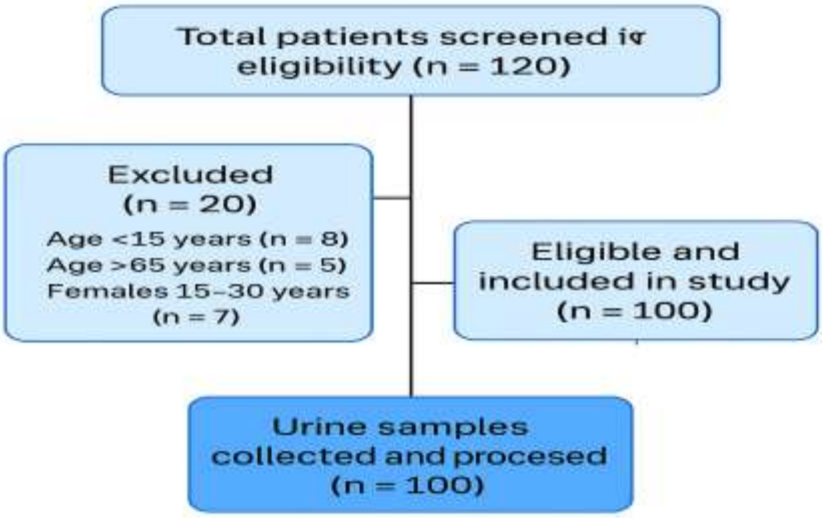

Figure 1. Flow diagram depicting participant screening, eligibility, inclusion, and sample processing

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Out of the 100 urine samples collected, 55 (55%) were from male patients and 45 (45%) from female patients, resulting in a male-to-female ratio of approximately 1:1.2. The age distribution of patients was as follows: 8 patients (8%) were aged 20–30 years, 28 patients (28%) were 31–40 years, 20 patients (20%) were 41–50 years, 34 patients (34%) were 51–60 years, and 10 patients (10%) were between 61–65 years. Male patients predominated in the 20–30, 31–40, and 61–65-year age groups, whereas female patients constituted a higher proportion in the 41–50year age group. Both genders were equally represented in the 51–60year age group. Figure 2 illustrates the distribution of patients by age and gender.

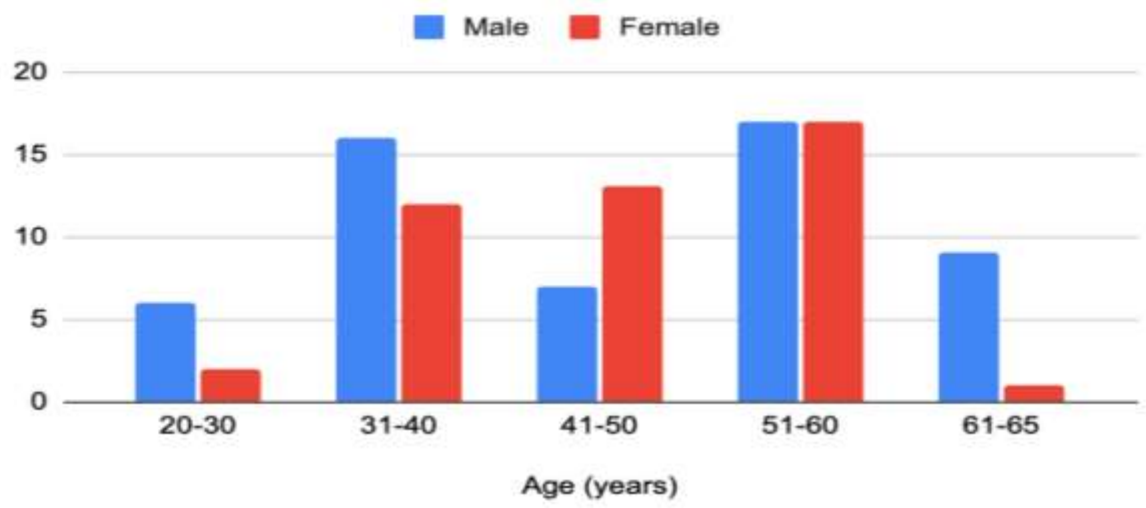

Figure 2: Age and Gender-wise distribution

Out of the 100 urine samples analyzed, 34 samples (34%) showed significant bacteriuria, while 66 samples (66%) exhibited no bacterial growth, resulting in a culture positivity rate of 34%. Among the 34 positive samples, 3 isolates (8.8%) were Gram-positive bacteria, and 31 isolates (91.2%) were Gram-negative bacteria. Of the Gram-positive isolates, 2 (66.7%) were *Staphylococcus aureus*, and 1 (33.3%) was *Enterococcus* species. Among the 31 Gram-negative isolates, *Escherichia coli* was the most prevalent, accounting for 15 isolates (48.4%), followed by *Klebsiella* species with 7 isolates (22.6%) —including *Klebsiella oxytoca* (4 isolates) and *Klebsiella pneumoniae* (3 isolates). *Proteus* species were the next most common with 6 isolates (19.3%)—comprising *Proteus vulgaris* (5 isolates) and *Proteus mirabilis* (1 isolate). Lastly, *Pseudomonas aeruginosa* accounted for 3 isolates (9.7%). Figure 3 visually depicts the distribution of these bacterial isolates.

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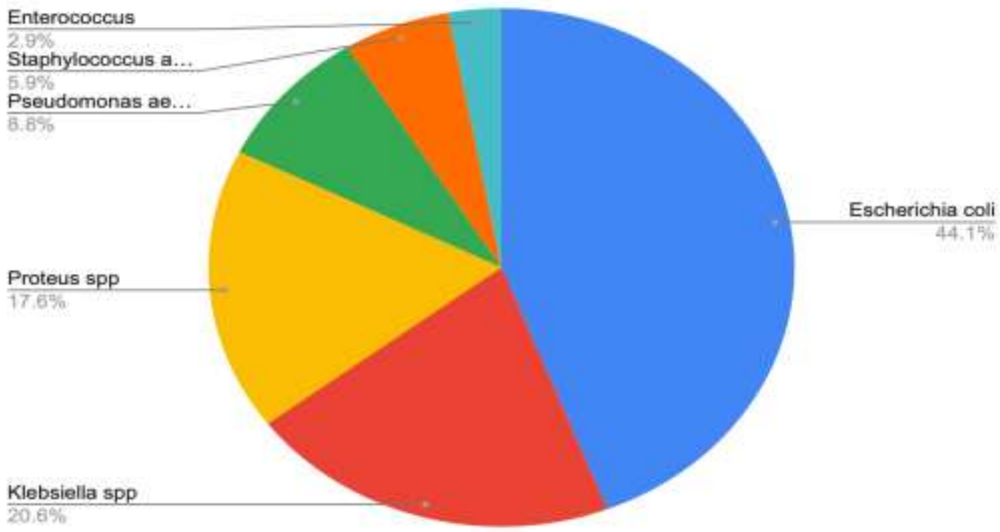

Figure 3: Gram-positive and Gram-negative organisms isolated

Among the 2 isolates of Staphylococcus aureus, all (100%) were sensitive to Gentamicin and Nitrofurantoin. Additionally, one isolate was sensitive to Cefoxitin (CX), and the other to Clindamycin (CD). The single Enterococcus isolate showed 100% sensitivity to Imipenem and Nitrofurantoin.
Of the 6 Proteus spp. Isolates, 5 (83.3%) were sensitive to Nitrofurantoin, 4 (66.7%) to Imipenem, and 3 (50%) to Ciprofloxacin. All 3 Pseudomonas aeruginosa isolates The detailed antibiotic sensitivity patterns of Gram-negative isolates are summarized in Table 1

Of the 15 Escherichia coli isolates, 14 (93.3%) were sensitive to Nitrofurantoin, 10 (66.7%) to Imipenem, and 8 (53.3%) to Meropenem. Among 7 Klebsiella spp. Isolates, 5 (71.4%) were sensitive to Nitrofurantoin, and 4 (57.1%) showed sensitivity to Amoxicillin-Clavulanic Acid, Piperacillin-Tazobactam, and Imipenem.
(100%) were sensitive to Piperacillin-Tazobactam and Imipenem, while 2 isolates (66.7%) showed sensitivity to Gentamicin and Amikacin.

Table 1: Antibiotic sensitivity pattern of the Gram-negative isolates (n=31)

Antibiotics	E. coli (n=15)		Klebsiella spp. (n=7)		Proteus (n=6)		P. aeruginosa (n=3)	
	S	(%)	S	(%)	S	(%)	S	(%)
NIT	14	93.3	5	71.4	5	83.3	0	0
CIP	2	13.3	1	14.2	3	50	0	0
CPM	2	13.3	2	28.5	1	16.7	1	33.3
AMC	4	26.7	4	57.1	2	33.3	0	0
PIT	4	26.7	4	57.1	2	33.3	3	100
CTR	0	0	2	28.5	0	0	0	0
IPM	10	66.7	4	57.1	4	66.7	3	100
GEN	5	33.3	2	28.5	0	0	2	66.7

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MRP	8	53.3	0	0	1	16.7	1	33.3
AK	6	40	0	0	0	0	2	66.7
ETP	1	6.7	1	14.2	0	0	0	0
AMP	0	0	0	0	0	0	0	0
CTX	1	6.7	2	28.5	0	0	0	0

S- sensitive, (%)- percentage, spp- species, NIT- Nitrofurantoin, CIP- Ciprofloxacin, CPM- Cefepime, AMC- Amoxicillin-clavulanic acid, PIT- Piperacillin Tazobactam, CTR- Ceftriaxone, IPM- Imipenem, GEN- Gentamicin, MRP- Meropenem, AK- Amikacin, AMP- Ampicillin, CTX- Cefotaxime

Discussion

In the present study, a higher proportion of urine samples were obtained from male patients (53.2%), which differs from earlier studies that reported a female predominance of 61% and 74.6%, respectively [8,9]. This variation can be explained by the deliberate exclusion of women within the reproductive age group, a population known to have a higher incidence of asymptomatic bacteriuria. Most samples in this study were from older adults, with the largest group (34%) belonging to the 50–60 years age bracket, followed by 28% in the 31–40 years category. These findings are consistent with previous research indicating a higher prevalence of urinary tract infections among individuals aged 40 years and above [9]. Male predominance was noted in the 31–40 and 61–65 years age groups, consistent with reported data showing male predominance in patients aged 45 years and above [10].

Of the 100 urine samples collected, 34% demonstrated significant bacterial growth, a positivity rate comparable to earlier reports of 36.14% [9,10]. Gram-negative bacteria predominated among isolates (91.2%), consistent with prior studies reporting Gram-negative prevalence ranging from 78.3% to 98% [8,9,10,11]. Among Gram-positive organisms isolated, *Staphylococcus aureus* was predominant (66.7%), followed by *Enterococcus* (33.3%), reflecting similar distributions found in previous studies [9,10].

Within Gram-negative isolates, Escherichia coli was the most frequent (48.4%), followed by Klebsiella species (22.6%). This finding aligns with the well-established understanding that *E. coli* is the predominant uropathogen responsible for both community-acquired and healthcare-associated urinary tract infections. The higher prevalence of *E. coli* can be attributed to its ability to adhere to uroepithelial cells through specialized virulence factors such as pili and adhesins, which facilitate colonization of the urinary tract. The detection of *Klebsiella* spp. as the second most common pathogen is consistent with its recognized role in complicated UTIs, particularly among hospitalized or immunocompromised patients.

The antimicrobial susceptibility patterns observed in this study highlight the continued efficacy of Nitrofurantoin and Imipenem against most uropathogens, including *E. coli*, *Klebsiella*, and *Proteus* species. This supports the role of Nitrofurantoin as an effective empirical agent for uncomplicated UTIs. The high resistance rates against Ampicillin, Ceftriaxone, and Cefotaxime reinforce concerns about the overuse and declining effectiveness of these commonly prescribed antibiotics.

The complete susceptibility of Pseudomonas aeruginosa to Piperacillin-Tazobactam and Imipenem is in agreement with global trends, reflecting the limited but reliable therapeutic options against this inherently resistant organism. The high sensitivity of Staphylococcus aureus and Enterococcus isolates to Nitrofurantoin further supports its broad-spectrum utility in both Gram-negative and Gram-positive UTIs [8,9,10]. Among *E. coli* isolates, 93.3% were sensitive to Nitrofurantoin, followed by 66.7% sensitivity to Imipenem, corroborating previous reports indicating Nitrofurantoin as the most effective antibiotic against *E. coli* [9,10,12]. For *Klebsiella* species, 71.4% sensitivity to Nitrofurantoin and 57.1% sensitivity to Amoxicillin-Clavulanic Acid, Piperacillin-Tazobactam, and Imipenem were observed, aligning with earlier studies showing similar susceptibility profiles [9,10,12]. In the case of *Proteus* isolates, 83.3% demonstrated susceptibility to Nitrofurantoin, while 66.7% were sensitive to Imipenem, findings that are in line with previously documented susceptibility patterns [9,10]. All *Pseudomonas aeruginosa* isolates demonstrated 100% sensitivity to Piperacillin-Tazobactam and Imipenem, which is consistent with previous findings [10,14].

Generalizability

The findings of this study provide valuable insights into the local epidemiology and antibiotic susceptibility patterns of uropathogens in a tertiary care setting in South India. While the results apply to similar healthcare institutions in resource-limited settings, the

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generalizability may be limited by the single-center design, exclusion of certain patient populations, and the relatively small sample size. Differences in prescribing practices, local resistance trends, and patient demographics across regions may influence the applicability of these findings to other populations. Multicentric studies with larger and more diverse patient groups would enhance the external validity and generalizability of the conclusions drawn.

Conclusion

Out of 100 urine samples tested, 34 showed positive bacterial growth, with Gram-negative bacteria predominating. *Escherichia coli* was the most frequently isolated pathogen, followed by *Klebsiella* spp., *Proteus* spp., and *Pseudomonas aeruginosa*. Among Gram-positive bacteria, *Staphylococcus aureus* was more common than *Enterococcus*. *Staphylococcus aureus* isolates demonstrated high sensitivity to Gentamicin and Nitrofurantoin, while *Enterococcus* showed susceptibility to Imipenem and Nitrofurantoin. Most isolates of *E. coli*, *Klebsiella* spp., and *Proteus* spp. Exhibited good sensitivity to Nitrofurantoin and Imipenem. All *Pseudomonas aeruginosa* isolates were fully sensitive to Piperacillin-Tazobactam and Imipenem. These findings emphasize the importance of local antibiogram surveillance to guide effective empirical therapy and combat antimicrobial resistance.

Limitations

The study had several limitations. It involved a small sample size from a single center, which limited the statistical power and generalizability of the findings. Certain patient groups, including children, elderly individuals, and reproductive-age females, were excluded, which may have introduced selection bias. Additionally, molecular resistance testing was not performed, and long-term clinical outcomes were not assessed, which limited the depth of antimicrobial resistance insights. Future studies involving larger, multicentric cohorts and advanced molecular techniques are required to validate and extend these findings.

Recommendations

Regular surveillance of uropathogen prevalence and antibiotic susceptibility is essential to update local antibiograms. Empirical treatment should prioritize antibiotics like Nitrofurantoin and Imipenem, given their high efficacy. Rational antibiotic use must be promoted through stewardship programs to reduce resistance development. Inclusion of molecular diagnostic methods is recommended for detailed resistance profiling. Expanding studies to multiple centers with larger sample sizes will improve data reliability. Clinicians should be educated on current susceptibility trends to optimize therapy and patient outcomes.

Acknowledgments

The authors gratefully acknowledge the support and assistance provided by Dr. NTRUHS and the Department of Microbiology, Guntur Medical College, Guntur, throughout this study.

List of abbreviations

UTI: Urinary Tract Infection
ESBL: Extended-Spectrum Beta-Lactamases
AST: Antibiotic Susceptibility Testing
CLED: Cysteine Lactose Electrolyte Deficient agar
CFU: Colony Forming Units
CLSI: Clinical and Laboratory Standards Institute
ATCC: American Type Culture Collection
NIT: Nitrofurantoin
CIP: Ciprofloxacin
CPM: Cefepime
AMC: Amoxicillin-clavulanic acid
PIT: Piperacillin-Tazobactam
CTR: Ceftriaxone
IPM: Imipenem
GEN: Gentamicin
MRP: Meropenem
AK: Amikacin
AMP: Ampicillin
CTX: Cefotaxime
CX: Cefoxitin
CD: Clindamycin

Source of funding

The study had received funding from Dr. NTRUHS, Vijayawada.

Conflict of interest

The authors declare no conflict of interest.

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https://doi.org/10.51168/sjhrafrica.v6i6.1859
Original Article

Author contributions

NBM-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. CRC-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript, revision of the manuscript. JP-Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation. KP-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.

Data availability

Data is available on request.

Author biography

Dr. Nazia Begum Mohammed is currently working as an assistant professor in the Department of Microbiology at Guntur Medical College. She completed her MBBS from Konaseema Institute of Medical Sciences, Amalapuram, and holds her MD in Microbiology from Siddhartha Medical College, Vijayawada. With over 4 years of teaching experience, she successfully guided undergraduate students in research projects for NTR University of Health Sciences. She has contributed to 3 research publications in research publications in reputed journals with a focus on microbiology. ORCID ID: https://orcid.org/0009-0000-0182-5352

Richa Choudary Cherukuri is currently pursuing an MBBS degree as a phase three medical student at Guntur Medical College, Guntur. She has done 2 research projects under NTR University of Health Sciences at the undergraduate level. ORCID ID: https://orcid.org/0009-0001-1969-0334

Dr. Jyothi Pendyala is currently working as an associate professor in the department of Microbiology at Andhra Medical College, Visakhapatnam. She completed her MBBS from Guntur Medical College, Guntur, and holds her MD in Microbiology from Andhra Medical College, Visakhapatnam. With over 12 years of teaching experience, she successfully guided undergraduate students in UGSRS projects and postgraduate dissertations. She authored 6 research publications in reputed journals focusing on Microbiology. ORCID ID: https://orcid.org/0009-0004-8193-6202

Dr.K. Parameswari is currently serving as Professor, Department of Microbiology, Nimra Medical College, Ibrahimpatnam. She completed her MBBS and MD in Microbiology from Rangaraya Medical College, Kakinada. With over 24 years of experience, she successfully guided undergraduate students in UGSRS projects and postgraduate dissertations. She authored 15 research publications in reputed journals focusing on Microbiology.

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PUBLISHER DETAILS

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa