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Prevalence and antimicrobial resistance patterns of bacterial isolates of pyogenic infections in a tertiary care centre in Southern India

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Abstract:

Background: Pyogenic infections, characterized by pus formation due to acute inflammation, remain a common clinical problem, particularly in hospital settings. Antimicrobial resistance (AMR) among causative bacterial pathogens poses a significant threat to treatment efficacy. The objective of this study is to assess the prevalence and antimicrobial resistance patterns of bacterial isolates from pyogenic infections in a tertiary care hospital in Southern India.
Methodology: An observational laboratory-based study was conducted from January to April 2025 in the Microbiology Department of Apollo Institute of Medical Sciences and Research, Hyderabad, India. A total of 138 pus, aspirates and wound swab samples were processed using standard aerobic culture techniques. Bacterial identification and antimicrobial susceptibility testing were performed using the VITEK 2 Compact system following the CLSI 2025 guidelines.
Results: Out of 138 specimens, 79 (57.3%) were culture-positive for clinically significant bacterial isolates. Gram-negative isolates predominated (73.4%, n=58), with *Klebsiella pneumoniae* (22.9%) as the most prevalent pathogen, followed by *Staphylococcus aureus* (20.3%) and *Pseudomonas aeruginosa* (15.2%). Notably, 50.0% of *K. pneumoniae* and 16.7% of *P. aeruginosa* isolates were resistant to carbapenems. Multidrug resistance (MDR) was observed in 16.5% of the isolates. Among *S. aureus* isolates, 75.0% were methicillin-resistant (MRSA) but all the Gram-positive isolates were susceptible to vancomycin and linezolid.
Conclusion: This study underscores the predominance of *K. pneumoniae*, *S. aureus*, and *P. aeruginosa* in pyogenic infections and highlights alarming levels of antimicrobial resistance, including carbapenem resistance and MRSA. The findings emphasize the urgent need for robust antimicrobial stewardship, continuous surveillance, and adherence to infection control measures to manage AMR effectively.

Keywords: Pyogenic infections; Antimicrobial resistance; Multidrug-resistant bacteria; VITEK 2; Southern India

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Prévalence et profils de résistance aux antimicrobiens d'isolats bactériens d'infections pyogènes dans un centre de soins tertiaires du sud de l'Inde

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Résumé:

Contexte: Les infections pyogènes, caractérisées par la formation de pus due à une inflammation aiguë, restent un problème clinique fréquent, notamment en milieu hospitalier. La résistance aux antimicrobiens (RAM) des bactéries pathogènes responsables constitue une menace importante pour l'efficacité des traitements. L'objectif de cette étude est d'évaluer la prévalence et les profils de résistance aux antimicrobiens d'isolats bactériens d'infections pyogènes dans un hôpital de soins tertiaires du sud de l'Inde.
Méthodologie: Une étude observationnelle en laboratoire a été menée de janvier à avril 2025 au département de microbiologie de l'Institut Apollo des sciences médicales et de la recherche, à Hyderabad, en Inde. Français Un total de 138 échantillons de pus, d'aspirats et d'écouvillons de plaies ont été traités à l'aide de techniques de culture aérobie standard. L'identification bactérienne et les tests de sensibilité aux antimicrobiens ont été réalisés

à l'aide du système VITEK 2 Compact conformément aux directives CLSI 2025.
Résultats: Sur 138 échantillons, 79 (57,3%) étaient positifs à la culture pour des isolats bactériens cliniquement significatifs. Les isolats Gram négatifs prédominaient (73,4%, n=58), *Klebsiella pneumoniae* (22,9%) étant l'agent pathogène le plus répandu, suivi de *Staphylococcus aureus* (20,3%) et de *Pseudomonas aeruginosa* (15,2%). Notamment, 50,0% des isolats de *K. pneumoniae* et 16,7% des isolats de *P. aeruginosa* étaient résistants aux carbapénèmes. Une multirésistance aux médicaments (MDR) a été observée chez 16,5% des isolats. Parmi les isolats de *S. aureus*, 75.0% étaient résistants à la méthicilline (SARM), mais tous les isolats à Gram positif étaient sensibles à la vancomycine et au linézolide.
Conclusion: Cette étude souligne la prédominance de *K. pneumoniae*, *S. aureus* et *P. aeruginosa* dans les infections à pyogènes et met en évidence des niveaux alarmants de résistance aux antimicrobiens, notamment aux carbapénèmes et au SARM. Ces résultats soulignent l'urgence d'une gestion rigoureuse des antimicrobiens, d'une surveillance continue et du respect des mesures de contrôle des infections pour gérer efficacement la RAM.

Mots-clés: Infections à pyogènes; Résistance aux antimicrobiens; Bactéries multirésistantes; VITEK 2; Inde du Sud

Introduction:

Pyogenic infections, characterized by the production of pus due to acute inflammation, are among the most common presentations in clinical practice. These infections may arise from wounds, abscesses, surgical sites or secondary bacterial invasions in immunocompromised individuals (1). The etiological agents vary widely depending on the anatomical sites and patient factors but *Staphylococcus aureus, Escherichia coli*, *Klebsiella* spp, *Pseudomonas aeruginosa* and *Proteus* spp are frequently implicated (2).

The growing threat of antimicrobial resistance (AMR) among pyogenic pathogens has emerged as a serious challenge in both community and hospital settings. The irrational and indiscriminate use of antibiotics, coupled with poor infection control practices, has led to the emergence of multidrug-resistant (MDR), extensively drug-resistant (XDR), and even pandrug-resistant (PDR) organisms (3,4). Infections caused by these resistant pathogens are associated with higher morbidity, prolonged hospital stays, increased treatment costs, and poor patient outcomes (5).

In India, recent surveillance reports indicate alarmingly high resistance rates among common pathogens, especially in tertiary care settings (6). Studies have shown that MRSA rates range from 30–50%, while Gram-negative bacilli such as *Klebsiella* spp and *E. coli* exhibit increasing resistance to carbapenems and the third-generation cephalosporins (7,8). The Indian Council of Medical Research (ICMR) and the World Health Organization (WHO) have highlighted AMR as a critical public health concern, especially in the context of limited antibiotic development and inadequate stewardship (9,10).

Despite the growing burden, there is a paucity of region-specific data on the microbiological profile and resistance patterns of pyogenic infections, particularly from tertiary care centres in Southern India. Understanding local resistance trends is crucial to guide empirical therapy and develop region-specific antibiotic policies. Thus, this study was conducted to determine the most prevalent pathogens in pyogenic samples and their resistance pattern.

Materials and method:

Study setting:

This four-month observational study was conducted in the Department of Microbiology of Apollo Institute of Medical Sciences, Hyderabad, India from January 2025 to April 2025. Apollo Medical College and Hospital, Hyderabad is an established hospital in the southern part of India with a 660-bed capacity.

Sample collection and laboratory analysis:

During the study period, 138 samples (pus aspirate and wound swab) were received for aerobic culture in the Microbiology Laboratory, as part of medical care for patients from various outpatient and inpatient departments, and intensive care units. Within two hours of their aseptic collection, the samples were transferred to the laboratory for analysis. The specimens were cultured on MacConkey and Blood agar media and incubated for 48 hours at 37°C. In accordance with conventional laboratory procedure, species identification was carried out using colony features and the BioMérieux Vitek 2 compact identification system.

Antimicrobial susceptibility testing (AST) was also carried out using BioMérieux Vitek 2 compact system. Aminoglycosides, cephalosporins, quinolones, carbapenems, piperacillin/tazobactam, and cotrimoxazole were tested against Gram negative isolates, while penicillin, aminoglycosides, quinolones, erythromycin, clindamycin, and cotrimoxazole were tested against Gram-positive isolates. The 35th edition (2025) of the Clinical and Laboratory Standards Institute (CLSI) guideline M-100 was followed in AST interpretation process.

Statistical analysis:

Microsoft Excel was used to evaluate and analyse the data. The quantitative data were presented in tabular form and figures as numbers and percentages.

Results:

Demographic characteristics of the patients with suspected pyogenic infections:

During the study period from January to April 2025, a total of 138 clinical specimens were collected from patients with suspected pyogenic infections. The study population comprised 86 (62.3%) male and 52 (37.7%) female patients, with age ranging from 1 to 82 years (mean age: 45.5±18.5 years). The most commonly affected age group was the 51-60 years category, accounting for 11.6% of the cases. The frequency distribution of the samples of patients is shown in Fig 1.

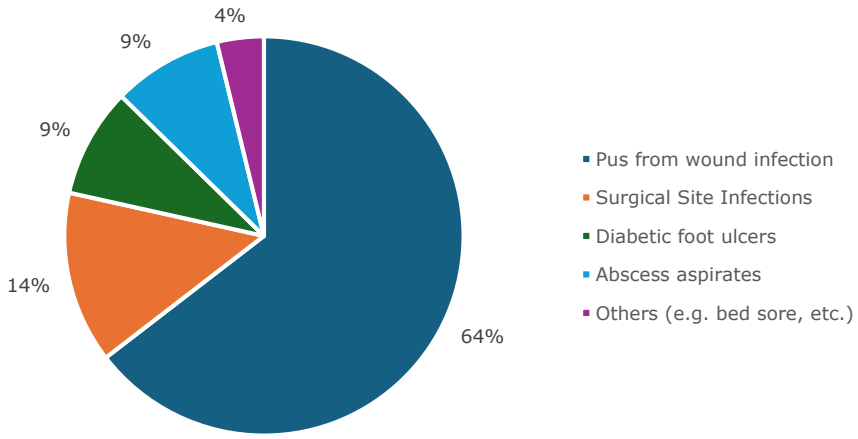


Fig 1: Frequency distribution of clinical samples from patients with pyogenic infections received at the microbiology laboratory of Apollo Institute of Medical Sciences and Research, Hyderabad, India

Table 1: Frequency distribution of bacterial isolates from clinical samples of patients with pyogenic infections at Apollo Institute of Medical Sciences and Research, Hyderabad, India

Bacterial isolate	Number of Isolates	Percentage (%)
Klebsiella pneumoniae	18	22.8
Staphylococcus aureus	16	20.3
Pseudomonas aeruginosa	12	15.2
Escherichia coli	10	12.7
Proteus mirabilis	4	5.1
Enterobacter cloacae	4	5.1
Enterococcus faecalis	3	3.8
Pseudomonas luteola	2	2.5
Morganella morganii	2	2.5
Enterococcus faecium	1	1.3
Burkholderia cepacia	1	1.3
Streptococcus agalactiae	1	1.3
Acinetobacter haemolyticus	1	1.3
Providencia rettgeri	1	1.3
Stenotrophomonas maltophilia	1	1.3
Serratia marcescens	1	1.3
Enterobacter aerogenes	1	1.3

Prevalence and bacterial isolates of pyogenic infections:

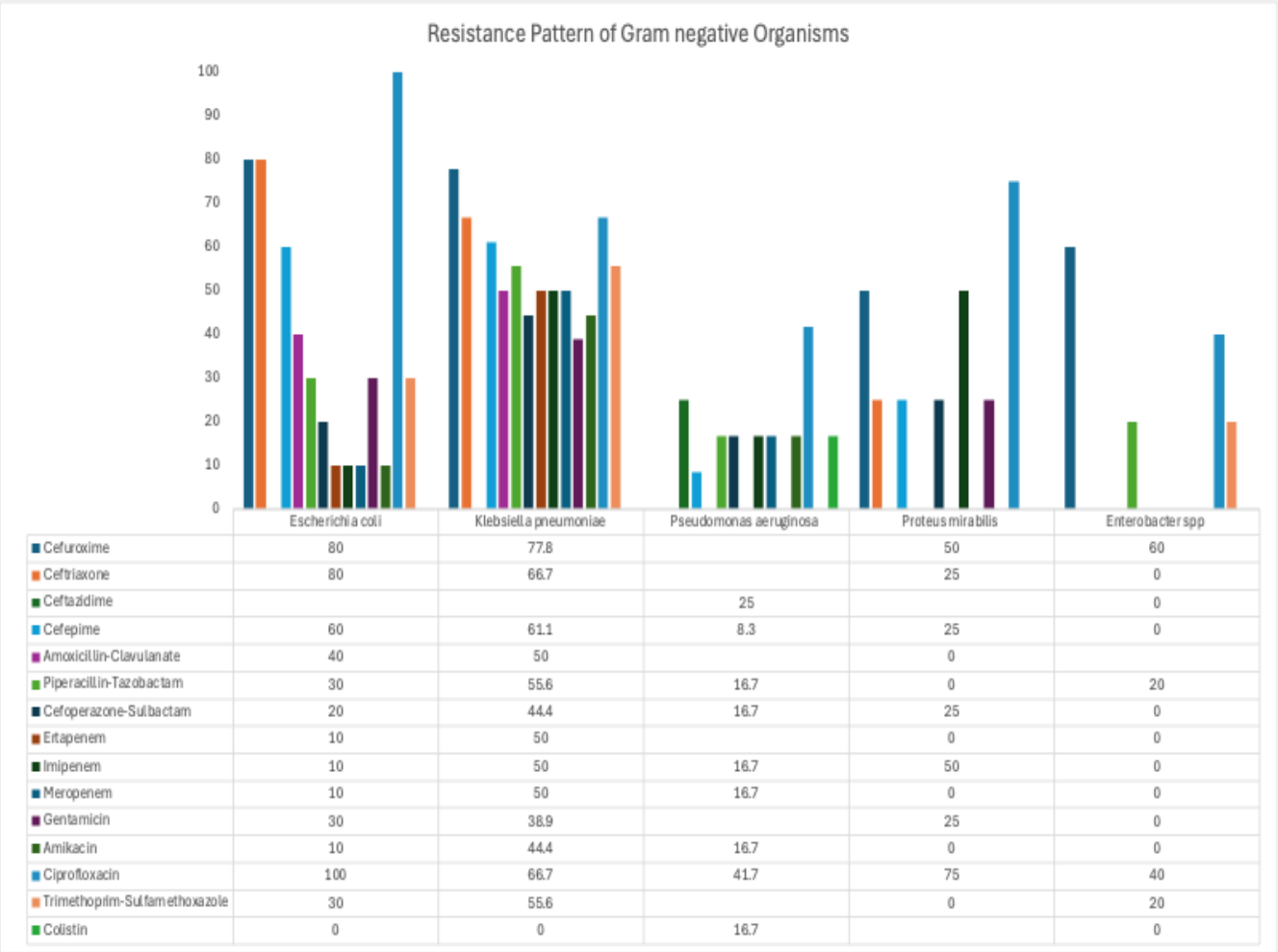
Of the 138 clinical samples from the patients, 79 (57.3%) yielded clinically significant bacterial isolates on culture and were included in the analysis, while the remaining 59 (42.8%) showed either no bacterial growth or grew contaminants and were excluded. Among total culture positives, 58 (73.4%) isolates were Gram negative and 21 (26.6%) isolates were Gram positive.

The most prevalent isolate was *Klebsiella pneumoniae* (n=18, 22.9%), followed by *Staphylococcus aureus* (n=16, 20.3%) and *Pseudomonas aeruginosa* (n=12, 15.2%). The distribution of bacterial isolates is shown in Table 1.

Antimicrobial resistance of bacterial isolates of pyogenic infections:

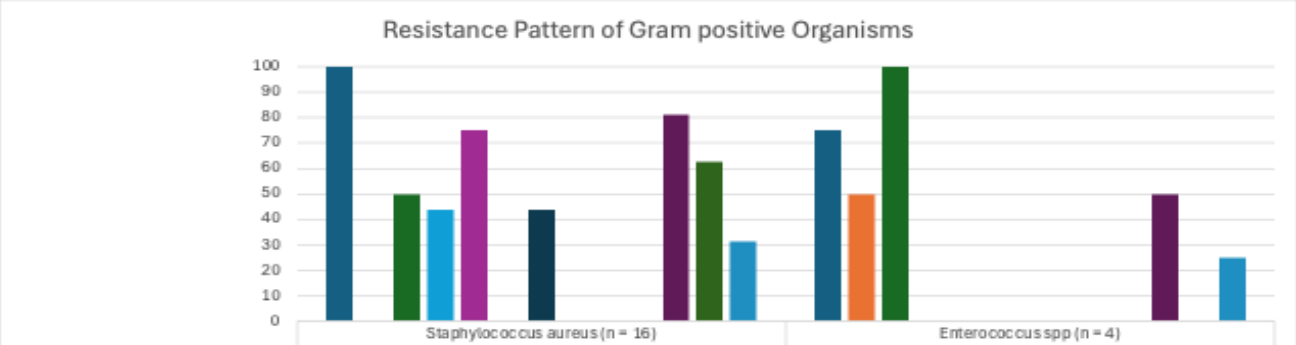
The antimicrobial resistance pattern of the Gram-negative bacteria is detailed in Fig 2. Only 16.7% of *P. aeruginosa* demonstrated resistance to colistin while all the others showed no resistance to colistin, except for the ones with intrinsic resistance. Most of the Gram-negative bacteria exhibited high resistance rates to cephalosporins and quinolones. Carbapenem resistance was observed in 50% of *K. pneumoniae*, 16.7% of *P. aeruginosa* and 10% of *Escherichia coli* isolates. Multidrug resistance (MDR), defined as resistance to at least one antimicrobial agent in three separate antimicrobial groups or classes (11), was observed in 13 Gran-negative bacterial isolates (8 *K. pneumoniae*, 3 *P. aeruginosa* and 2 other isolates).

Among the *S. aureus* isolates, methicillin resistance was observed in 12 isolates (75%). The *S. aureus* isolates showed high resistance rates against penicillin, erythromycin and fluoroquinolones. However, none of the Gram-positive isolates was resistant to vancomycin or linezolid. The resistance pattern of the Gram-positive isolates is shown in Fig 3.



	Escherichia coli	Klebsiella pneumoniae	Pseudomonas aeruginosa	Proteus mirabilis	Enterobacter spp
Cefuroxime	80	77.8		50	60
Ceftriaxone	80	66.7		25	0
Ceftazidime			25		0
Cefepime	60	61.1	8.3	25	0
Amoxicillin-Clavulanate	40	50		0	
Piperacillin-Tazobactam	30	55.6	16.7	0	20
Cefoperazone-Sulbactam	20	44.4	16.7	25	0
Ertapenem	10	50		0	0
Imipenem	10	50	16.7	50	0
Meropenem	10	50	16.7	0	0
Gentamicin	30	38.9		25	0
Amikacin	10	44.4	16.7	0	0
Ciprofloxacin	100	66.7	41.7	75	40
Trimethoprim-Sulfamethoxazole	30	55.6		0	20
Colistin	0	0	16.7		0

Fig 2: Resistance pattern of Gram-negative bacterial isolates from clinical samples of patients with pyogenic infections at Apollo Institute of Medical Sciences and Research, Hyderabad, India



	Staphylococcus aureus (n = 16)	Enterococcus spp (n = 4)
Penicillin	100	75
Ampicillin		50
Erythromycin	50	100
Clindamycin	43.7	
Cefoxitin	75	
Tetracycline	0	
Trimethoprim-Sulfamethoxazole	43.7	
Vancomycin	0	0
Daptomycin	0	0
Linezolid	0	0
Ciprofloxacin	81.2	50
Levofloxacin	62.5	
Gentamicin	31.2	25

Fig 3: Resistance pattern of Gram-positive bacterial isolates from clinical samples of patients with pyogenic infections at Apollo Institute of Medical Sciences and Research, Hyderabad, India

Discussion:

This study provides a snapshot of the bacterial pathogens implicated in pyogenic infections in a tertiary care hospital in Southern India, with *K. pneumoniae* as the predominant isolate, followed by *S. aureus* and *P. aeruginosa*. These findings align with previous studies conducted in similar settings, where *K. pneumoniae* and *P. aeruginosa* were frequently reported as leading causes of nosocomial and community-acquired infections, especially in immunocompromised individuals and patients with prolonged hospital stays (12–14).

The high prevalence of *K. pneumoniae* (22.9%) is concerning, particularly given the observed 50.0% resistance rate to carbapenems. This reinforces growing global concerns about carbapenem-resistant *Klebsiella* spp, which are associated with limited therapeutic options and poor clinical outcomes (15). Similarly, the detection of carbapenem resistance in *P. aeruginosa* (16.7%) and *E. coli* (10.0%) underscores the need for stringent antimicrobial stewardship and robust infection control practices in the hospital.

Multidrug resistance (MDR), observed in 16.5% (13/79) of the isolates, particularly among *K. pneumoniae* and *P. aeruginosa*, further complicates management. This is consistent with data from the Indian Council of Medical Research (ICMR), which reported rising MDR rates among Gram-negative bacterial pathogens in tertiary care centres across India (16). The MDR criteria applied in this study follow the international guidelines established by the CDC and ECDC, which provide a standardized framework for resistance classification in bacteria (11).

Among the Gram-positive isolates, the high prevalence of methicillin-resistant *S. aureus* (MRSA) at 75% is significant. MRSA remains a major cause of healthcare-associated infections and often exhibits resistance to multiple non-beta-lactam antibiotics (17,18), as was evident in the resistance to penicillin, erythromycin, and quinolones in this study. Encouragingly, all Gram-positive isolates remained susceptible to vancomycin and linezolid, preserving these agents as viable therapeutic options, which is in line with global trends (19).

The age distribution indicated that individuals in the 51–60 years age group were most commonly affected by pyogenic infections, likely reflecting a combination of age-related immune decline, comorbidities, and increased healthcare interactions in this demographic. Male predominance was also noted, which may relate to higher exposure risks or differences in health-seeking behaviours, as observed in other regional studies (17,20).

Overall, the findings of this study highlight the evolving bacterial landscape of pyogenic infections and the mounting threat of antimicrobial resistance. Continuous Surveillance, rational antibiotic use, and implementation of infection control policies are imperative to curb the spread of resistant pathogens. Future studies with larger sample sizes and

molecular characterization of resistance genes may provide further insights into the mechanisms and transmission dynamics of AMR in this region.

Conclusion:

This study highlights the predominance of *K. pneumoniae*, *S. aureus*, and *P. aeruginosa* as the leading bacterial pathogens causing pyogenic infections in our tertiary care centre. The high prevalence of MDR, particularly among Gram-negative bacteria, and the significant proportion of methicillin resistance among *S. aureus* isolates underscore the urgent need for enhanced antimicrobial stewardship and routine surveillance programs.

The continued susceptibility of Gram-positive bacteria to vancomycin and linezolid provides some reassurance, but the rising resistance to other antibiotic classes remains a serious concern. Implementing strict infection control measures, promoting rational antibiotic use, and conducting further research, including molecular characterization of resistance genes, are critical steps toward curbing the spread of antimicrobial resistance and improving patient outcomes.

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Contributions of authors:

AB was involved in the conception and design of the study, data collection, laboratory analysis, data interpretation, and drafting of the manuscript. PG provided overall supervision, critical review, and final approval of the manuscript. Both authors read and approved the final version of the manuscript.

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Conflict of interest:

Authors declare no conflict of interest

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