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RESEARCH ARTICLE

Antibiotic Resistance Pattern among Bacteria Causing Urinary Tract Infections in Elderly Patients

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Abstract: Urinary tract infections in the elderly population are significantly high due to physiological vulnerability and escalating antimicrobial resistance. Evaluation of 300 positive urine cultures from patients aged over 60 years in a South Indian tertiary care facility reveals a 30% isolation rate among suspected cases. Female predominance at 60% and a high prevalence in outpatient settings (85%) characterize the demographic distribution. *Escherichia coli* constitutes the primary uropathogen at 50%, followed by *Klebsiella* species at 16% and *Enterococcus* species at 10%. High resistance levels are observed in *Escherichia coli* against Ampicillin (93%), Amoxicillin-Clavulanic acid (80%), and Nalidixic acid (65%). In contrast, Meropenem, Piperacillin-Tazobactam, and Amikacin maintain superior sensitivity profiles. *Klebsiella* isolates exhibit significant resistance to Amoxicillin-Clavulanic acid at 88%, while *Enterococcus* species remain entirely susceptible to Vancomycin and largely responsive to Linezolid. The emergence of multidrug-resistant isolates in this demographic necessitates the implementation of localized antibiograms and stringent antimicrobial stewardship to mitigate risks of treatment failure. Targeted diagnostic methods and evidence-based therapeutic selection are essential to manage the complex interplay of immunosenescence and bacterial virulence factors in geriatric urology.

Keywords: *Escherichia coli*; Geriatric Urology; Antimicrobial Susceptibility; Multidrug Resistance; South India

1. Introduction

Urinary tract infections represent a primary category of infectious pathologies encountered in clinical practice, with an estimated global incidence ranging between 120 and 150 million cases annually [1]. These infections constitute a leading cause for primary care consultations and contribute significantly to global morbidity [1, 2]. Even with the administration of appropriate antimicrobial therapy, these pathologies are frequently associated with high recurrence rates and a substantial reduction in the quality of life for affected individuals [2, 3]. Beyond clinical outcomes, the economic impact is profound, involving direct healthcare costs and indirect losses related to productivity and workplace absenteeism [4, 5].

Clinically, these infections are categorized based on anatomical involvement into upper tract pathologies, such as pyelonephritis, and lower tract conditions, including cystitis, urethritis, and prostatitis [6]. Further classification into uncomplicated and complicated types depends on the presence of structural or functional abnormalities that facilitate bacterial colonization or impede therapeutic efficacy [6, 7]. Gram-negative bacteria remain the predominant causative agents, with *Escherichia coli* identified as the most frequent pathogen in both uncomplicated cystitis and pyelonephritis [1, 8]. Other significant isolates include *Proteus mirabilis*, *Klebsiella pneumoniae*, and Gram-positive organisms such as *Enterococcus faecalis* and *Staphylococcus saprophyticus* [1, 8].

Therapeutic management is increasingly complicated by the rise of antimicrobial resistance, often driven by the unregulated use of antibiotics [9, 10]. The prevalence of bacteria producing extended-spectrum beta-lactamases (ESBLs) is rising, rendering many conventional treatments ineffective and leaving carbapenems as the few remaining viable options [9, 10]. These uropathogens utilize a specialized array of virulence factors and physiological adaptations to survive the mechanical forces of urinary flow and adhere to the urothelium [11]. While *Escherichia coli* remains the most common isolate [12], hospitalized and immunocompromised patients often present with non-conventional or opportunistic pathogens [13, 14]. The proliferation of multidrug-resistant bacteria in both community and healthcare settings presents clinicians with limited therapeutic choices [15, 16]. Notable examples of such resistant isolates include ESBL-producing Enterobacteriaceae, carbapenem-resistant *Pseudomonas* species, and vancomycin-resistant *Enterococcus* [17, 18].

Geriatric patients face an elevated risk for these infections due to a combination of intrinsic and extrinsic factors [19]. Intrinsic factors include age-related immunosenescence, malnutrition, immobility, and underlying comorbidities such as Type II diabetes or

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benign prostatic hyperplasia [19, 20]. Extrinsic factors often involve hospitalization, the use of indwelling urinary catheters, and various chemotherapeutic interventions [19]. Therapeutic success in the elderly is further limited by the need to avoid certain antimicrobial classes that may cause adverse reactions or are contraindicated due to age-related declines in hepatic and renal function [21].

In India, the prevalence of these infections is reported to be between 21.8% and 31.3% [22]. The widespread use of fluoroquinolones, beta-lactams, and sulfonamides has acted as a driver for the selection of resistant strains [23]. ESBL and carbapenemase production are the primary mechanisms of resistance observed in Indian isolates, particularly within *Escherichia coli* populations [24, 25]. While multidrug-resistant strains were once confined to tertiary healthcare settings, they are now frequently identified in community-acquired infections [26]. Given the regional variations in microbial distribution and susceptibility patterns across India, localized data is essential for effective management [27, 28, 29]. This research work evaluates the resistance profiles and epidemiology of uropathogens among patients aged over 60 years in a South Indian tertiary care setting.

2. Materials and Methods

2.1. Study Design and Ethical Considerations

A retrospective observational investigation was conducted over a six-month period from April 2024 to September 2024. The study focused on evaluating the burden and resistance trends of urinary tract infections in the geriatric population at a tertiary care hospital in South India. The protocol received approval from the Institutional Ethics Committee (Approval Number: ECR/1534/Inst/AP/2024/112). Informed consent was secured from participants, ensuring they were cognizant of their rights to withdraw and the nature of the data collection process.

2.2. Inclusion Criteria and Data Collection

Data was retrieved from laboratory records in collaboration with the Department of Microbiology. The study included 300 non-repetitive positive urine cultures from patients aged 60 years and older who presented with clinical symptoms such as fever, dysuria, urinary urgency, or oliguria. For each patient, demographic and clinical variables including age, gender, recurrence history, and prior antibiotic exposure were documented.

2.3. Sample Processing and Pathogen Identification

Urine specimens were collected in sterile containers following standard clinical procedures [30]. Samples were transported in insulated containers and processed within 2.5 hours of collection. Primary isolation was performed by streaking samples onto MacConkey agar, Cysteine Lactose Electrolyte Deficient (CLED) agar, and HiCrome Chromogenic Coliform Agar using calibrated loops. All plates were incubated at 37°C to allow for the development of significant colony counts.

2.4. Antimicrobial Susceptibility Testing

Susceptibility testing and the interpretation of results were conducted in accordance with the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines [31]. The panel of antibiotics tested included:

1. Beta-lactams: Ampicillin, Amoxicillin-Clavulanic acid, Cloxacillin, Penicillin, and Piperacillin-Tazobactam.
2. Cephalosporins: Cefotaxime, Cefuroxime, Cefaclor, Cefixime, and Cefazolin.
3. Aminoglycosides: Amikacin, Gentamicin, and Tobramycin.
4. Fluoroquinolones: Ciprofloxacin and Norfloxacin.
5. Miscellaneous: Chloramphenicol, Co-trimoxazole, Linezolid, Meropenem, Nalidixic acid, Rifampicin, and Vancomycin.

All antibiotic discs were sourced from HiMedia, Mumbai. The prevalence of resistance was determined as the proportion of resistant isolates relative to the total number of positive cultures.

2.5. Statistical Analysis

Descriptive statistics were utilized to characterize the data, employing means, medians, and percentages. Data management was performed using Microsoft Excel 2013, while specialized statistical analyses were conducted using SPSS software version 22.

3. Results

3.1. Demographic Distribution of Study Subjects

The investigation identified a 30% isolation rate from 1,000 suspected cases of urinary tract infections, resulting in a final cohort of 300 confirmed isolates. Gender-based analysis revealed a clear predominance of female cases, representing 60% (n=180) of the total population, while male cases accounted for 40% (n=120).

Age-based stratification showed that the highest concentration of infections occurred in the 70–75 age bracket, which represented 30% of the cohort. The 60–65 and 65–70 age groups each contributed 23.3%, while the oldest demographic (above 75 years) constituted 20% of the study population.

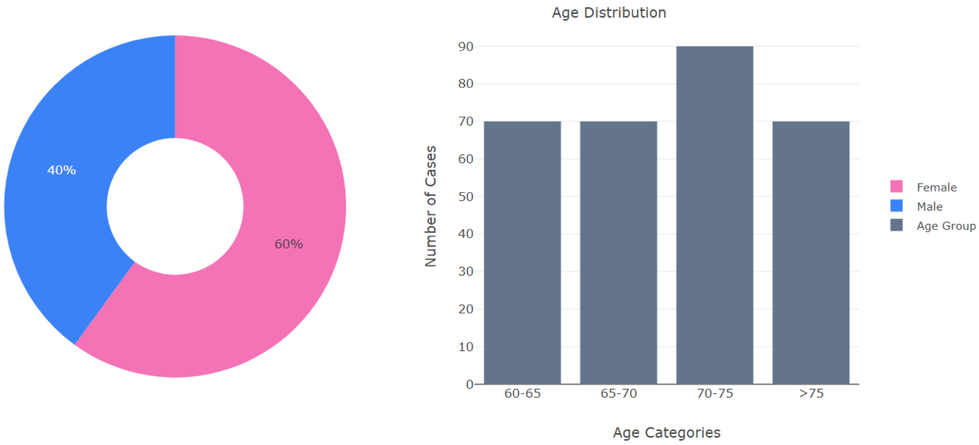

Figure 1. Gender and age-wise Distribution of Patients

3.2. Microbiological Profile and Setting

Data regarding the clinical setting indicated that 85% of the isolates were recovered from outpatient departments (OPD), with the remaining 15% originating from inpatient departments (IPD). Among the pathogens isolated, Gram-negative bacteria were the primary contributors. *Escherichia coli* was the most frequently identified species, occurring in 50% of the cases (n=150). This was followed by *Klebsiella* species at 16% (n=50), and *Enterococcus* species at 10% (n=30). Other pathogens, including *Pseudomonas* species (6%), *Acinetobacter* species (3%), *Proteus* species (3%), *Citrobacter* species (3%), and *Staphylococcus aureus* (3%), were isolated at lower frequencies. Fungal isolates, specifically *Candida* species, accounted for 3% of the samples.

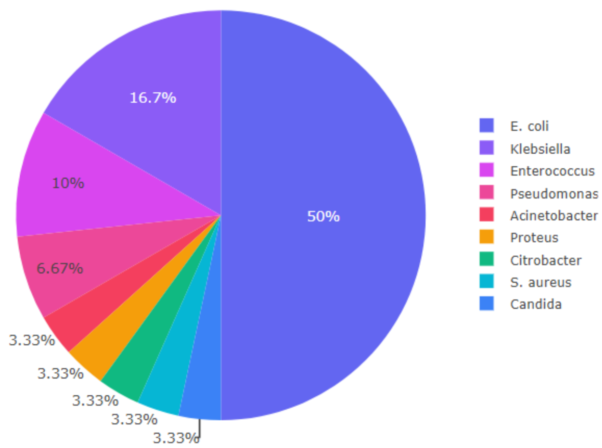

Figure 2. Prevalence of Diverse Uropathogens Among the Cohort

3.3. Antimicrobial Susceptibility Trends

3.3.1. Susceptibility Profile of Escherichia coli

The analysis of *Escherichia coli* isolates revealed significant resistance levels against commonly prescribed oral antibiotics. Ampicillin showed the highest resistance rate at 93%, followed by Amoxicillin-Clavulanic acid at 80% and Nalidixic acid at 65%. Resistance to third-generation cephalosporins was also notable, with Cefotaxime at 60%, and both Cefixime and Cefuroxime at 51%. Fluoroquinolone resistance was recorded at 40% for both Ciprofloxacin and Norfloxacin. Conversely, the highest sensitivity was observed for Meropenem (97%), Piperacillin-Tazobactam (98%), Amikacin (79%), and Gentamicin (80%).

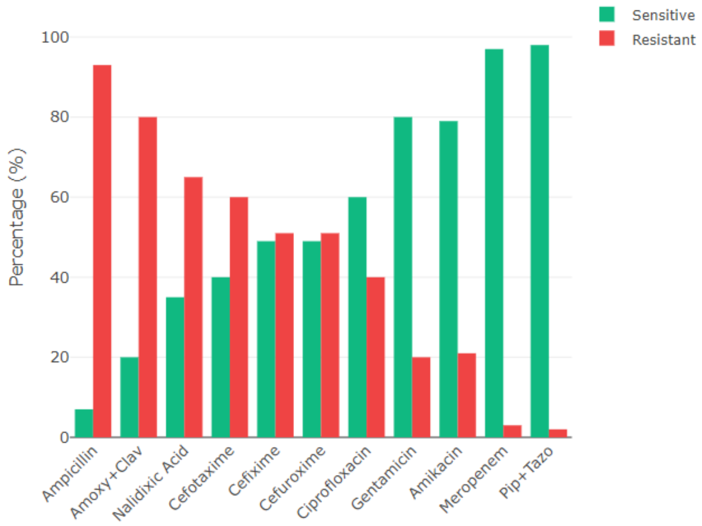

Figure 3. Susceptibility pattern for E. coli isolates

3.3.2. Susceptibility Profile of Klebsiella species

For *Klebsiella* species, high resistance rates were identified for Amoxicillin-Clavulanic acid (88%) and Ampicillin (88%). However, susceptibility remained relatively high for Meropenem (88%), Gentamicin (88%), Amikacin (88%), and Piperacillin-Tazobactam (86%). Resistance to fluoroquinolones and cephalosporins ranged between 18% and 20%, showing a distinct profile compared to *E. coli* isolates.

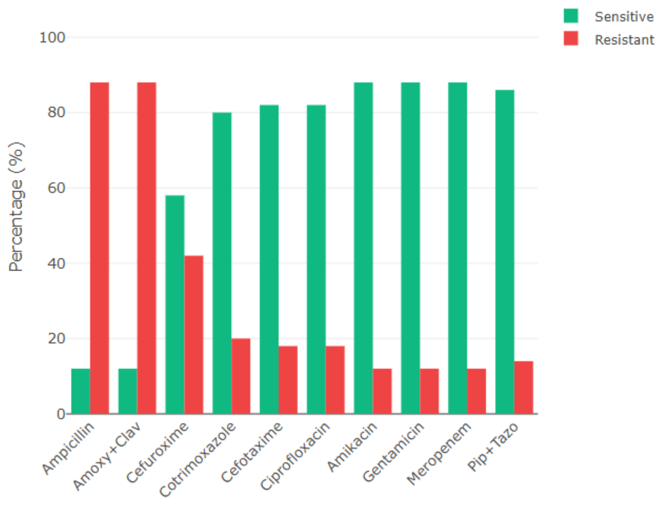

Figure 4. Susceptibility pattern for Klebsiella species

3.3.3. Susceptibility Profile of Enterococcus species

Enterococcus isolates demonstrated total susceptibility to Vancomycin (100%), with Linezolid (73%) and Chloramphenicol (70%) also showing efficacy. However, high resistance levels were observed for Penicillin (93%) and Norfloxacin (67%), indicating limited utility for these agents in managing Gram-positive urogenital infections in this population.

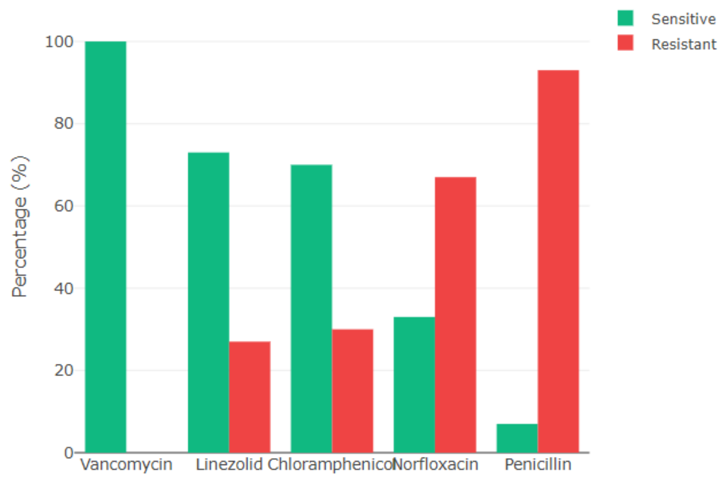

Figure 5. Susceptibility pattern for Enterococcus species

4. Discussion

The 30% isolation rate observed in this investigation aligns with similar clinical reports from the Indian subcontinent. For instance, data from Jaipur indicated an isolation rate of 17.19% [32]. The higher prevalence in females (60%) corresponds with established physiological predispositions and anatomical factors that facilitate ascending infections, reflecting trends noted in studies from Odisha where female prevalence reached 78.8% [33]. The concentration of cases in the elderly male demographic, particularly those over 70 years, corroborates documentation that immunodepletion and prostatic factors in older men significantly increase infection risk [33]. The high outpatient prevalence (85%) is consistent with reports from Nagaland, which identified 82.9% of cases as community-originating [34].

The dominance of *Escherichia coli* as the primary uropathogen (50%) followed by *Klebsiella* species (16%) follows global patterns where Enterobacteriaceae are the most frequent isolates [35]. The isolation rates for *Citrobacter*, *Proteus*, and *Enterococcus* in this study are remarkably consistent with findings from Bengaluru [36]. The resistance trends for *Escherichia coli* reveal a worrying trajectory. While resistance to Cefuroxime (51%) and Cefotaxime (60%) in this South Indian setting is slightly lower than the 66.67% and 70% reported in Rajasthan, the high resistance to Amoxicillin-Clavulanic acid (80%) and Nalidixic acid (65%) mirrors the escalating threat of multidrug-resistant organisms [32]. Sensitivity remains preserved for carbapenems and aminoglycosides, which is supported by earlier observations in Karnataka, suggesting these remain critical salvage therapies [37].

The resistance of *Klebsiella* to Amoxicillin-Clavulanic acid at 88% is higher than reports from Punjab (77.2%) and significantly exceeds figures from Bhopal and Pakistan, which registered resistance at approximately 63% [38, 39]. This regional variation highlights the need for localized surveillance. In the case of *Enterococcus* species, the preservation of Vancomycin sensitivity (100%) and high responsiveness to Linezolid provide clear therapeutic pathways for Gram-positive infections. However, the high resistance to Penicillin (93%) suggests that empiric use of older beta-lactams is increasingly inappropriate for this demographic [40].

The results indicate that the geriatric population represents a highly vulnerable group requiring specific diagnostic and therapeutic attention [40]. The intersection of immunosenescence and bacterial resistance necessitates proactive measures. The use of antiseptic solutions and standardized protocols for indwelling catheterization could reduce the incidence of healthcare-associated complications [41, 42]. The development of demographic-specific antibiograms is essential to guide clinical decision-making and mitigate the risks of treatment failure in older patients who often present with complex comorbidities [43]. Several factors should be considered when interpreting these results. The retrospective design introduces potential selection bias and limits the availability of clinical data to assess independent risk factors. The reliance on manual microbiology records may involve data entry errors, and the short study duration may not capture long-term seasonal variations in resistance. Additionally, the absence of molecular testing for resistance genes limits the depth of mechanistic analysis

5. Conclusion

This research work provides evidence for the high prevalence of antimicrobial resistance among uropathogens in the geriatric population of South India. The substantial resistance observed against commonly used antibiotics like Ampicillin, Amoxicillin-Clavulanic acid, and Nalidixic acid necessitates a shift toward more rational prescribing based on localized data. The preservation of sensitivity to Meropenem, Amikacin, and Vancomycin highlights their role as essential treatments for severe or resistant cases. Implementing robust antimicrobial stewardship programs and improving public awareness regarding the risks of indiscriminate antibiotic use are vital steps toward curbing the proliferation of multidrug-resistant bacteria.

Compliance with ethical standards

Conflict of interest statement

The authors declare no conflict of interest regarding the publication of this research.

Statement of ethical approval

The study received formal approval from the Institutional Ethics Committee (ECR/1534/Inst/AP/2024/112). All procedures were conducted in accordance with the ethical standards of the institutional research committee.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study. Participants were briefed on the study protocol in their local language and provided voluntary consent, acknowledging their right to withdraw from the investigation at any stage.

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