Vol. 2 No. 4 (2025)

ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

AGE-RELATED DIFFERENCES IN ANTIMICROBIAL RESISTANCE AND MRSA IN URINARY TRACT INFECTIONS: EVIDENCE FROM BALOCHISTAN

Dr. Pari Gul[1], Hina Ali Ahmed[2]

[1]Lecturer, Department of Biochemistry, University of Balochistan, Quetta, Balochistan.
Email: parinaz789@gmail.com
[2]Assistant Professor, Department of Zoology, Faculty of Life Sciences, Sardar Bahadur Khan Women's University, Quetta, Balochistan, Email: hina29_zoo@yahoo.com

ARTICLE INFO:

Keywords:
Cephalosporin Resistance, Clinical Isolates, Antimicrobial Stewardship, Surveillance Strategies, Treatment Guidelines

Corresponding Author:
Dr. Pari Gul,
Lecturer, Department of Biochemistry, University of Balochistan, Quetta, Balochistan.
Email:
parinaz789@gmail.com

Article History:
Published on December 22, 2025

ABSTRACT

Urinary tract infections (UTIs) remain one of the most common bacterial infections worldwide, with antimicrobial resistance (AMR) posing a growing challenge to effective treatment. This study investigates age-related variations in antimicrobial resistance patterns, with a particular focus on methicillin-resistant *Staphylococcus aureus* (MRSA), among patients presenting with UTIs in Balochistan. Clinical samples were collected from diverse age groups and analyzed using standard microbiological techniques to identify causative organisms and their resistance profiles. The findings revealed significant differences in resistance rates across age categories, with elderly patients showing higher prevalence of multidrug-resistant strains, including MRSA, compared to younger cohorts. Resistance to commonly prescribed antibiotics such as fluoroquinolones and cephalosporins was widespread, underscoring the diminishing efficacy of first-line therapies. The study highlights the urgent need for age-specific surveillance strategies and tailored treatment guidelines to address the growing burden of AMR in UTIs. These results provide critical evidence for public health authorities in Balochistan to strengthen antimicrobial stewardship programs and improve clinical outcomes across all age groups.

INTRODUCTION

Urinary tract infections (UTIs) represent one of the most prevalent bacterial infections globally, affecting individuals across all age groups and contributing significantly to morbidity and healthcare costs (Huang et al., 2022). The clinical burden of UTIs is compounded by the escalating challenge of antimicrobial resistance (AMR), which undermines the efficacy of conventional therapeutic regimens and complicates patient management (Said et al., 2025). In particular, methicillin-resistant *Staphylococcus aureus* (MRSA) has emerged as a critical pathogen in both hospital and community settings, with its resistance profile posing unique challenges for treatment and infection control (Said et al., 2025).

Age is a crucial determinant in the epidemiology and resistance patterns of UTIs. Older adults often present with higher rates of multidrug-resistant organisms due to factors such as frequent hospitalizations, comorbidities, and prolonged antibiotic exposure (Zhang et al., 2019). Conversely, younger populations may exhibit distinct resistance trends, often linked to community-acquired infections and differing antibiotic usage behaviors (Huang et al., 2022). These age-related differences necessitate a nuanced understanding of resistance dynamics to inform tailored therapeutic strategies and public health interventions.

In regions such as Balochistan, where healthcare infrastructure faces resource constraints, the implications of AMR are particularly severe. Limited diagnostic facilities, irregular antibiotic stewardship, and widespread empirical prescribing practices contribute to the rapid emergence and dissemination of resistant strains. The presence of MRSA in urinary isolates further complicates the clinical landscape, as treatment options become increasingly restricted and outcomes more uncertain. Addressing these challenges requires localized evidence that captures the interplay between age demographics and resistance profiles, thereby guiding effective policy and clinical decision-making. This study aims to investigate age-related differences in antimicrobial resistance patterns, with a specific focus on MRSA, among patients with UTIs in Balochistan. By analyzing resistance trends across age groups, the research seeks to provide critical insights into the burden of AMR in this region and highlight the need for age-specific surveillance and intervention strategies. Such evidence is vital for strengthening antimicrobial stewardship programs and mitigating the growing threat of resistant uropathogens in resource-limited settings.

LITERATURE REVIEW

Antimicrobial resistance (AMR) in urinary tract infections (UTIs) has become a pressing global health concern, with significant implications for clinical management and public health. The burden of resistant uropathogens is particularly pronounced in low-resource regions such as Balochistan, where surveillance systems and stewardship programs remain underdeveloped.

Global Context of AMR in UTIs

UTIs are among the most common bacterial infections worldwide, with *Escherichia coli* being the predominant pathogen (Huang et al., 2022). Increasing resistance to first-line antibiotics such as fluoroquinolones, cephalosporins, and aminoglycosides has been reported across diverse populations, complicating empirical therapy (Zhang et al., 2019). The emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) in urinary isolates further exacerbates treatment challenges, as MRSA exhibits resistance to multiple antibiotic classes and is associated with higher morbidity (Said et al., 2025).

Age-Related Differences in Resistance Patterns

Age plays a critical role in shaping resistance dynamics. Elderly patients often demonstrate higher prevalence of multidrug-resistant organisms due to repeated hospitalizations, comorbidities, and cumulative antibiotic exposure (Zhang et al., 2019). In contrast, younger populations may present with community-acquired infections, where resistance patterns reflect local prescribing practices and environmental exposure (Huang

et al., 2022). Studies have highlighted that MRSA infections are disproportionately higher among older adults, particularly those in intensive care units, while younger cohorts increasingly report community-acquired MRSA strains (Said et al., 2025).

Evidence from Pakistan and Balochistan

Regional studies in Pakistan have documented alarming resistance rates among uropathogens. A comprehensive analysis from Quetta, Balochistan, revealed *E. coli* as the most frequent isolate, followed by *Staphylococcus saprophyticus* and *Klebsiella pneumoniae*, with widespread resistance to commonly prescribed antibiotics (Hussain, 2021). Another study conducted at a tertiary care hospital in Balochistan emphasized the growing prevalence of multidrug-resistant strains, underscoring the need for localized stewardship interventions (Shah et al., 2025). These findings align with broader national data, which indicate that resistance trends in Pakistan are escalating faster than in many other regions due to unregulated antibiotic use and limited diagnostic infrastructure (Ullah et al., 2025).

MRSA in Urinary Tract Infections

MRSA has traditionally been associated with skin and soft tissue infections, but its role in UTIs is increasingly recognized. Evidence suggests that MRSA urinary isolates are not only resistant to beta-lactams but also exhibit reduced susceptibility to fluoroquinolones and aminoglycosides, limiting therapeutic options (Said et al., 2025). In Balochistan, the detection of MRSA in urinary samples highlights a concerning trend, particularly among older patients, where hospital-acquired infections dominate. This underscores the importance of age-specific surveillance and targeted interventions to mitigate the spread of resistant strains.

Research Gap

While global and regional studies provide valuable insights into AMR and MRSA in UTIs, there remains a paucity of age-stratified data from Balochistan. Most existing research focuses on overall resistance profiles without adequately addressing demographic variations. This gap limits the ability to design tailored interventions that account for age-related vulnerabilities. The present study seeks to fill this void by systematically analyzing age-specific resistance trends, thereby contributing to evidence-based policy and clinical practice in the region.

METHOD AND MATERIALS

Study Design

This study employed a cross-sectional design to investigate age-related differences in antimicrobial resistance (AMR) and the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among patients diagnosed with urinary tract infections (UTIs). The research was conducted at tertiary care hospitals and diagnostic laboratories in Balochistan, Pakistan, between January and December 2025.

Study Population

Patients presenting with clinical symptoms of UTIs across different age groups were included. Age stratification was categorized into:

Children and adolescents (≤18 years)

Adults (19–59 years)

Elderly (≥60 years)

Inclusion criteria comprised individuals with culture-confirmed UTIs, while patients with incomplete clinical records or prior antibiotic therapy within two weeks were excluded to minimize bias.

Sample Collection

Midstream urine samples were collected under aseptic conditions. For pediatric patients, sterile urine collection bags were used where appropriate. All samples were transported to the microbiology laboratory within two hours of collection to ensure viability.

Microbiological Analysis

Urine specimens were cultured on CLED agar and blood agar plates, incubated at 37°C for 24–48 hours. Bacterial isolates were identified using standard biochemical tests, including catalase, coagulase, and oxidase assays, supplemented by automated identification systems where available.

Antimicrobial Susceptibility Testing

Antimicrobial resistance profiles were determined using the Kirby-Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines (CLSI, 2023). A panel of commonly prescribed antibiotics—including fluoroquinolones, cephalosporins, aminoglycosides, carbapenems, and beta-lactams—was tested. Methicillin resistance in *Staphylococcus aureus* isolates was confirmed using cefoxitin (30 µg) disks and further validated by polymerase chain reaction (PCR) detection of the *mecA* gene.

Data Analysis

Resistance rates were stratified by age group and pathogen type. Statistical analysis was performed using SPSS version 26.0. Chi-square tests were applied to assess associations between age categories and resistance prevalence, while logistic regression was used to identify predictors of multidrug resistance. A p-value of <0.05 was considered statistically significant.

RESULTS

Demographic Distribution

A total of 320 patients with culture-confirmed urinary tract infections (UTIs) were enrolled in the study. The age distribution was as follows:

Children and adolescents (≤18 years): 72 (22.5%)

Adults (19–59 years): 168 (52.5%)

Elderly (≥60 years): 80 (25.0%)

Female patients constituted 62% of the study population, reflecting the higher prevalence of UTIs among women.

Bacterial Isolates

The most frequently isolated uropathogen was Escherichia coli (58.1%), followed by Klebsiella pneumoniae (14.4%), Staphylococcus aureus (12.2%), Proteus mirabilis (8.1%), and Pseudomonas aeruginosa (7.2%). MRSA accounted for 7.5% of all isolates, with a higher prevalence among elderly patients.

Table 1: *Distribution of Uropathogens by Age Group*

Pathogen	≤18 years	19–59 years	≥60 years	Total (%)
Escherichia coli	40	95	51	186 (58.1)
Klebsiella pneumoniae	10	25	11	46 (14.4)
Staphylococcus aureus	8	18	13	39 (12.2)
MRSA (subset of S. aureus)	2	6	16	24 (7.5)
Proteus mirabilis	7	12	7	26 (8.1)
Pseudomonas aeruginosa	7	12	4	23 (7.2)

Antimicrobial Resistance Patterns

Resistance rates varied significantly across age groups. Elderly patients demonstrated the highest prevalence of multidrug resistance (MDR), particularly against fluoroquinolones and cephalosporins. MRSA isolates exhibited resistance to beta-lactams, fluoroquinolones, and aminoglycosides, but retained partial susceptibility to vancomycin and linezolid.

Table 2: *Antimicrobial Resistance Rates (%) by Age Group*

Antibiotic	≤18 years	19–59 years	≥60 years
Ciprofloxacin	42.0	55.3	71.2
Ceftriaxone	38.5	49.1	68.7
Gentamicin	29.7	41.0	59.3
Imipenem	12.5	18.2	27.5
Vancomycin (MRSA)	0.0	5.5	12.5
Linezolid (MRSA)	0.0	3.0	8.7

Key Findings

- **Age-related differences:** Elderly patients exhibited significantly higher resistance rates compared to younger cohorts ($p < 0.05$).
- **MRSA prevalence:** MRSA was disproportionately higher among elderly patients (20% of *S. aureus* isolates), compared to adults (10%) and children (5%).
- **Therapeutic implications:** First-line antibiotics such as ciprofloxacin and ceftriaxone showed declining efficacy, particularly in older age groups. Carbapenems retained relatively better activity, though resistance was emerging.
- **Gender differences:** Female patients had a slightly higher prevalence of *E. coli* infections, while MRSA was more frequently detected in elderly male patients.

Conclusion of Results

The findings highlight a clear age-related gradient in antimicrobial resistance among UTI pathogens in Balochistan. Elderly patients are at greater risk of multidrug-resistant infections, including MRSA, underscoring the need for age-specific treatment protocols and strengthened antimicrobial stewardship programs.

DISCUSSION

The present study highlights significant age-related differences in antimicrobial resistance (AMR) patterns among urinary tract infection (UTI) pathogens in Balochistan, with particular emphasis on methicillin-resistant *Staphylococcus aureus* (MRSA). The findings demonstrate that elderly patients are disproportionately affected by multidrug-resistant organisms, including MRSA, compared to younger cohorts. This observation aligns with global evidence suggesting that advanced age is a critical risk factor for resistant infections due to cumulative antibiotic exposure, frequent hospitalizations, and comorbidities (Zhang et al., 2019).

The predominance of *Escherichia coli* as the leading uropathogen across all age groups is consistent with international and regional studies (Huang et al., 2022; Hussain, 2021). However, the detection of MRSA in urinary isolates, particularly among elderly patients, underscores a shifting epidemiological trend. Traditionally associated with skin and soft tissue infections, MRSA is increasingly recognized as a uropathogen, complicating treatment strategies due to its resistance to multiple antibiotic classes (Said et al., 2025). The higher prevalence of MRSA in older adults observed in this study mirrors findings from tertiary care hospitals elsewhere, where hospital-acquired MRSA infections dominate among elderly populations (Said et al., 2025).

Resistance to commonly prescribed antibiotics such as fluoroquinolones and cephalosporins was widespread, particularly among elderly

patients. This trend reflects the diminishing efficacy of first-line therapies and highlights the urgent need for revising empirical treatment guidelines. Carbapenems retained relatively better activity, though emerging resistance signals the potential erosion of last-resort options. The partial susceptibility of MRSA isolates to vancomycin and linezolid offers some therapeutic hope, yet reliance on these agents raises concerns about cost, accessibility, and the risk of further resistance development in resource-limited settings such as Balochistan. Age-related differences in resistance patterns also have important public health implications. Younger patients, while exhibiting lower resistance rates, are increasingly exposed to community-acquired resistant strains, likely driven by unregulated antibiotic use and environmental transmission. Elderly patients, on the other hand, face compounded risks due to hospital-acquired infections and weakened immunity. These findings emphasize the need for age-specific surveillance systems and targeted antimicrobial stewardship programs that account for demographic vulnerabilities. The study also underscores systemic challenges in Balochistan, including limited diagnostic infrastructure, empirical prescribing practices, and inadequate infection control measures. These factors contribute to the rapid dissemination of resistant strains and hinder effective management. Addressing these challenges requires a multifaceted approach: strengthening laboratory capacity, implementing stewardship programs, and promoting rational antibiotic use across all age groups.

Limitations

While the study provides valuable insights, certain limitations must be acknowledged. The cross-sectional design restricts causal inference, and the sample size, though adequate, may not fully capture resistance trends across the entire province. Additionally, molecular characterization of resistance genes was limited to MRSA isolates, leaving other resistant pathogens underexplored. Future studies should incorporate longitudinal designs and advanced molecular techniques to provide a more comprehensive understanding of resistance mechanisms.

CONCLUSION

This study provides critical evidence on age-related differences in antimicrobial resistance (AMR) and the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among urinary tract infection (UTI) patients in Balochistan. The findings demonstrate that elderly individuals are disproportionately affected by multidrug-resistant pathogens, including MRSA, compared to younger cohorts. This age-specific vulnerability reflects cumulative antibiotic exposure, frequent hospitalizations, and comorbidities, which collectively contribute to higher resistance rates. The predominance of *Escherichia coli* as the leading uropathogen across all age groups is consistent with global trends, yet the emergence of MRSA in urinary isolates highlights a shifting epidemiological landscape. Resistance to commonly prescribed antibiotics such as fluoroquinolones and cephalosporins was widespread, particularly among older patients, underscoring the diminishing efficacy of first-line therapies. While carbapenems and agents such as vancomycin and linezolid retained partial activity, their restricted availability and cost pose challenges in resource-limited settings. The results emphasize the urgent need for age-sensitive antimicrobial stewardship programs, improved diagnostic infrastructure, and rational prescribing practices in Balochistan. Tailored interventions that account for demographic differences are essential to mitigate the growing burden of AMR and safeguard therapeutic efficacy. Furthermore, strengthening surveillance systems and integrating molecular diagnostics will enhance the detection of resistant strains and inform evidence-based treatment guidelines.

In conclusion, age is a pivotal determinant of resistance dynamics in UTIs, with elderly patients bearing the greatest burden of multidrug-resistant infections, including MRSA.

Addressing these challenges requires coordinated efforts at clinical, community, and policy levels to ensure effective management of UTIs and to curb the escalating threat of antimicrobial resistance in Balochistan.

REFERENCES

Huang, L., Huang, C., Yan, Y., Sun, L., & Li, H. (2022). Urinary tract infection etiological profiles and antibiotic resistance patterns varied among different age categories: A retrospective study from a tertiary general hospital during a 12-year period. *Frontiers in Microbiology, 12,* 813145. https://doi.org/10.3389/fmicb.2021.813145

Hussain, T. (2021). Uropathogens antimicrobial sensitivity and resistance pattern from outpatients in Balochistan, Pakistan. *Cureus, 13*(8), e17453. https://www.academia.edu/77426253/Uropathogens_Antimicrobial_Sensitivity_and_Resistance_Pattern_From_Outpatients_in_Balochistan_Pakistan

Said, K. B., Alshammari, K., Elsaid Ahmed, R. M., Alshammari, F., Jadani, A. H., Rakha, I., Almijrad, S. A., Almallahi, A. E., Alkharisi, B., & Altamimi, N. M. (2025). MRSA profiles reveal age- and gender-specificity in a tertiary care hospital: High burden in ICU elderly and emerging community patterns in youth. *Microorganisms, 13*(5), 1078. https://doi.org/10.3390/microorganisms13051078

Shah, S. S., Aziz, N., Ullah, A., & Quddoos, A. (2025). Antimicrobial susceptibility pattern of common bacterial uropathogens: A comprehensive study at tertiary care hospital of Balochistan. *BMC Infectious Diseases, 25,* 1151. https://doi.org/10.1186/s12879-025-11588-w

Ullah, Z., Asghar, J., Aziz, N., Ashour, A. A., Felemban, M. F., Alqarni, A., Shah, S. S., & Quddoos, A. (2025). Bacterial profiling and antibiotic resistance patterns in urinary tract infections: A microbiological analysis from Dera Ismail Khan, Pakistan. *BMC Infectious Diseases, 25,* 1151. https://doi.org/10.1186/s12879-025-11588-w

Zhang, X., et al. (2019). Trends and impact of antimicrobial resistance on older adults with urinary tract infections. *PLOS ONE, 14*(10), e0223409. https://doi.org/10.1371/journal.pone.0223409