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Research Article

Age-Related Differences in Antimicrobial Resistance and MRSA in Urinary Tract Infections: Evidence from Pakistan

Syeda Fatima Rizvi, Zainab Mustafa, Tahir Mahmood, Nasir Khan, Tahir Shahzad Nawaz Babar, Zainab Awais

1. Analyst, Health & Population Department, Government of Punjab.
2. Demonstrator, King Edward Medical University, Lahore.
3. Associate Professor Pediatrics, Abwa Medical College, Khurrianwala, Faisalabad.
4. Assistant Professor Paediatrics, Women Medical College.
5. Assistant Professor Paediatric Surgery, Children Hospital Faisalabad.
6. Senior Demonstrator, Pathology Department, University College of Medicine and Dentistry, University of Lahore.

Corresponding author: Syeda Fatima Rizvi

Abstract: Urinary tract infections (UTIs) remain among the most common bacterial infections across all age groups in Pakistan, but age-related variation in antimicrobial resistance (AMR), especially methicillin-resistant Staphylococcus aureus (MRSA), has not been comprehensively characterized. In a prospective study of 240 consecutive culture-positive UTI patients stratified into three age cohorts — pediatric (≤ 18 years, n = 62), adult (19–59 years, n = 128), and elderly (≥ 60 yearas, n = 50) — overall prevalence of MRSA was 18.3%. MRSA rates were significantly higher in the elderly group (28.0%) compared to adults (16.4%) and pediatric patients (11.3%) ($p = 0.02$). Among Gram-negative uropathogens, resistance to third-generation cephalosporins and fluoroquinolones increased progressively with age (e.g., ceftazidime resistance: pediatric 34.8%, adult 45.3%, elderly 62.0%, $p < 0.001$). High-level multidrug resistance (resistance to ≥ 3 antibiotic classes) was observed in 56.0% of isolates in the elderly group versus 42.2% in adults and 29.0% in pediatric patients ($p < 0.001$). These findings indicate a clear age-dependent increase in antimicrobial resistance and MRSA prevalence among UTI pathogens in Pakistan, underscoring the necessity for age-tailored empirical therapy and robust antimicrobial stewardship.

Keywords: urinary tract infection; antimicrobial resistance; MRSA; age differences; Pakistan

Introduction: Urinary tract infections (UTIs) impose a substantial burden on health systems globally and remain among the most frequently diagnosed bacterial infections in Pakistan. The challenge posed by antimicrobial resistance (AMR) among uropathogens has escalated in

recent years, compromising the efficacy of standard empirical therapies and contributing to recurrent infections, treatment failures, and increased healthcare costs. Although multiple studies from Pakistan have delineated the antibiotic susceptibility patterns of uropathogens, few have stratified data according to patient age, and even fewer have systematically assessed the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) across different age groups.[1-4]

Age is a critical but often underappreciated determinant of both host susceptibility and bacterial behavior. Pediatric patients may exhibit different risk factors — anatomical abnormalities, immature immune response, and distinct exposure history — compared with adults. Elderly individuals face additional challenges: reduced immune competence, comorbidities, frequent prior antibiotic exposure, and more hospital contact, all of which may favor colonization or infection with resistant organisms. This age-dependent divergence could influence the distribution of pathogens causing UTI, the spectrum of antimicrobial resistance, and particularly the prevalence of MRSA among gram-positive uropathogens.[5-8]

Recent local investigations have documented rising resistance among common uropathogens. A study from Rawalpindi–Islamabad reported high resistance to second- and third-line agents; their data showed that a substantial proportion of isolates exhibited resistance to multiple antibiotics. Similarly, surveillance in tertiary-care centers has identified Escherichia coli and Klebsiella species as dominant pathogens, with only limited susceptibility to older agents such as nitrofurantoin and fosfomycin. Notably, there is emerging but variable detection of Gram-positive bacteria including Staphylococcus aureus, but many studies do not elaborate on age-wise MRSA rates or compare resistance patterns across age brackets.[9-12]

Global data suggest that elderly patients with UTIs are at heightened risk for multidrug-resistant (MDR) organisms and MRSA, but due to geographic variation and differences in antibiotic use policies, such findings cannot be directly extrapolated to Pakistan. The absence of robust age-stratified AMR data impedes evidence-based empirical therapy guidelines and stewardship interventions tailored to vulnerable populations.

Given this background, a dedicated investigation is warranted to determine whether antimicrobial resistance and MRSA prevalence vary with age among UTI patients in Pakistan. Such data would have important implications for empirical prescribing, antimicrobial

stewardship, and public health policy, particularly in guiding therapy for pediatric and elderly populations.

This study was designed to address these gaps by prospectively collecting and analyzing urine culture data from a broad age spectrum of patients presenting with UTI. The primary objectives were to compare antimicrobial resistance patterns across pediatric, adult, and elderly age groups, to quantify MRSA prevalence in each group, and to assess the burden of multidrug resistance. The hypothesis was that older age would be associated with higher AMR rates and increased prevalence of MRSA among UTI pathogens.

Methodology: A prospective observational study was conducted at King Edward Medical University, Lahore Pakistan. All patients presenting with clinical features suggestive of urinary tract infection — dysuria, frequency, urgency, flank pain, or fever — were invited to provide a midstream clean-catch or catheterized urine sample as appropriate. After obtaining verbal informed consent from adult participants or from parents/guardians for minors, consecutive patients of all ages were enrolled. Exclusion criteria comprised recent antimicrobial treatment within the previous two weeks, known structural urinary tract abnormalities under active surgical management, patients on immunosuppressive therapy, and those refusing consent.

Urine samples underwent quantitative culture on standard media, bacterial identification was performed by conventional biochemical methods or automated systems, and antimicrobial susceptibility testing was conducted using the disc-diffusion method following Clinical and Laboratory Standards Institute (CLSI) guidelines. Methicillin resistance in Staphylococcus aureus isolates was determined using cefoxitin disc diffusion. Multidrug resistance (MDR) was defined as resistance to at least three distinct antibiotic classes commonly used in UTI management.

Patients were stratified into three age groups for analysis: pediatric (≤ 18 years), adult (19–59 years), and elderly (≥ 60 years). Demographic data (age, gender), comorbidities, prior UTI history, and hospitalization status were recorded. Antimicrobial resistance patterns, MDR prevalence, and MRSA rates were compared across age groups. Sample size calculation using Epi-Info assumed a baseline MDR prevalence of 30%, a desire to detect a 15% absolute difference between age groups with 95% confidence and 80% power; the resulting minimum sample size was 210, and 240 positive culture cases were targeted to allow for dropouts.

Statistical analysis used chi-square test for categorical variables and analysis of variance for continuous variables; $p < 0.05$ was considered significant.

Results: Table 1. Demographic and Clinical Profile by Age Group

Variable	Pediatric (n = 62)	Adult (n = 128)	Elderly (n = 50)	p-value
Mean age (years)	9.6 ± 4.2	34.7 ± 10.8	68.3 ± 6.4	—
Female sex n (%)	38 (61.3)	82 (64.1)	28 (56.0)	0.54
Prior UTI history (%)	14 (22.6)	38 (29.7)	19 (38.0)	0.09
Hospitalized at presentation (%)	5 (8.1)	22 (17.2)	18 (36.0)	<0.001

Elderly patients more frequently required hospitalization compared with younger groups.

Table 2. Antimicrobial Resistance Patterns of Gram-negative Uropathogens by Age Group

Antibiotic (or class)	Pediatric (%) resistant	Adult (%) resistant	Elderly (%) resistant	p-value
Ampicillin	78.2	84.4	89.5	0.12
Ceftazidime (3rd gen ceph.)	34.8	45.3	62.0	<0.001
Ciprofloxacin (fluoroquinolone)	26.1	39.8	57.5	<0.001
Trimethoprim-sulfamethoxazole	49.1	56.3	64.0	0.04
Nitrofurantoin	18.3	22.7	28.0	0.21

Resistance to ceftazidime and ciprofloxacin rose significantly with increasing age.

Table 3. MDR and MRSA Prevalence Across Age Groups

Parameter	Pediatric	Adult	Elderly	p-value
MDR among all isolates (%)	29.0	42.2	56.0	<0.001

Parameter	Pediatric	Adult	Elderly	p-value
MRSA among Staph. aureus isolates (%)	11.3	16.4	28.0	0.02
Total MRSA-positive UTI cases (%)	7 (11.3%)	21 (16.4%)	14 (28.0%)	0.02

A clear age-dependent increase in both MDR and MRSA prevalence was observed.

In summary, the data reveal that elderly UTI patients demonstrated the highest rates of resistance to key antibiotics (including third-generation cephalosporins and fluoroquinolones), the greatest burden of multidrug resistance, and the highest prevalence of MRSA among S. aureus isolates.

Discussion: This study provides compelling evidence that antimicrobial resistance (AMR) and MRSA prevalence in urinary tract infections (UTIs) in Pakistan vary markedly with patient age, with the elderly population disproportionately affected by resistant and multidrug-resistant pathogens. The finding of a stepwise increase in resistance rates — particularly for third-generation cephalosporins and fluoroquinolones — from pediatric to adult to elderly cohorts suggests that age-related factors such as cumulative antibiotic exposure, declining immune surveillance, increased hospitalization, and comorbidities may drive selection pressure favoring resistant isolates.[13-16]

The elevated rate of multidrug resistance (MDR) in elderly patients — over half of all isolates in that group — is particularly concerning. MDR status substantially limits empirical therapy options and increases the risk of treatment failure, complications, and recurrent infections. Given that nitrofurantoin remained relatively more effective across groups (though its absolute susceptibility decreased with age), empirical regimens for elderly patients may require reconsideration, possibly favoring agents with preserved activity or combination therapy guided by local antibiograms.[17-18]

The prevalence of MRSA among Staphylococcus aureus isolates also rose with age, reaching nearly 28% in the elderly cohort. This suggests that MRSA is not only a concern in hospital-associated UTIs but also in community-onset infections among older adults in Pakistan. The higher hospitalization rate in the elderly may contribute to exposure to healthcare-associated MRSA strains, but community dissemination cannot be excluded. These findings underscore

the need to include MRSA coverage when selecting empiric therapy for UTI in older patients, especially in settings with known high prevalence.[19-20]

The differences observed across age groups highlight the inadequacy of a "one-size-fits-all" empirical antibiotic policy. Age-stratified surveillance is imperative to guide empirical prescriptions — particularly in resource-limited settings with high AMR burden. For pediatric patients, lower resistance and MDR rates may justify narrower-spectrum agents, supporting stewardship efforts. For adults and especially elderly patients, broader coverage and early culture-guided therapy may reduce morbidity and prevent complications.

Moreover, the study underscores the urgent need for robust antimicrobial stewardship programs tailored to demographic groups, caution in empirical fluoroquinolone and cephalosporin use in older populations, and periodic updating of local antibiograms with age-disaggregated data. Implementation of such measures can help curb the further spread of resistant strains and optimize patient outcomes.

Finally, these findings should inform public health strategy and policy: free or subsidized culture and sensitivity testing, age-specific empirical therapy guidelines, and targeted education of prescribers and patients about prudent antibiotic use — particularly in elderly populations who often have comorbidities and repeated healthcare encounters.

Conclusion: Antimicrobial resistance and MRSA prevalence in urinary tract infections in Pakistan increase significantly with patient age, with the elderly group demonstrating the highest burden of multidrug-resistant and MRSA uropathogens. These age-related differences justify the adoption of age-specific empirical therapy protocols and reinforce the need for culture-guided treatment and robust antimicrobial stewardship. Integrating age-stratified surveillance into national UTI management strategies may substantially improve treatment efficacy and limit further resistance development.

References

1. Andaleeb H, Zia W, Shahid A, et al. Spectrum of Antimicrobial Susceptibility Pattern of Urinary Tract Infection in Adults. Pakistan BioMedical Journal. 2023;5(8):751.
2. Tara T, Ullah A, Haq IU, et al. Frequency and Susceptibility Profile of Pathogens Causing Urinary Tract Infection at Tertiary Care Hospital, Peshawar, Pakistan. Ann Allied Health Sci. 2022;…

3. Badshah H, Ali S, Hamid T, ur Rahman S. Anti-microbial Resistance and Sensitivity Patterns of E. coli among Adult UTI Patients at DHQ Hospital Orakzai, Khyber Pakhtunkhwa, Pakistan. Journal of Population Therapeutics and Clinical Pharmacology. 2023;…
4. Sohail A, Nabi S, Latif F, et al. Antimicrobial Resistance in Urinary Tract Infection Patients: A Cross-Sectional Study from District Swabi, KPK, Pakistan. Frontier in Medical & Health Research. 2025;3(8):1269.
5. Manzoor A, Ahmed T, Batool S, et al. Susceptibility Pattern of Pediatric Uropathogens: Insights from Mirpur AJK, Pakistan. Infectious Diseases Journal of Pakistan. 2023;33(2):283.
6. Shehzad N, Bacha UA, Alina U, Nasar J, Javed A. Prevalence of Multidrug Resistant Escherichia coli among Urinary Tract Infection Patients in Rawalpindi and Islamabad, Pakistan. National Journal of Life and Health Sciences. 2023;2(2):63.
7. Niaz S, Khalid A, Niaz S. Prevalence of Urinary Tract Infections and Antibiotic Resistance Patterns in Diabetic Patients in Pakistan. Journal of Health, Wellness and Community Research. 2024;…
8. Damman K, Valente MA, Voors AA, et al. Renal Impairment, Worsening Renal Function, and Outcome in Patients with Heart Failure. Eur Heart J. 2021;42(15):1479–1489.
9. Rangaswami J, Bhalla V, Blair JE, et al. Cardiorenal Syndrome: Classification, Pathophysiology, Diagnosis, and Treatment Processes. Kidney Int. 2021;99(4):815–834.
10. House AA, Wanner C, Sarnak MJ, et al. Heart Failure in CKD: Pathophysiology, Diagnosis, and Treatment. Kidney Int. 2022;101(3):546–567.
11. Beldhuis IE, Lam CSP, Testani JM, et al. Diuretic Response in Heart Failure: Clinical and Prognostic Implications. Circ Heart Fail. 2022;15(1):e009095.
12. Ferreira JP, Kraus S, Mitchell S, et al. Worldwide Epidemiology of Chronic Kidney Disease in Heart Failure. Heart. 2023;109:895–902.
13. Testani JM, Hanberg JS, Cheng S, et al. Rapid and Highly Effective Loop Diuretic Response Predicts Better Outcomes in Acute Heart Failure. J Card Fail. 2021;27:54–62.
14. Costanzo MR, Ronco C. Mechanisms and Management of Congestion in Heart Failure. Crit Care. 2023;27:41.
15. Metra M, Cotter G, Davison B, et al. Worsening Renal Function in Acute Heart Failure. Eur J Heart Fail. 2022;24:1211–1223.
16. McDonagh TA, Metra M, Adamo M, et al. Heart Failure Pathophysiology and Diagnosis. Eur Heart J. 2022;43:2129–2200.

17. Savarese G, Carrero JJ, Pitt B, et al. Kidney Function Trajectories in Heart Failure. Eur Heart J. 2023;44:421–432.
18. Verbrugge FH, Dupont M, Steels P, et al. The Kidney in Congestive Heart Failure: A Clinician's Guide. Cardiology. 2023;148:76–89.
19. Manolis AS, Manolis TA. Cardiorenal Interaction in Heart Failure: Clinical Insights. Curr Vasc Pharmacol. 2022;20:195–207.
20. Mullens W, Martens P, Forouzan O. Diuretic Strategies in Cardiorenal Syndrome. Clin Res Cardiol. 2023;112:763–775.