

Antimicrobial Susceptibility Patterns of Uropathogens in Tertiary Care Hospital: A Two Year Retrospective Analysis

Nabin Gyawali,¹ Rohan Sapkota,¹ Gaurav Singh,¹ Mallika Acharya,¹ Krisha Sapkota,¹ Gaurav Joshi,¹ Raunak Bista,² Sanjaya Mani Dixit³

¹Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal, ²Department of Community Medicine, Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal, ³Department of Pharmacology, Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal.

ABSTRACT

Introduction: Urinary tract infections are global health concerns requiring empirical antibiotic therapy. The increasing cases of antimicrobial resistance in developing countries, such as Nepal, are a challenge to standard treatment protocols. This study aims to determine the prevalence, antimicrobial susceptibility patterns and two-year trend of uropathogens at Kathmandu Medical College Teaching Hospital.

Methods: A retrospective cross-sectional study was conducted using 1,410 culture-positive urine samples collected between April 2023 and April 2025. The antimicrobial susceptibility was determined using the Kirby-Bauer disc diffusion method as per Clinical and Laboratory Standards Institute guidelines. The data were statistically analysed using IBM SPSS version 26.0.

Results: Out of 1,410 culture-positive samples, *Escherichia coli* was isolated in 912 (64.68%) and *Klebsiella pneumoniae* in 231 (16.38%). Multidrug resistance was detected in 661 (46.88%) isolates; males were 258 (62.02%) and females were 403 (40.54%). *Escherichia coli* demonstrated resistance to cefixime in 516 (58.04%) and ciprofloxacin in 83 (52.87%) isolates.

Conclusions: *Escherichia coli* continues to be the most common uropathogen and the two-year antimicrobial susceptibility trends show that nitrofurantoin is still useful in uncomplicated cases despite increasing resistance trends.



doi: 10.31729/jnma.v64i299.9543

Submission Date: April 27, 2026

Reviewed Date: June 8, 2026

Accepted Date: June 26, 2026

Published Date: June 30, 2026

Correspondence:

Name: Nabin Gyawali

Affiliation: Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal

Email: imnabin77@gmail.com

Phone: +977-9866407538



Keywords: antimicrobial resistance; *escherichia coli*; multidrug resistance; nitrofurantoin; uropathogens.

INTRODUCTION

Urinary tract infections (UTIs) are huge health problem with an estimated 150 million cases worldwide and cost exceeding \$6 billion annually.^{1,2} The most common causative organisms are *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*.² Increasing antimicrobial resistance (AMR) caused by over-the-counter access and changing local bacterial susceptibility patterns, severely limits the success of routine empirical treatments.^{3,4}

Despite evidence of the emergence of AMR in uropathogens,^{5,6} data on the institution-specific longitudinal antibiogram from tertiary hospitals in Kathmandu is lacking. Previous studies have not provided resistance trend data for two years and lack analysis of multidrug resistance (MDR) trends for select demographic subgroups. Empirical prescribing is less accurate in the absence of local antimicrobial resistance data, leading to an increase in overall antimicrobial resistance.⁷

This study maps the prevalence and two-year resistance trends of uropathogens at a tertiary care hospital in Kathmandu, providing evidence to tailor empirical treatments, support antimicrobial

stewardship, and improve patient outcomes.

METHODS

This retrospective cross-sectional study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Secondary data were collected from the official digital records of Microbiology Laboratory, Kathmandu Medical College Teaching Hospital (KMCTH), Kathmandu, Nepal from April 2023 to April 2025. The census sampling method was used where all culture positive urine samples received by KMCTH Microbiology Laboratory from in-patients and out-patients during the study period were screened for eligibility. Samples were included if they demonstrated significant bacteriuria ($\geq 10^5$ CFU/mL) with a single organism isolated and complete bacterial identification. Samples with mixed bacterial growth, insignificant or sterile cultures, duplicate isolates from the same patient during a single episode of infection, or missing susceptibility results of the tested antibiotics were excluded. Individual missing susceptibility

values due to selective organism-based testing protocols were kept and are shown as not tested ('--') in the tables. Two investigators under the supervision of the senior co-investigator extracted the data from the laboratory's digital records and a second investigator cross-checked the compiled data set with the source records before analysis. Before analysing, all patient identifiers were removed and the data were kept in a password protected folder, which only the research team could access. A total of 1,410 bacterial isolates were eligible and used for final analysis.

The results of antimicrobial susceptibility testing were interpreted according to the guidelines of the Clinical and Laboratory Standards Institute (CLSI).⁸ Multidrug resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories, as per the international consensus criteria of Magiorakos et al.⁹ Isolates that were intermediately susceptible were reclassified as resistant for conservative estimates of clinical therapeutic failure, which comprised less than 0.5% of all interpretations and did not greatly influence the overall resistance estimates. Ethical approval was obtained from the Institutional Review Committee (IRC) of Kathmandu Medical College Public Ltd. (reference number: 15102025/15). The data were analysed with IBM SPSS Statistics (version 26.0). Categorical variables are expressed as frequencies and percentages. The chi-square test was used to examine associations between categorical variables. Statistical significance was set at $p < 0.05$.

was 112 (12.98%), amikacin 137 (15.10%), and meropenem 41 (4.59%), while resistance to cefixime was 516 (58.04%) and ciprofloxacin 83 (52.87%). Among *Klebsiella pneumoniae*, resistance to meropenem was 42 (18.67%) and amikacin 79 (35.11%), while ciprofloxacin resistance was 61 (80.26%). Among *Pseudomonas aeruginosa*, resistance to piperacillin-tazobactam was 11 (13.41%), meropenem 12 (15.00%), and amikacin 17 (20.99%) (Table 2).

Multidrug resistance was identified in 661 (46.88%) isolates. Among male patients, multidrug resistance was present in 258 (62.02%) and among female patients in 403 (40.54%) ($\chi^2=56.78$, $df=1$, $p<0.001$). Among patients aged 65 years and above, multidrug resistance was present in 149 (58.89%), in the 19-64 years age group in 443 (44.04%), and in the 0-18 years group in 69 (45.70%) ($\chi^2=20.45$, $df=2$, $p<0.001$). Among *Escherichia coli*, multidrug resistance was present in 393 (43.10%), *Klebsiella pneumoniae* in 120 (51.90%), and *Pseudomonas aeruginosa* in 31 (36.50%) isolates. The distribution of multidrug resistance by demographic variables and major uropathogens is presented in Table 3.

Multidrug-resistant isolates were 255 (40.10%) in 2023-24 AD and 406 (52.45%) in 2024-25 AD. In *Escherichia coli*, resistance to nitrofurantoin was 19 (4.80%) in 2023-24 AD and 93 (19.91%) in 2024-25 AD. In *Klebsiella pneumoniae*, piperacillin-tazobactam resistance was 12 (52.17%) in 2023-24 AD and 28 (84.85%) in 2024-25 AD.

Table 1. Distribution of uropathogens by gender and age group (N = 1410).

Microorganism	Female n(%)	Male n(%)	0–18 yrs n	19–64 yrs n	≥65 yrs n	Total n(%)
<i>E. coli</i>	710(71.43)	202(48.56)	90	661	161	912(64.68)
<i>K. pneumoniae</i>	152(15.29)	79(18.99)	29	162	40	231(16.38)
<i>P. aeruginosa</i>	32(3.22)	53(12.74)	7	65	13	85(6.03)
<i>K. oxytoca</i>	37(3.72)	22(5.29)	10	36	13	59(4.18)
<i>Enterococcus</i> spp.	23(2.31)	23(5.53)	10	26	10	46(3.26)
<i>A. baumannii</i>	12(1.21)	13(3.12)	1	21	3	25(1.77)
<i>C. freundii</i>	6(0.60)	11(2.64)	1	7	9	17(1.21)
Other organisms*	22(2.21)	13(3.12)	3	28	4	35(2.48)

*Others include *Proteus mirabilis*, *Enterobacter species*, coagulase-negative *Staphylococcus*, *Citrobacter koseri*, *Staphylococcus aureus*, and *Proteus vulgaris*.

RESULTS

During the study period from April 2023 to April 2025, 1410 culture-positive urine samples were included in the analysis. Of these, 994 (70.50%) samples were from female and 416 (29.50%) samples were from male. The mean age of the study population was 44.20 ± 18.50 years. Based on age group, 1006 (71.35%) isolates were from the population aged 19-64 years, 253 (17.94%) were from the population aged 65 years and above, and 151 (10.71%) were from the population aged 0-18 years.

Escherichia coli was isolated in 912 (64.68%) cases, *Klebsiella pneumoniae* in 231 (16.38%) cases, *Pseudomonas aeruginosa* in 85 (6.03%) cases, *Klebsiella oxytoca* in 59 (4.18%) cases, and *Enterococcus species* in 46 (3.26%) cases (Table 1).

Among *Escherichia coli* isolates, resistance to nitrofurantoin

In *Pseudomonas aeruginosa*, meropenem resistance was 2 (4.26%) in 2023-24 AD and 10 (30.30%) in 2024-25 AD, and piperacillin-tazobactam resistance was 2 (4.35%) and 2 (25.00%). In *Klebsiella oxytoca*, ciprofloxacin resistance was 1 (33.33%) in 2023-24 AD and 11 (91.67%) in 2024-25 AD, and meropenem resistance was 1 (4.55%) and 12 (32.43%). The year-to-year resistance comparison for selected organism-antibiotic pairs is presented in Table 4.

DISCUSSION

This study is a two-year retrospective study of 1410 culture positive urine samples collected in Kathmandu Medical College Teaching Hospital (KMCTH). The analysis shows an interesting change in antimicrobial resistance trends in Kathmandu valley.

Table 2. Antibiotic resistance pattern of major uropathogens (N=1410).

Antibiotic	<i>E. coli</i> R/N (%R)	<i>K. pneumoniae</i> R/N (%R)	<i>P. aeruginosa</i> R/N (%R)	<i>K. oxytoca</i> R/N (%R)	<i>Enterococcus</i> spp. R/N (%R)
Amikacin	137/907(15.10)	79/225(35.11)	17/81(20.99)	14/58(24.14)	25/43(58.14)
Amoxycillin-Clavulanic Acid	298/880(33.86)	97/207(46.86)	5/6(83.33)	26/53(49.06)	17/37(45.95)
Ampicillin-Sulbactam	364/638(57.05)	59/88(67.05)	0/1(0)	17/19(89.47)	0/1(0)
Cefixime	516/889 (58.04)	146/221(66.06)	3/6(50)	45/57 (78.95)	4/7 (57.14)
Ceftriaxone	391/876 (44.63)	110/217 (50.69)	2/4 (50)	35/55 (63.64)	4/8 (50)
Ceftazidime	48/51(94.12)	53/54(98.15)	46/77(59.74)	12/13(92.31)	--
Ciprofloxacin	83/157(52.87)	61/76(80.26)	36/79(45.57)	12/15(80)	28/35(80)
Meropenem	41/893(4.59)	42/225(18.67)	12/80(15.00)	13/59(22.03)	5/12(41.67)
Nitrofurantoin	112/863(12.98)	114/220(51.82)	16/20(80)	26/55(47.27)	13/35(37.14)
Piperacillin-Tazobactam	32/56(57.14)	40/56(71.43)	11/82(13.41)	9/12(75)	--
Polymyxin-B	0/61(0)	0/60(0)	3/78(3.85)	0/13(0)	--
Colistin	0/61(0)	0/61(0)	3/66(4.55)	0/14(0)	--

Note: R/N = number resistant/number tested; %R = percentage resistant Percentages are calculated based on the number of isolates tested for each antimicrobial agent. The denominator(N) varies by antibiotic according to selective testing protocols. – indicates antibiotic not routinely tested for this organism; "--" : not tested.

Table 3. Multidrug Resistance(MDR) status by demographic variables and microorganism (N=1,410).

Variable	Non-MDR n(%)	MDR n(%)
Gender		
Female (n=994)	591(59.46)	403(40.54)
Male (n=416)	158(37.98)	258(62.02)
Age Group		
0–18 years (n=151)	82(54.30)	69(45.70)
19–64 years (n=1,006)	563(55.96)	443(44.04)
≥65 years (n=253)	104(41.11)	149(58.89)
Microorganism		
<i>E. coli</i> (n=912)	519(56.91)	393(43.09)
<i>K. pneumoniae</i> (n=231)	111(48.05)	120(51.95)
<i>P. aeruginosa</i> (n=85)	54(63.53)	31(36.47)
<i>K. oxytoca</i> (n=59)	23(38.98)	36(61.02)
<i>Enterococcus</i> spp. (n=46)	6(13.04)	40(86.96)
<i>A. baumannii</i> (n=25)	8(32.00)	17(68.00)

Table 4. Year-to-Year Resistance Comparison for Selected Organism-Antibiotic Pairs.

Microorganism	Antibiotic	2023-24 AD(Resistant/Tested, %)	2024-25 AD(Resistant/Tested, %)
<i>Escherichia coli</i>	Nitrofurantoin	19/396(4.80)	93/467(19.91)
<i>Escherichia coli</i>	Cefixime	218/395(55.19)	298/494(60.32)
<i>Escherichia coli</i>	Ciprofloxacin	12/29(41.38)	71/128(55.47)
<i>Klebsiella pneumoniae</i>	Piperacillin-Tazobactam	12/23(52.17)	28/33(84.85)
<i>Klebsiella pneumoniae</i>	Meropenem	14/100(14.00)	28/125(22.40)
<i>Pseudomonas aeruginosa</i>	Meropenem	2/47(4.26)	10/33 (30.30)
<i>Pseudomonas aeruginosa</i>	Piperacillin-Tazobactam	2/46(4.35)	9/36(25.00)
<i>Klebsiella oxytoca</i>	Ciprofloxacin	1/3(33.33)	11/12(91.67)
<i>Klebsiella oxytoca</i>	Meropenem	1/22(4.55)	12/37(32.43)

Note: Numerators and denominators reflect the number of isolates resistant and total tested for each antibiotic in each year; "--" : not tested.

One of the important results of this study is the significant variability in the effectiveness of common antimicrobial drugs.

Although *Escherichia coli* is the most common uropathogen (64.68%), the resistance to nitrofurantoin which is the first choice

for treating simple urinary tract infection (UTI) in Nepal, is declining rapidly,⁶ with a 4-fold increase in resistance from 4.80% (2023-24 AD) to 19.91% (2024-25 AD). At the same time, there has been a significant rise in carbapenem resistance, from 4.26% to 30.30%, in *Pseudomonas aeruginosa* over the

time period. These trends suggest that the current clinical care based on historical susceptibility data may be suboptimal for clinical outcomes and safety.

The demographic composition of the sample, with females accounting for 70.5% of culture-positive specimens, is broadly consistent with what has been reported in Nepal and the wider region. Thapa et al., for instance, documented a 69.5% female proportion in a central Nepali cohort.⁶ This is not definitive evidence of differences in prevalence between males and females, but existing literature suggests that the higher prevalence of UTIs in women is generally due to differences in anatomy, e.g. the short urethra in females being closer to the anal region.^{2,6}

For antimicrobial resistance, the data clearly shows that there is a difference in MultiDrug-Resistance (MDR) percentages between male and female. While a greater number of female patients were sampled, a significantly larger percentage of MDR organisms were detected among males. In particular, male patients were found to be more likely to have MDR organisms (62.02% versus 40.54% in females). This finding is consistent with the results of Shakya et al., who reported higher MDR rates in males at another center in Kathmandu.¹⁰ These mechanistic explanations are only hypotheses, however, and should be confirmed with future multivariable studies because the current analysis was univariate and unadjusted for potential confounding factors; uropathogenic bacteria can be incorporated as a separate category within male UTIs, as can urinary tract instrumentation or incomplete bladder emptying, which are known to lead to increased MDR.¹¹⁻¹³ The prostate may also serve as a sanctuary site for uropathogenic bacteria, which can also be categorized separately as a risk factor for increased MDR, and indwelling instruments can promote the growth of biofilms, which is a bacterial community intrinsically resistant to antibiotic penetration and immune clearance.^{14,15}

The most common uropathogens at KMCTH are *E. coli* (64.68%), then *Klebsiella pneumoniae* (16.38%) and *Pseudomonas aeruginosa* (6.03%) which is similar to other hospitals in the South Asian region.^{16,17} However, the resistance profiles of *E. coli* against oral cephalosporins and fluoroquinolones demonstrate a concerning upward trajectory. The resistance to Cefixime and Ciprofloxacin were found to be 58.04% and 52.87% respectively. These results indicate that oral cephalosporins are of limited value for empirical treatment of UTIs at our institution. The guidelines for the treatment of infectious diseases by the Infectious Diseases Society of America (IDSA) state that antibiotic treatment should not be administered empirically when the local resistance rate exceeds 20%.¹⁸ Our data shows that Cefixime and Ciprofloxacin have surpassed this limit. This is a high resistance which echoes the “post-fluoroquinolone” era mentioned in the recent literature from Nepal. Thapa et al. reported similar resistance levels (32.67% to ciprofloxacin) in central Nepal, whereas Basnet et al. observed that cephalosporin resistance increased over a decade.^{6,19} The reasons are numerous, including unrestricted over-the-counter availability and unregulated agricultural use.⁴ Consequently, the empirical use of Cefixime or Ciprofloxacin is associated with a

high probability of therapeutic failure and is not recommended based on local antibiograms.

Perhaps the most clinically important finding from this study is how quickly nitrofurantoin is losing its effectiveness. For years, it has served as the first-line drug for uncomplicated cystitis in Nepal, largely because resistance stayed under 10%.²⁰ Our 2023–24 data (4.80% resistance) fit that pattern well. But in 2024–25, resistance in *E. coli* jumped to 19.91%, a shift too large to dismiss. That figure is notably higher than the 12.15% resistance reported nearby by Thapa et al.⁶ One plausible driver is rising selective pressure from antimicrobial use.^{4,21} As ciprofloxacin and cefixime have become less reliable, clinicians have leaned on nitrofurantoin more heavily as a first-choice oral agent. High-level resistance like this usually traces back to mutations in the *nfxA* and *nfxB* genes,^{22,23} and frequent use combined with incorrect dosing only speeds up selection for these resistant strains. Nitrofurantoin still works for most patients, but with resistance now approaching 20%, that margin is shrinking. If the trend holds, KMCTH may increasingly need to fall back on parenteral options like aminoglycosides, or costlier oral alternatives such as fosfomycin.²⁰ Taken together, these findings point to a clear need for stronger antimicrobial stewardship: nitrofurantoin should be reserved for uncomplicated cystitis only, not used for asymptomatic bacteriuria or upper urinary tract infections.

In the case of *Pseudomonas aeruginosa*, data suggest meropenem resistance increased to 30.30% in 2024–25 AD compared to 4.26% in 2023–24 AD. This increase in *Pseudomonas* resistance is also likely to be hospital-acquired through surfaces, equipment, or hands, unlike in *E. coli* where resistance is usually community-based.^{20,21} Fortunately, we found 100% susceptibility to Polymyxin B and Colistin, rendering these agents the definitive therapeutic option for Extensively Drug-Resistant (XDR) isolates, despite their known safety profile.

However, Amikacin is still effective. *E. coli* and *P. aeruginosa* had a resistance rate of only 15.10% and 20.99% respectively. This can be compared to the recommendations of Sah et al., and Thapa et al., who suggest that aminoglycosides are very effective and underutilized drugs in Nepal.^{6,16} Amikacin is one of the main agents that can be used to spare carbapenems. It has low resistance, which makes it a rational option for patients with complicated UTIs requiring parenteral therapy who are not critically ill. Amikacin should be used in place of Ceftriaxone (which has >40% resistance) or Meropenem to reserve carbapenems for the most difficult cases. Amikacin is an injection that can be given once a day, which can also be administered at an outpatient clinic to save money. It should be used with caution though, and renal function monitored.⁷

Our study shows a high overall MDR rate of 46.88%. Although it is lower than the 75.66% reported by Pradhan et al. at TUTH, probably because TUTH is a central referral centre receiving the most refractory cases, it is still alarming.⁵ There is a definite change in the pattern of antimicrobial susceptibility in KMCTH in the last two years. The development of nitrofurantoin-resistant *E.*

coli jeopardizes the first-line treatment for uncomplicated UTIs and the rise of carbapenem-resistant *Pseudomonas aeruginosa* signifies an increasing problem with infection control. The data clearly suggest that Cefixime and Ciprofloxacin have very little empirical utility at this institution, and that their status as first line drugs should be formally re-evaluated. These findings underscore an urgent need for institutional review of antibiotic prescribing protocols. Amikacin should be the first choice parenteral agent in stable complicated UTIs, enabling a carbapenem-sparing strategy. Constant surveillance is vital and continuous resistance patterns may necessitate addition of other agents like Fosfomycin to the national protocols.

This study has several limitations. First, being a retrospective analysis of laboratory records, we could not precisely distinguish between community-acquired (CA-UTI) and hospital-acquired (HA-UTI) infections based on patient history. However, the high prevalence of organisms like *Pseudomonas* and *Acinetobacter* suggests many were hospital-acquired.^{6,12,24} Our age-stratified data show that the elderly suffer most from MDR. Patients aged 65 years and older had an MDR rate of 58.89%. This is likely due to weaker immune systems, frequent hospital visits, and a history of antibiotic use.²⁵

Second, molecular genotyping was not performed. Although the phenotypic patterns are strongly suggestive of ESBLs (indicated by Ceftazidime resistance) and Carbapenemases (indicated by Meropenem resistance), the specific resistance genes (e.g., bla-CTX-M or bla-NDM-1) cannot be confirmed without PCR analysis.²⁵ Third, this is a single-centre study and the findings may not be generalizable to smaller community hospitals or primary care centres in rural Nepal. Fourth, the study covers only two consecutive years, which limits the ability to establish long-term resistance trends. Future studies incorporating additional time points would provide more robust longitudinal data.

CONCLUSION

This two-year retrospective analysis describes the antimicrobial

susceptibility patterns of uropathogens at a tertiary care hospital. *Escherichia coli* emerged as the most prevalent uropathogen with high resistance rates found against cefixime and ciprofloxacin. Nitrofurantoin resistance in *E. coli* increased substantially over the two year study period, approaching the threshold that may limit its empirical utility. *Pseudomonas aeruginosa* demonstrated notable increases in resistance to meropenem and piperacillin-tazobactam.

Acknowledgment: The authors would like to express their sincere gratitude to the Department of Microbiology, Kathmandu Medical College Teaching Hospital, for providing access to laboratory data and for their continuous support throughout this research. We acknowledge the laboratory staff of the Microbiology Department for their meticulous work in bacterial culture and antimicrobial susceptibility testing, which made this study possible.

Authors' Contribution: **Nabin Gyawali:** Conceptualization, methodology, formal analysis, data curation, literature review, writing - original draft, writing - review & editing; **Rohan Sapkota:** Conceptualization, literature review, writing - original draft; **Gaurav Singh:** Methodology, literature review, writing - original draft, writing - review & editing; **Mallika Acharya:** Formal analysis, literature review, writing - original draft; **Krishna Sapkota:** Literature review, writing - original draft; **Gaurav Joshi:** Literature review, writing - original draft; **Raunak Bista:** Literature review, writing - review & editing; **Sanjaya Mani Dixit:** Conceptualization, supervision, validation.

Conflict of Interest: None.

Data Availability Statement: The data are available from the corresponding author upon reasonable request.

Ethical Consideration: Ethical issues (including plagiarism, data fabrication, and double publication) have been completely observed by the authors

Funding: None.

REFERENCES

1. Zeng Z, Zhan J, Zhang K, Chen H, Cheng S. Global, Regional, and National burden of Urinary Tract Infections From 1990 to 2019: An Analysis of the Global Burden of Disease Study 2019. *World J Urol.* 2022 Jan;40(3):755-763. DOI: [10.1007/s00345-021-03913-0](https://doi.org/10.1007/s00345-021-03913-0)
2. Amiri F, Safiri S, Aletaha R, Sullman MJM, Hassanzadeh K, Kolahi AA, et al. Epidemiology of Urinary Tract Infections in the Middle East and North Africa, 1990-2021. *Trop Med Health.* 2025 Feb 5;53(1):16. DOI: [10.1186/s41182-025-00692-x](https://doi.org/10.1186/s41182-025-00692-x)
3. Acharya KP, Wilson RT. Antimicrobial Resistance in Nepal. *Front Med (Lausanne).* 2019;6:105. DOI: [10.3389/fmed.2019.00105](https://doi.org/10.3389/fmed.2019.00105)
4. Ghimire K, Banjara MR, Marasini BP, Gyanwali P, Poudel S, Khatri E, et al. Antibiotics Prescription, Dispensing Practices and Antibiotic Resistance Pattern in Common Pathogens in Nepal: A Narrative Review. *Microbiol Insights.* 2023;16 DOI : [10.1177/11786361231167239](https://doi.org/10.1177/11786361231167239)
5. Pradhan MM, Sharma S, Poudyal S, Gnyawali D, Adhikari S, Chapagain S, et al. Prevalence and Antimicrobial Susceptibility of Multi-Drug Resistant Uropathogens in a Tertiary Hospital in Nepal: A One-Year Audit. *J Nepal Med Assoc.* 2025;63(287):523-8. DOI: <https://doi.org/10.31729/jnma.9129>
6. Thapa RB, Shrestha S, Adhikari P, Shrestha R. Antibiotic Resistance Patterns in Uropathogens: Insights From a Nepalese Tertiary Care Setting. *Ther Adv Infect Dis.* 2025;12:20499361251339383. DOI: [10.1177/20499361251339383](https://doi.org/10.1177/20499361251339383)
7. Ministry of Health and Population. National Antimicrobial Treatment Guidelines. Kathmandu, Nepal: Government of Nepal; 2023. Available from: <https://mohp.gov.np/content/149/national-antimicrobial-treatment-guideline-2023/>
8. CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 34th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; 2024. Available from: <https://clsi.org/shop/standards/m100/>
9. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, Extensively Drug-resistant

- and Pandrug-resistant bacteria: An International Expert Proposal for Interim Standard Definitions for Acquired Resistance. *Clin Microbiol Infect.* 2012;18(3):268-81. DOI: [10.1111/j.1469-0691.2011.03570.x](https://doi.org/10.1111/j.1469-0691.2011.03570.x)
10. Shakya S, Edwards J, Gupte HA, Shrestha S, Shakya BM, Parajuli K, et al. High Multidrug Resistance in Urinary Tract Infections in a Tertiary Hospital, Kathmandu, Nepal. *Public Health Action.* 2021;11(Suppl 1):24-31. DOI: [10.5588/pha.21.0035](https://doi.org/10.5588/pha.21.0035)
11. Lipsky BA, Byren I, Hoey CT. Treatment of Bacterial Prostatitis. *Clin Infect Dis.* 2010;50(12):1641-52. DOI: [10.1086/652861](https://doi.org/10.1086/652861)
12. Tenke P, Köves B, Nagy K, Hultgren SJ, Mendling W, Wullt B, et al. Update on Biofilm Infections in the Urinary Tract. *World J Urol.* 2012;30(1):51-7. DOI: [10.1007/s00345-011-0689-9](https://doi.org/10.1007/s00345-011-0689-9)
13. Panagopoulos P, Antoniadou A, Kanellakopoulou K, Tsiodras S, Katsarolis I, Papadopoulos A, et al. Fluoroquinolone Treatment of Chronic Bacterial Prostatitis: A Prospective Cohort Study. *J Chemother.* 2009;21(3):317-21. DOI: [10.1179/joc.2009.21.3.317](https://doi.org/10.1179/joc.2009.21.3.317)
14. Donlan RM. Biofilms and Device-Associated Infections. *Emerg Infect Dis.* 2001;7(2):277-81. DOI: [10.3201/eid0702.010226](https://doi.org/10.3201/eid0702.010226)
15. Trautner BW, Darouiche RO. Role of Biofilm in Catheter-Associated Urinary Tract Infection. *Am J Infect Control.* 2004;32(3):177-83. DOI: [10.1016/j.ajic.2003.08.005](https://doi.org/10.1016/j.ajic.2003.08.005)
16. Sah BK, Dahal P, Mallik SK, Paul AD, Mainali U, Shah C, et al. Uropathogens and Their Antimicrobial-Resistant Pattern Among Suspected Urinary Tract Infections Patients in Eastern Nepal: A Hospital Inpatients-Based Study. *SAGE Open Med.* 2023;11:20503121231220821. DOI: [10.1177/20503121231220821](https://doi.org/10.1177/20503121231220821)
17. Bajracharya S, Basnet A, Pokhrel N, Gupta A, Khanal LK. Uropathogens and Their Antimicrobial Resistance Profile at a Pediatric Tertiary Care Hospital in Kathmandu, Nepal. *Am J Trop Med Hyg.* 2025;112(6):1245-51. DOI: [10.4269/ajtmh.24-0624](https://doi.org/10.4269/ajtmh.24-0624)
18. Gupta K, Hooton TM, Naber KG, Wullt B, Colgan R, Miller LG, et al. International Clinical Practice Guidelines for the Treatment of Acute Uncomplicated Cystitis and Pyelonephritis in Women: A 2010 Update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. *Clin Infect Dis.* 2011;52(5):e103-20. DOI: [10.1093/cid/ciq257](https://doi.org/10.1093/cid/ciq257)
19. Basnet A, Shrestha A, Sharma GR, Shrestha S, Khanal LK, Rai JR, et al. A Decade-Long Analysis of Trends in Antimicrobial Resistance in a Neurosurgical Hospital in Kathmandu, Nepal. *Microbiol Immunol.* 2025;69(1):10-24. DOI: <https://doi.org/10.1111/1348-0421.13185>
20. Wagle S, Khanal BR, Tiwari BR. High Susceptibility of Fosfomycin to Uropathogenic *Escherichia coli* Isolated at Tertiary Care Hospital of Nepal. *J Adv Microbiol.* 2018;13(2):1-8. DOI: [10.9734/JAMB/2018/44514](https://doi.org/10.9734/JAMB/2018/44514)
21. Shrestha R, Khanal S, Poudel P, et al. Extended-Spectrum β -Lactamase Producing Uropathogenic *Escherichia coli* and the Correlation of Biofilm With Antibiotics Resistance in Nepal. *Ann Clin Microbiol Antimicrob.* 2019;18:42. DOI: [10.1186/s12941-019-0340-y](https://doi.org/10.1186/s12941-019-0340-y)
22. Whiteway J, Koziarz P, Veall J, Sandhu N, Kumar P, Hoecher B, et al. Oxygen-Insensitive Nitroreductases: Analysis of the Roles of *nfsA* and *nfsB* in Development of Resistance to 5-Nitrofurantoin Derivatives in *Escherichia coli*. *J Bacteriol.* 1998;180(21):5529-39. DOI: [10.1128/jb.180.21.5529-5539.1998](https://doi.org/10.1128/jb.180.21.5529-5539.1998)
23. Vallee M, Harding C, Hall J, Aldridge PD, Tan A. Exploring the In Situ Evolution of Nitrofurantoin Resistance in Clinically Derived Uropathogenic *Escherichia coli* Isolates. *J Antimicrob Chemother.* 2023;78(2):373-9. DOI: <https://doi.org/10.1093/jac/dkac398>
24. Adhikari RP, Khadka S, Rai SK. Antimicrobial Resistance Among *Pseudomonas aeruginosa* Isolated at a Tertiary Care Hospital, Nepal: A Descriptive Cross-sectional Study. *Nepal Med Coll J.* 2025;27(2):129-34. DOI: <https://doi.org/10.3126/nmcj.v27i2.80541>
25. Gomila A, Shaw E, Carratalà J, Leibovici L, Tebé C, Wiegand I, et al. Predictive Factors for Multidrug-resistant Gram-negative Bacteria Among Hospitalised Patients With Complicated Urinary Tract Infections. *Antimicrob Resist Infect Control.* 2018;7:111. DOI: [10.1186/s13756-018-0401-6](https://doi.org/10.1186/s13756-018-0401-6)