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Improving Antibiotic Prescribing for Urinary Tract Infections through Prospective Audit and Feedback: A Before–After Antimicrobial Stewardship Study in a Tertiary Care Hospital

Vishakha Jain

vishakhajain1079@gmail.com

All India Institute of Medical Sciences Bibinagar

S Siddharth Rao

All India Institute of Medical Sciences Bibinagar

Saaket Buddhiraju

All India Institute of Medical Sciences Bibinagar

Saiprasad Mishra

All India Institute of Medical Sciences Bibinagar

Tajnur Hossain

All India Institute of Medical Sciences Bibinagar

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Abstract

Background

Urinary tract infections (UTIs) are a leading indication for antimicrobial therapy and a common source of inappropriate prescribing. Prospective audit and feedback (PAF) is recommended by international stewardship guidelines, but syndrome-specific data integrating diagnostic and antimicrobial stewardship from resource-limited settings are scarce.

Methods

We conducted a prospective, quasi-experimental, three-phase (pre-intervention, intervention, post-intervention) study in adult inpatients with suspected or confirmed UTI at a tertiary care teaching hospital (100 patients/phase). During the intervention phase, a multidisciplinary team performed structured PAF within 24–48 hours of antibiotic initiation. Diagnostic stewardship, prescribing appropriateness, antimicrobial utilization (DOT, LOT, DDD), and clinical outcomes were compared across phases.

Results

Documentation of syndromic diagnosis (78% to 100%), pre-antibiotic urine culture (74% to 95%), and blood culture collection (16% to 48%) improved significantly (all $p < 0.05$). Appropriate antimicrobial use increased from 41% to 91% and culture-guided de-escalation from 6% to 27–28% ($p < 0.001$). Renal dose adjustment and compliance with institutional guidelines also improved significantly. Overall antimicrobial exposure (DOT) remained stable, while LOT and DDD declined modestly. Fever defervescence occurred earlier post-intervention ($p = 0.004$), while hospital stay, ICU stay, and mortality were unchanged. A greater proportion of catheter-associated UTIs and comorbidities were noted in later phases.

Conclusions

A syndrome-specific PAF intervention integrated with diagnostic stewardship produced sustained improvements in antimicrobial appropriateness and diagnostic practices without compromising clinical safety, supporting its feasibility in resource-limited hospital settings.

Introduction

Urinary tract infections (UTIs) are among the commonest bacterial infections encountered in hospital practice and a major indication for antimicrobial prescribing worldwide. They span a heterogeneous spectrum from asymptomatic bacteriuria and uncomplicated cystitis to complicated UTI, pyelonephritis,

catheter-associated UTI (CAUTI), and urosepsis. Escherichia coli remains the predominant uropathogens, although Klebsiella pneumoniae, Enterococcus spp., Pseudomonas aeruginosa, and other multidrug-resistant (MDR) organisms are increasingly encountered in hospitalized patients, particularly those with catheter- or healthcare-associated infection.

Despite this burden, UTIs are also among the syndromes most frequently associated with inappropriate antimicrobial use, including treatment of asymptomatic bacteriuria, unnecessary broad-spectrum empirical therapy, failure to obtain cultures before antibiotic initiation, and delayed de-escalation. An estimated 20–50% of antimicrobial prescriptions in hospitalized patients are unnecessary or inappropriate, contributing to antimicrobial resistance (AMR), which was associated with an estimated 4.95 million deaths globally in 2019, including 1.27 million directly attributable to resistant infections.

Contemporary antimicrobial stewardship programmes (ASPs), as recommended by the Infectious Diseases Society of America (IDSA), the Society for Healthcare Epidemiology of America (SHEA), and the World Health Organization (WHO), increasingly emphasize optimization of antimicrobial therapy rather than restriction alone, with diagnostic stewardship recognized as an essential complementary strategy. Among core stewardship interventions, prospective audit and feedback (PAF) is one of the most widely adopted and effective approaches: prescriptions are reviewed after initiation and individualized recommendations are provided to the treating team, preserving prescriber autonomy while functioning as an educational intervention.

Despite the availability of national and international UTI management guidelines, inappropriate prescribing remains common, particularly in resource-limited settings, where few studies have simultaneously evaluated diagnostic stewardship, antimicrobial stewardship, and clinical outcomes within a structured, syndrome-specific intervention. UTIs, with multiple discrete opportunities for stewardship input — microbiological evaluation, rational empirical therapy, renal dose optimization, and culture-guided de-escalation — provide a suitable model for such an evaluation.

We therefore conducted a prospective, three-phase study to evaluate the impact of a syndrome-specific, PAF-based antimicrobial stewardship intervention on diagnostic stewardship, antimicrobial prescribing quality and utilization, and clinical outcomes among hospitalized adults with UTI in a tertiary care teaching hospital.

Methods

Study design, setting, and duration

This prospective, quasi-experimental, before–during–after study was conducted over nine months (September 2025–May 2026) in the adult medical and surgical wards and intensive care units of a tertiary care teaching hospital in Telangana, India. The study comprised three sequential three-month phases: pre-intervention (baseline, no stewardship input), intervention (structured PAF), and post-intervention (routine practice after withdrawal of active feedback, to assess sustainability).

Study population

Adult inpatients (≥ 18 years) with clinically suspected or microbiologically confirmed UTI who were initiated on systemic antimicrobial therapy and had urine microscopy and/or culture requested were eligible. Patients with incomplete records, early discharge/transfer precluding evaluation, or an alternative final diagnosis were excluded. Only the first eligible UTI episode per admission was included. Consecutive eligible patients were enrolled prospectively (100 per phase, 300 total) based on an a priori sample size calculation (baseline appropriateness 40%, expected improvement to 55%, α = 0.05, power = 80%; minimum 98/phase).

Intervention

During the intervention phase, a multidisciplinary stewardship team (infectious diseases physician, microbiologist etc.) reviewed each eligible prescription within 24–48 hours of antibiotic initiation using a structured audit framework based on institutional policy, ICMR and IDSA guidelines, and the local antibiogram. Audited domains included clinical indication, syndromic documentation, empirical antibiotic choice and spectrum, dosing (including renal adjustment), route, duration, and appropriateness of microbiological workup. Recommendations — continuation, modification, escalation, de-escalation, discontinuation, dose optimization, or additional investigation — were communicated verbally to the treating team and documented in the medical record; acceptance was classified as accepted, partially accepted, or rejected. No stewardship review was performed during the pre- or post-intervention phases, which used identical data collection methods to the baseline phase.

Definitions and outcomes

Antimicrobial prescribing was classified as appropriate only if indication, agent selection, spectrum, dose (including renal adjustment), route, duration, and modification per culture results were all satisfied; any deviation was classified as inappropriate. Diagnostic stewardship indicators included syndromic documentation, pre-antibiotic urine/blood culture collection, and culture-guided modification. The primary outcome was the change in appropriateness of antimicrobial prescribing across phases. Secondary outcomes spanned diagnostic stewardship, antimicrobial utilization (Days of Therapy [DOT], Length of Therapy [LOT], Defined Daily Dose [DDD]), acceptance of recommendations, and clinical outcomes (clinical response, length of stay, readmission, mortality, and adverse events).

Statistical analysis and ethics

Data were analyzed in Jamovi (v2.7). Continuous variables were summarized as mean ± SD or median (IQR) per distribution (Shapiro–Wilk) and compared using Student's t-test or Mann–Whitney U test; categorical variables were compared using chi-square or Fisher's exact test. A two-sided $p < 0.05$ was considered significant; multiple comparisons were not formally corrected, and no multivariable

adjustment for the observed shift in case-mix (comorbidity burden, catheter exposure) across phases was performed. Antimicrobial utilization was benchmarked using WHO Defined Daily Dose methodology, with DOT and LOT calculated per 1000 patient-days to enable standardized comparison across phases. The study was approved by the Institutional Ethics Committee (approval no. AIIMS/BBN/IEC/October/2025/838, dated 23 October 2025), which granted a waiver of individual informed consent given the quality-improvement, standard-of-care nature of the intervention not altering routine clinical management. All patient data were anonymized and assigned unique study identifiers prior to analysis, and the study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice principles.

Results

A total of 300 patients (100 per phase) were included. The three cohorts were broadly comparable in age, sex, comorbidity burden, and severity of illness (APACHE II), although catheter-associated UTI increased significantly from the pre-intervention to the intervention phase (12% vs. 24%; p = 0.028), with parallel increases in chronic kidney disease and chronic liver disease documented by the post-intervention phase (Table 1). Documentation of syndromic diagnosis rose from 78% at baseline to 93% during intervention and 100% post-intervention (p = 0.003).

Table 1
Baseline demographic and clinical characteristics

Characteristic	Pre-intervention (n = 100)	Intervention (n = 100)	Post-intervention (n = 100)	p*
Age, years (mean ± SD)	48.8 ± 16.8	49.7 ± 16.3	49.3 ± 19.7	0.72
Female sex, n (%)	62 (62)	59 (59)	58 (58)	0.66
Diabetes mellitus, n (%)	30 (30)	33 (33)	38 (38)	0.65
Hypertension, n (%)	19 (19)	22 (22)	24 (24)	0.60
Chronic kidney disease, n (%)	9 (9)	11 (11)	28 (28)	0.64
Catheter-associated UTI, n (%)	12 (12)	24 (24)	21 (21)	0.028
Community-acquired UTI, n (%)	88 (88)	76 (76)	79 (79)	0.028
APACHE II score > 15, n (%)	8 (8)	15 (15)	19 (19)	0.12
Hospital length of stay, days (mean ± SD)	4.97 ± 1.73	5.10 ± 1.62	5.24 ± 1.81	0.58

Diagnostic stewardship improved markedly with the intervention: pre-antibiotic urine culture collection rose from 74% to 95% ($p < 0.001$), and blood culture collection nearly tripled from 16% to 48% ($p < 0.001$), both sustained post-intervention. These changes were accompanied by higher microbiological confirmation (positive urine cultures 18% to 35%, $p = 0.007$; positive blood cultures 6% to 24%, $p < 0.001$), while ultrasound KUB utilization fell significantly (97% to 74%, $p < 0.001$), consistent with more selective, guideline-based imaging (Table 2).

Table 2
Diagnostic stewardship indicators across study phases

Diagnostic stewardship indicator	**Pre-intervention (n = 100)**	**Intervention (n = 100)**	**Post-intervention (n = 100)**	**p***
Syndromic diagnosis documented, n (%)	78 (78)	93 (93)	100 (100)	0.003
Urine culture before antibiotics, n (%)	74 (74)	95 (95)	95 (95)	< 0.001
Blood culture before antibiotics, n (%)	16 (16)	48 (48)	39 (39)	< 0.001
Positive urine culture, n (%)	18 (18)	35 (35)	18 (18)	0.007
Positive blood culture, n (%)	6 (6)	24 (24)	13 (13)	< 0.001
Ultrasound KUB performed, n (%)	97 (97)	74 (74)	87 (87)	< 0.001

Renal dose adjustment at initiation increased from 13% to 27% during the intervention phase and to 31% post-intervention ($p = 0.013$). Among patients on a single empirical antibiotic, guideline concordance was high throughout (88.9% vs. 91.3%; $p = 0.72$), while documented justification for antibiotic choice improved from 74.1% to 98.6% ($p < 0.001$, not tabulated). Appropriate antimicrobial use rose from 41% to 72% during intervention and to 91% post-intervention ($p < 0.001$), with a corresponding fall in inappropriate use; culture-guided de-escalation increased nearly five-fold (6% to 28%, $p = 0.017$) and was sustained post-intervention. Total DOT/1000 patient-days remained stable across phases, whereas LOT and DDD declined modestly, indicating optimization rather than reduction of overall antimicrobial exposure (Table 3). During the intervention phase, the stewardship team most often recommended discontinuation of unnecessary antimicrobials (121 recommendations), de-escalation (66), and continuation of appropriate therapy (59), with the majority fully or partially accepted by treating teams.

Table 3
Antimicrobial prescribing appropriateness and utilization across study phases

Prescribing / utilization indicator	Pre-intervention (n = 100)	Intervention (n = 100)	Post-intervention (n = 100)	p*
Guideline-concordant single empirical antibiotic, n/N (%)	24/27 (88.9)	63/69 (91.3)	66/71 (93.0)	0.72
Renal dose adjustment performed, n (%)	13 (13)	27 (27)	31 (31)	0.013
Appropriate antimicrobial use, n (%)	41 (41)	72 (72)	91 (91)	< 0.001
Compliance with hospital antibiotic policy, n (%)	48 (48)	71 (71)	90 (90)	< 0.001
Culture-guided de-escalation, n (%)	6 (6)	28 (28)	27 (27)	0.017
Total DOT / 1000 patient-days	249.5	252.0	255.4	—
Total DDD / 1000 patient-days	234.4	211.7	207.5	—

Clinical outcomes were preserved despite intensified stewardship activity. Fever defervescence occurred significantly earlier in the intervention phase (3.18 ± 0.86 vs. 3.55 ± 0.95 days; p = 0.004), and clinical resolution by day 5 improved numerically (70% to 80–88%) without reaching significance. Hospital and ICU length of stay, mortality, adverse drug events, Clostridioides difficile infection, candidemia, and MDR organism prevalence remained comparable across phases. Thirty-day readmission increased during the intervention phase (0% vs. 6%; p = 0.029), coinciding with a greater proportion of catheter-associated and microbiologically confirmed infections in that cohort (Table 4).

Table 4
Clinical outcomes across study phases

Clinical outcome	Pre-intervention (n = 100)	Intervention (n = 100)	Post-intervention (n = 100)	p*
Clinical resolution by day 5, n (%)	70 (70)	80 (80)	88 (88)	0.10
Fever defervescence, days (mean ± SD)	3.55 ± 0.95	3.18 ± 0.86	2.91 ± 0.81	0.004
ICU length of stay, days (mean ± SD)	0.30 ± 1.41	0.36 ± 1.38	0.29 ± 1.24	0.76
30-day readmission, n (%)	0 (0)	6 (6)	5 (5)	0.029
In-hospital mortality, n (%)	2 (2)	1 (1)	2 (2)	1.0
ESBL-producing isolates, n (%)	2 (2)	4 (4)	6 (6)	0.68

Discussion

In this three-phase study, a syndrome-specific, PAF-based antimicrobial stewardship intervention produced substantial and largely sustained improvements in diagnostic evaluation, documentation, guideline-concordant prescribing, antimicrobial appropriateness, renal dose optimization, and culture-guided de-escalation among hospitalized patients with UTI, without adverse effects on major clinical outcomes. These findings support the growing consensus that the primary goal of antimicrobial stewardship is optimization — ensuring the right agent, dose, route, and duration — rather than indiscriminate reduction of antimicrobial use.

A notable feature of our intervention was its integration of diagnostic stewardship with antimicrobial stewardship. Improved documentation of syndromic diagnosis and increased pre-antibiotic culture collection translated into higher rates of microbiological confirmation, which in turn facilitated culture-guided de-escalation. This is consistent with the broader recognition that diagnostic accuracy underlies rational antimicrobial decision-making, and that stewardship interventions confined to antibiotic selection alone may overlook an important upstream determinant of prescribing quality. The concurrent reduction in non-selective ultrasound imaging further suggests that PAF influenced resource utilization more broadly than antimicrobial choice alone.

Despite marked improvements in prescribing quality, overall antimicrobial exposure (DOT) remained essentially unchanged across phases, while LOT and DDD declined modestly. This finding should not be interpreted as stewardship failure. DOT captures duration of exposure but not appropriateness, spectrum, or targeting of therapy. The intervention cohort included a significantly higher proportion of catheter-associated and microbiologically confirmed infections — generally warranting longer or more complex treatment — which plausibly offset reductions in antimicrobial exposure achieved through de-

escalation and discontinuation of unnecessary agents elsewhere. This distinction between antimicrobial optimization and antimicrobial reduction is central to contemporary stewardship practice and is reinforced by our data.

Reassuringly, improvements in prescribing quality were not associated with adverse clinical consequences. Hospital and ICU stay, mortality, adverse drug events, and MDR organism prevalence were comparable across phases, and fever resolved significantly earlier during the intervention phase — a plausible marker of more timely, appropriately targeted therapy. The higher 30-day readmission rate observed during the intervention phase requires cautious interpretation: it coincided with a more complex case-mix (more CAUTI and confirmed infection) and is based on small absolute numbers, limiting causal inference. This finding warrants confirmation in larger, risk-adjusted studies rather than attribution to the stewardship intervention itself.

The high proportion of stewardship recommendations that were accepted or partially accepted by treating teams — spanning discontinuation, de-escalation, continuation of appropriate therapy, and susceptibility-guided modification — underscores the acceptability of a collaborative, non-restrictive PAF model in a teaching hospital setting, and likely reflects its dual function as both a prescription-review mechanism and an educational intervention for trainees.

This study has important limitations. Its quasi-experimental, non-randomized, single-center design cannot fully exclude secular trends, seasonal variation across sequential three-month phases, or confounding from the observed shift toward a more comorbid and catheter-exposed patient population; adjusted or risk-stratified analyses were not performed. Multiple comparisons were not corrected for multiplicity, and the sample size, while adequate for the primary outcome, was underpowered for infrequent events such as mortality or C. difficile infection. As a single tertiary center, generalizability to other settings and case-mixes is uncertain.

Notwithstanding these limitations, our findings add to the limited evidence base from resource-constrained settings and demonstrate that a syndrome-specific, diagnostic-stewardship-integrated PAF programme is feasible, acceptable to clinicians, and capable of producing durable improvements in antimicrobial prescribing quality without compromising patient safety.

Several features distinguish this study from prior stewardship evaluations and merit emphasis. First, most published PAF studies report antimicrobial consumption as the principal metric of success; by simultaneously tracking diagnostic indicators, prescribing quality, utilization, and clinical safety, our data illustrate why consumption metrics alone can be misleading when case-mix evolves over time. Second, the persistence of improvements into the post-intervention phase — for syndromic documentation, culture collection, guideline compliance, and appropriate use — suggests that PAF may produce durable practice change and institutional learning rather than transient, feedback-dependent compliance, although a longer follow-up would be needed to confirm true sustainability beyond three months. Third, the high rate of acceptance of stewardship recommendations, even for discontinuation and de-escalation, indicates that a collaborative, advisory model can achieve meaningful prescribing change in a

teaching-hospital environment without resorting to restrictive or preauthorization-based strategies, which are often less acceptable to clinicians and trainees.

These findings have practical implications for stewardship programme design in similar settings. Embedding diagnostic stewardship prompts (timely culture collection, syndromic documentation) alongside antimicrobial review may yield larger downstream gains in appropriateness than antimicrobial-focused audit alone. Renal dose optimization, frequently under-emphasized in stewardship audits relative to agent selection, also improved substantially with structured review and merits routine inclusion in PAF checklists. Future work should test whether these gains can be maintained with reduced review intensity, whether electronic decision-support or automated flagging can reduce the manual workload of PAF, and whether similar approaches translate to other high-volume infectious syndromes and to multicenter settings with differing resistance patterns and staffing models. Randomized or stepped-wedge cluster designs, with risk-adjustment for case-mix, would strengthen causal inference beyond what a single-center before-after study can provide.

Conclusion

A structured, syndrome-specific prospective audit and feedback intervention, integrated with diagnostic stewardship, significantly improved documentation, microbiological evaluation, guideline-concordant and appropriate antimicrobial prescribing, renal dose optimization, and culture-guided de-escalation among hospitalized patients with urinary tract infection, with improvements largely sustained after withdrawal of active feedback. These gains were achieved without adverse effects on mortality, length of stay, or other major clinical outcomes, despite a more complex patient case-mix over time. Overall antimicrobial exposure was unchanged, reinforcing that PAF-based stewardship optimizes rather than simply restricts antimicrobial use. Wider adoption of multidisciplinary, syndrome-specific PAF programmes — combined with robust diagnostic stewardship and locally adapted treatment guidelines — may help strengthen antimicrobial stewardship in resource-limited tertiary care settings, though confirmation through randomized or risk-adjusted multicenter studies is needed.

Declarations

Funding

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Institutional Ethics Board Statement

Ethical approval was obtained from the Institutional Ethics Committee at All India Institute of Medical Sciences, Bibinagar, Hyderabad. IEC Ref No: AIIMS/BBN/IEC/October/2025/838, dated 23 October 2025.

Informed Consent Statement

Written informed consent was obtained from all participants (or their attendants, where applicable) prior to enrolment.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Author Contributions

Conceptualization —VJ, SSR; Methodology —VJ, SSR; Data curation — SB, SM, TG; Formal analysis — VJ, SB; Writing — original draft — VJ, SSR; Writing — review & editing — all authors. All authors read and approved the final manuscript.

Data Availability Statement

The de-identified dataset analysed in this study is available from the corresponding author on reasonable request, subject to institutional approval.

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