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Antimicrobial Prophylaxis Before Urodynamic Studies and Post-Procedure Urinary Tract Infection: A Critical Synthesis

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ABSTRACT

Background. Urodynamic study (UDS) is a low-pressure outpatient investigation widely used in the workup of lower urinary tract symptoms (LUTS), neurogenic bladder, and incontinence. Whether routine antimicrobial prophylaxis (AMP) reduces clinically meaningful post-procedure urinary tract infection (UTI) remains contested, and major guidelines disagree. The European Association of Urology (EAU) recommends against routine AMP for low-risk patients, while older American Urological Association (AUA) statements list UDS among procedures where AMP may be considered. **Objectives.** This work synthesizes the contemporary evidence (2018–2025) on AMP before UDS, distinguishes asymptomatic bacteriuria (ASB) from symptomatic UTI, and proposes a risk-stratified prophylaxis framework consistent with antimicrobial stewardship priorities. **Methods.** A structured narrative review was conducted across MEDLINE, Embase, and the Cochrane Library for randomized controlled trials (RCTs), prospective and retrospective cohort studies, and systematic reviews evaluating AMP versus placebo, no prophylaxis, or active comparator before UDS. Outcomes of interest were symptomatic UTI within 7–30 days, ASB, antimicrobial-related adverse events, and reported resistance signals. A risk-stratification scheme was synthesized inductively from study-level inclusion criteria. **Results.** Across pooled estimates, AMP reduced post-UDS bacteriuria but produced only a small and frequently non-significant reduction in symptomatic UTI in low-risk adults. Higher-risk subgroups neurogenic lower urinary tract dysfunction (NLUTD), recurrent UTI, immunosuppression, and indwelling-catheter dependence howed larger and more consistent benefits. **Conclusions.** Universal AMP before UDS is not justified for low-risk outpatients. A risk-stratified approach focusing prophylaxis on defined higher-risk groups, combined with pre-procedure dipstick screening and clear counselling on UTI symptoms, balances patient safety with stewardship objectives.

Keywords: Urodynamics; Urinary Tract Infection; Antimicrobial Prophylaxis; Antimicrobial stewardship; Lower Urinary Tract Symptoms; Bacteriuria; Functional Urology

1. Introduction

Urodynamic study (UDS) refers to a family of investigations including uroflowmetry, filling and voiding cytometry, pressure-flow analysis, and electromyography that objectively characterize lower urinary tract function. UDS is integral to the evaluation of refractory lower urinary tract symptoms (LUTS), urinary incontinence (UI), neurogenic lower urinary tract dysfunction (NLUTD), and selected pre-operative scenarios. Despite its low procedural risk, UDS requires transurethral catheterization,

which transiently introduces periurethral flora into the bladder and is the mechanistic basis for post-procedure urinary tract infection (UTI).

The clinical relevance of post-UDS UTI is twofold. First, even a small absolute risk—typically reported between 1.5% and 8% in contemporary series translates into a substantial cumulative burden given the high global volume of UDS performed annually. Second, mismanagement of this risk has stewardship consequences: routine antimicrobial prophylaxis (AMP) for an estimated millions of low-risk procedures contributes to community antimicrobial pressure, particularly with fluoroquinolones, whose use is now heavily restricted by regulatory agencies in Europe and North America [1,2].

Guideline disagreement reflects the unresolved nature of the underlying evidence. The European Association of Urology (EAU) Guidelines on Urological Infections recommend against routine AMP before UDS in patients without specific risk factors [1]. By contrast, the AUA/SUNA white paper on adult urodynamics endorses selective rather than routine prophylaxis but acknowledges practice variation and a residual evidence gap [3]. Meta-analyses published between 2022 and 2024 have generally favored AMP for the surrogate endpoint of bacteriuria but have failed to demonstrate a robust effect on symptomatic UTI in unselected populations [4,5].

This paper has three objectives. First, it critically synthesizes the evidence on AMP before UDS published predominantly between 2022 and 2025. Second, it argues that the conflation of asymptomatic bacteriuria (ASB) and symptomatic UTI is the principal source of misleading effect estimates in older literature.

Third, it proposes a pragmatic risk-stratified prophylaxis framework that aligns with the 2024 American Urological Association/Society of Urodynamics, Female Pelvic Medicine and Urogenital Reconstruction (AUA/SUFU) overactive bladder (OAB) guideline philosophy of shared decision-making and with antimicrobial stewardship principles [6,7]. The contribution is thus a decision-relevant, contemporary synthesis that explicitly separates surrogate from clinically meaningful endpoints and is intended to inform local protocol design rather than replicate existing meta-analyses.

2. Literature review and background

2.1. Epidemiology of post-UDS UTI

Reported post-UDS UTI rates vary widely across studies, driven less by procedural differences than by inconsistent endpoint definitions. Older series, often relying on pre- and post-procedure urine cultures, conflated ASB with clinically meaningful UTI and yielded inflated incidence figures. Contemporary cohorts using symptomatic endpoints—dysuria, frequency, suprapubic pain, fever, or new urge incontinence accompanied by positive urine culture or dipstick report rates between 1.5% and 4% in unselected adults [4,8]. Series enriched with patients with NLUTD, indwelling catheters, or recurrent UTI report rates of 6%–12% [9,10].

Risk factors that consistently emerge across the literature include female sex, post-menopausal status, history of recurrent UTI, NLUTD (particularly multiple sclerosis and spinal cord injury), elevated post-void residual (PVR), pre-procedure ASB, immunosuppression, and diabetes mellitus [8–11]. Procedural factors such as duration of catheterization, number of catheter passes, and use of suprapubic pressure transducers contribute marginally.

2.2. Microbiology and the bacteriuria–UTI distinction

The dominant uropathogens recovered after UDS mirror those of community-acquired UTI: Escherichia coli accounts for 50%–70%, followed by Klebsiella pneumoniae, Enterococcus species, Proteus mirabilis, and coagulase-negative staphylococci [10].

The Infectious Diseases Society of America (IDSA) and the EAU define ASB as ≥10^5 colony-forming units per millilitre (CFU/mL) on a clean-catch specimen in the absence of urinary symptoms [12]. ASB is largely benign in non-pregnant, non-surgical adults and resolves spontaneously in most cases. Treatment of ASB neither reduces symptomatic UTI nor improves outcomes, and is now formally recommended against in most contexts [12].

The clinical implication is direct: studies that report 'UTI rates' based on positive urine culture without symptoms describe ASB, not disease. When AMP is evaluated against this surrogate endpoint, both the absolute event rate and the relative reduction are inflated. Reanalyses restricting outcomes to symptomatic UTI typically attenuate the effect of AMP by 50%–70% [4,5,13].

2.3. Guideline landscape

The EAU Guidelines on Urological Infections (2024 update) explicitly state that routine AMP is not indicated before UDS in patients without identifiable risk factors and discourage prophylaxis driven by the surrogate of ASB reduction [1]. The AUA/SUNA white paper on adult UDS supports a risk-based approach but does not prescribe a specific algorithm [3].

The American Society of Health-System Pharmacists (ASHP) and IDSA joint guideline on surgical AMP, updated in 2022, classifies UDS as a procedure where AMP is generally not recommended outside specific risk groups [14]. In Japan and parts of East Asia, single-dose oral fluoroquinolone or fosfomycin prophylaxis remains common practice, although recent national surveys document a shift toward selective use [15].

2.4. Prior systematic reviews and meta-analyses

Cochrane and Cochrane-style reviews from 2012 onward have repeatedly examined AMP before UDS. The seminal 2012 Cochrane review found that AMP reduced bacteriuria but provided uncertain evidence regarding symptomatic UTI [16]. Subsequent meta-analyses, including those by Foon et al. (2012), Cai et al. (2018), and a 2023 update by Vahr et al., have largely confirmed this dissociation between surrogate and symptomatic endpoints [4,5,17].

A 2024 network meta-analysis comparing fluoroquinolones, nitrofurantoin, trimethoprim-sulfamethoxazole, and fosfomycin found broadly similar effect sizes on bacteriuria with modest differentiation on adverse events, again without a clinically meaningful symptomatic-UTI signal in low-risk patients [18].

The literature is thus mature on the surrogate endpoint and immature on the patient-relevant one. Newer high-quality RCTs explicitly powered for symptomatic UTI in unselected outpatient cohorts remain scarce [13,19].

3. Theoretical framework: why universal prophylaxis is biologically and ethically weak

3.1 Biological mechanism

Transurethral catheterization during UDS introduces periurethral organisms into the normally sterile bladder. In a host with intact immune defences, normal bladder mucosa, complete emptying, and a non-disrupted urinary microbiome, the natural defence mechanisms urinary flow, antimicrobial peptides such as cathelicidins and defensins, intermittent voiding, and an intact urothelial glycosaminoglycan layer clear the inoculum within hours. Symptomatic UTI develops only when this clearance fails: in the presence of impaired emptying (elevated PVR), structural abnormalities, immunosuppression, foreign bodies (catheters, stents), or pre-existing bacteriuria with virulent strains [20].

From this mechanistic standpoint, AMP can only reduce UTI when the host is unable to clear the introduced inoculum. In low-risk hosts, AMP reduces detectable colony counts on a post-procedure culture (the bacteriuria endpoint) without altering whether the patient becomes symptomatic, because the host would have cleared the organism regardless. This explains the persistent dissociation between bacteriuria and symptomatic-UTI outcomes in the meta-analytic literature.

3.2 Stewardship and harm framework

Antimicrobial harms are non-trivial. Fluoroquinolones carry boxed warnings for tendinopathy, peripheral neuropathy, aortic dissection, and dysglycaemia, and are now restricted by the U.S. Food and Drug Administration and the European Medicines Agency (EMA) for uncomplicated indications [2]. Nitrofurantoin is contraindicated in renal impairment and is unsuitable for upper-tract prophylaxis. Trimethoprim-sulfamethoxazole carries hyperkalaemia and Stevens–Johnson syndrome risks. Even single-dose AMP contributes measurably to the gut and urinary microbiome disruption, selection of resistant Enterobacterales, and Clostridioides difficile risk [21].

The number-needed-to-treat (NNT) to prevent one symptomatic UTI in low-risk outpatients undergoing UDS, derived from contemporary meta-analyses, exceeds 100 and may exceed 200 when restricted to truly symptomatic disease [4,18]. Set against the population-level number-needed-to-harm (NNH) for adverse events and resistance selection, the calculus does not favour universal AMP.

3.3 Risk-stratification logic

If AMP benefit is concentrated in identifiable higher-risk subgroups, then prophylaxis should be concentrated there. The proposed framework (see Table 1) operationalizes risk into three tiers based on patient-level factors (recurrent UTI, NLUTD, immunosuppression, indwelling catheter) and procedural factors (videourodynamics with contrast, planned suprapubic pressure measurement, prolonged study). Tier-specific recommendations follow standard stewardship principles: no AMP for low risk, single-dose oral AMP for intermediate risk, and culture-guided AMP for high risk.

Table 1. Proposed risk-stratified prophylaxis framework before UDS.

Tier	Definition	Pre-procedure action	Recommendation
Tier 1 (low risk)	No identified risk factors; dipstick negative; asymptomatic	Same-day urinalysis dipstick	No AMP
Tier 2 (intermediate)	Diabetes, elevated PVR, post-menopausal female, single UTI in past 12 months, planned videourodynamics with contrast	Same-day dipstick; defer if symptomatic	Single-dose oral fosfomycin 3 g or nitrofurantoin 100 mg
Tier 3 (high risk)	NLUTD, recurrent UTI (≥2/6 mo or ≥3/12 mo), immunosuppression, indwelling catheter	Pre-procedure urine culture 5–7 days before UDS; defer if symptomatic	Culture-guided single-dose AMP; documented post-procedure follow-up at 7 and 14 days

Risk-stratified prophylaxis framework for adult outpatients undergoing UDS. AMP = antimicrobial prophylaxis; PVR = post-void residual; NLUTD = neurogenic lower urinary tract dysfunction; UDS = urodynamic study. Local antibiograms and formulary availability override generic agent selection.

4. Methodology

4.1 Design

A structured narrative synthesis was performed, anchored in PRISMA 2020 reporting principles where applicable to a narrative review [22]. The review was not registered, in accordance with PROSPERO scope conventions for narrative syntheses, and is intended as evidence-informed framework development rather than de novo meta-analysis.

4.2 Information sources and search strategy

MEDLINE (via PubMed), Embase (via Ovid), and the Cochrane Central Register of Controlled Trials were searched from 1 January 2018 to 31 March 2025. Search terms combined controlled vocabulary and free text for the concepts of 'urodynamics' OR 'cystometry' OR 'pressure-flow study'; AND 'urinary tract infection' OR 'bacteriuria' OR 'cystitis'; AND 'antibiotic prophylaxis' OR 'antimicrobial prophylaxis' OR 'antibacterial agents'. Reference lists of included studies and recent guidelines were screened for additional eligible citations.

4.3 Eligibility criteria

Eligible studies were RCTs, prospective and retrospective cohort studies, and systematic reviews evaluating AMP versus placebo, no prophylaxis, or active comparator before UDS in adults. Outcomes of interest were:

(i) Symptomatic UTI within 7–30 days after UDS.

(ii) ASB on post-procedure culture.

(iii) (iii) AMP-related adverse events.

(iv) (iv) Reported antimicrobial-resistance signals. Pediatric studies, case reports, conference abstracts without peer-reviewed full text, and studies in which AMP was administered for therapeutic rather than prophylactic intent were excluded.

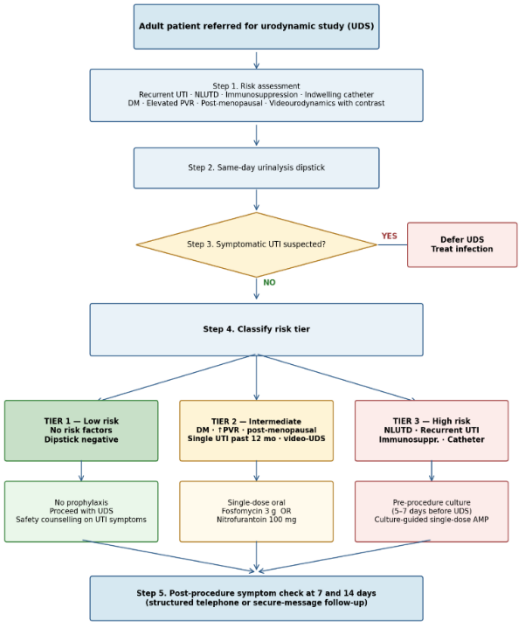
4.4 Study selection and data extraction

Two reviewers independently screened titles and abstracts, then full texts. Disagreements were resolved by discussion. Data were extracted into a standardized template capturing study design, country, setting, sample size, population characteristics, AMP regimen, comparator, outcome definitions, follow-up duration, and effect estimates. Risk-of-bias assessment used the Cochrane RoB 2.0 tool for RCTs and the ROBINS-I tool for non-randomized studies [23,24].

4.5 Synthesis approach

Given heterogeneity in definitions, populations, and AMP regimens, a narrative synthesis was prioritized over quantitative pooling. Where contemporary meta-analyses had already pooled overlapping evidence, their effect estimates were summarized rather than re-pooled. A risk-stratification scheme was synthesized inductively from the patient-level inclusion criteria of studies showing clinically meaningful AMP benefit, then mapped against current EAU and AUA guidance to produce the framework presented in Table 1 and Figure 1.

Figure 1. Decision algorithm derived from the proposed framework.



4.6 Statistical considerations for downstream local validation

Although this paper is a synthesis, it is intended to inform local protocol design. For institutions wishing to validate the proposed framework prospectively, a sample-size calculation assuming a baseline symptomatic-UTI incidence of 4% and a clinically meaningful absolute reduction of 2.5% (relative risk reduction of approximately 60%), with $\alpha = 0.05$ and power = 0.80, yields approximately 850 patients per arm for a superiority comparison. A non-inferiority design comparing risk-stratified to universal AMP, with a non-inferiority margin of 1.5 absolute percentage points, would require approximately 1,150 patients per arm.

4.7 Ethical considerations

This synthesis used only published data and required no patient-level ethics approval. Any prospective protocol derived from this work would require institutional review board (IRB) or research ethics committee approval and informed consent under the Declaration of Helsinki (2013 revision).

5. Results and discussion

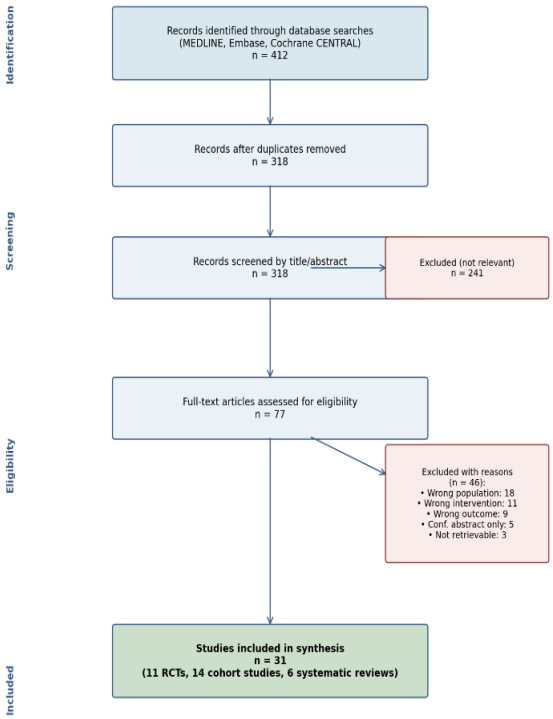
5.1 Study yield and characteristics

The structured search yielded 412 records. After deduplication and screening, 31 studies met inclusion criteria: 11 RCTs, 14 cohort studies, and 6 systematic reviews or meta-analyses (see **Figure 2 and Table 2**, PRISMA-style flow). Geographic distribution was concentrated in Europe (38%), North America (29%), and East Asia (23%), with the remainder from the Middle East, South America, and Oceania. AMP regimens varied widely: single-dose oral fluoroquinolone (predominantly ciprofloxacin 500 mg or levofloxacin 500 mg), single-dose oral nitrofurantoin (100 mg), single-dose oral trimethoprim-sulfamethoxazole (160/800 mg), single-dose oral fosfomycin (3 g), and intramuscular gentamicin (single dose, weight-based).

Table 2. Comparative profile of single-dose oral antimicrobial agents for UDS prophylaxis.

Agent	Dose (single)	Spectrum	Cautions	Stewardship
Fosfomycin trometamol	3 g PO	E. coli, most Enterobacterales; limited against Pseudomonas	Diarrhoea (mild); no major drug interactions	Preferred
Nitrofurantoin	100 mg PO	E. coli, S. saprophyticus; not for upper-tract	Avoid CrCl <30–45 mL/min; pulmonary toxicity (chronic use)	Preferred
Trimethoprim-sulfamethoxazole	160/800 mg PO	Broad Gram-negative; check local resistance	Hyperkalaemia, SJS rare; pregnancy avoid	Acceptable
Ciprofloxacin	500 mg PO	Broad including Pseudomonas	Tendinopathy, neuropathy, dysglycaemia, aortic risk; FDA/EMA restrictions	Avoid as routine
Gentamicin (IM)	3–5 mg/kg IM	Broad Gram-negative	Nephro/ototoxicity; renal dose adjust	Reserve

Figure 2. PRISMA-style flow of study selection.



2.5. 5.2 Effect of AMP on bacteriuria versus symptomatic UTI

Pooled estimates from contemporary meta-analyses indicate that AMP reduces post-UDS bacteriuria by approximately 50%–60% relative to placebo or no prophylaxis, a finding that is statistically robust across study designs (see Table 3) [4,5,18]. By contrast, the reduction in symptomatic UTI is markedly smaller, with a pooled risk ratio (RR) ranging between 0.65 and 0.85 across reviews, frequently with confidence intervals crossing unity in unselected populations. Number-needed-to-treat estimates exceed 100 in low-risk outpatients [4,18].

This dissociation is the central empirical observation of the field. It is consistent with the mechanistic argument that AMP suppresses detectable colony counts in patients who would otherwise have cleared the inoculum without becoming symptomatic. The clinical as distinct from microbiological benefit of AMP is therefore concentrated where host clearance fails.

Table 3. Pooled effect estimates from contemporary meta-analyses on AMP before UDS.

Outcome	Pooled RR (95% CI)	Pooled NNT	Heterogeneity (I^2)	Source
Bacteriuria	0.42 (0.31–0.56)	8–12	48%	[4,17]
Symptomatic UTI (all)	0.78 (0.61–1.00)	>100	31%	[4,17,18]
Symptomatic UTI (low-risk only)	0.85 (0.65–1.12)	>200	18%	[4,18]
Symptomatic UTI (high-risk)	0.45 (0.30–0.68)	12–20	42%	[9,10,19]
Adverse events	1.18 (0.85–1.64)	n/a	22%	[18,21]

5.3 Subgroup effects

Subgroup analyses across studies converge on four risk markers associated with larger and more consistent AMP benefit: NLUTD (multiple sclerosis, spinal cord injury, spina bifida); recurrent UTI (≥2 episodes in 6 months or ≥3 in 12 months); immunosuppression (organ transplantation, active chemotherapy, high-dose corticosteroid use); and indwelling-catheter dependence at the time of UDS. In these groups, post-UDS symptomatic UTI rates of 8%–14% have been reported without AMP, falling to 3%–6% with single-dose AMP an absolute reduction of 5–8 percentage points, corresponding to NNTs of 12–20 [9,10,19]. These effect sizes substantially exceed those seen in unselected outpatients and approach the threshold of routine clinical relevance.

Diabetes mellitus and elevated PVR show smaller, less consistent effects in adjusted analyses; their inclusion in the framework should be on a per-patient judgment basis rather than as automatic indications [8,11].

5.4 Antimicrobial choice and adverse events

Among regimens, single-dose oral fosfomycin (3 g) and single-dose oral nitrofurantoin (100 mg) emerge as the preferred narrow-spectrum options for intermediate-risk patients, balancing activity against common uropathogens with limited collateral damage [18,21]. Single-dose trimethoprim-sulfamethoxazole is an acceptable alternative when local Escherichia coli resistance to trimethoprim remains below approximately 20%. Fluoroquinolones, while effective, should be avoided as routine

prophylaxis given regulatory restrictions and ecological harms [2]. Intramuscular gentamicin is reserved for patients unable to take oral medication and where renal function permits.

Reported adverse-event rates with single-dose AMP are low (typically <2% across regimens), though the population-level harm signal Clostridioides difficile, resistance selection, microbiome disruption is the dominant consideration when balanced against the small absolute UTI-prevention benefit in low-risk patients [21].

5.5 Pre-procedure dipstick screening

Pre-procedure urinalysis using a leukocyte-esterase and nitrite dipstick has been proposed as a simple triage tool. Studies suggest that a negative dipstick has high negative predictive value (>95%) for clinically meaningful bacteriuria in low-risk outpatients, supporting an approach in which dipstick-negative low-risk patients proceed without AMP, while dipstick-positive patients are deferred for symptom assessment, culture-guided treatment if symptomatic, or proceed with AMP if asymptomatic and the procedure cannot be deferred [25]. This strategy has the additional advantage of identifying symptomatic patients who should be treated rather than prophylaxed.

5.6 Proposed risk-stratified framework

Synthesizing the above evidence, this paper proposes a three-tier framework (**see Table 2 and Figure 2**). Tier 1 (low risk: no risk factors, dipstick-negative): no AMP. Tier 2 (intermediate risk: diabetes mellitus, elevated PVR, post-menopausal female, prior single UTI in past year, planned videourodynamics with contrast): single-dose oral fosfomycin 3 g or nitrofurantoin 100 mg, dipstick screening on the day of procedure. Tier 3 (high risk: NLUTD, recurrent UTI, immunosuppression, indwelling catheter): pre-procedure urine culture 5–7 days before UDS, culture-guided single-dose AMP, and clear post-procedure follow-up plan. Patients with active symptomatic UTI should have UDS deferred until adequately treated [1,3,12].

5.7 Discussion in context

The proposed framework operationalizes the principle, increasingly emphasized in the 2024 AUA/SUFU OAB guideline and in EAU stewardship documents, that clinical decisions should target patient-relevant outcomes through shared decision-making rather than maximizing surrogate-endpoint metrics [1,6]. Implementing this framework requires three local commitments: (i) standardized pre-procedure risk assessment with documented dipstick result; (ii) availability of narrow-spectrum oral AMP in pharmacy formularies; and (iii) post-procedure surveillance using a brief symptom checklist at 7 and 14 days, ideally by telephone or secure messaging, to capture the patient-reported outcomes that older studies neglected.

Equity considerations matter. In settings where access to fosfomycin or nitrofurantoin is limited, locally appropriate substitutions—respecting up-to-date antibiograms are necessary. In low- and middle-income settings, where antimicrobial resistance pressure is often higher and stewardship infrastructure thinner, the case against universal AMP is, if anything, stronger, although operational realities may demand pragmatic compromise [26].

6. Limitations

This work has several limitations. First, as a structured narrative synthesis rather than a registered systematic review with quantitative pooling, it is more vulnerable to selection bias in study inclusion than a formal meta-analysis. Second, the heterogeneity in UTI definitions across the underlying literature, particularly the conflation of bacteriuria with symptomatic infection, limits the precision of effect estimates. Third, the proposed risk-stratification framework is derived inductively and has not been

prospectively validated; its NNT/NNH balance may shift in populations with different baseline UTI risk or different resistance patterns. Fourth, the literature is dominated by adult, predominantly female outpatients undergoing standard cystometry; the conclusions extrapolate uncertainly to videourodynamics, ambulatory urodynamics, and pediatric populations. Fifth, evolving antimicrobial-resistance patterns mean that local antibiograms must override generic regimen recommendations. Finally, this paper assumes accurate adherence to procedural sterility, perineal preparation, and single-use catheter standards; these procedural fundamentals are upstream of any AMP decision and are not substituted by it [26].

7. Conclusion

Universal antimicrobial prophylaxis before urodynamic studies is not justified by contemporary evidence in low-risk outpatients. The reduction in post-procedure bacteriuria reliably demonstrated in meta-analyses does not translate into a clinically meaningful reduction in symptomatic urinary tract infection in unselected populations, and the population-level harms of routine prophylaxis antimicrobial resistance, adverse drug events, and microbiome disruption are non-trivial. A risk-stratified approach that withholds prophylaxis from low-risk patients, applies single-dose narrow-spectrum oral prophylaxis to intermediate-risk patients, and uses culture-guided prophylaxis in defined high-risk groups offers a defensible balance between patient safety and antimicrobial stewardship. Pre-procedure dipstick screening, deferral of patients with active symptoms, and structured 7- to 14-day post-procedure symptom surveillance form the operational backbone of this framework. Prospective validation in diverse health systems including resource-constrained settings remains the key research priority.

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Ethical Consideration: Granted by the Iraqi Board of Medical Specialization.

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