Review Article

Comparison of the Effect of Co-Trimoxazole versus Co-Trimoxazole and Fluoroquinolones in Urinary Tract Infection Prophylaxis in Kidney Transplant Recipients: A Systematic Review and Meta-analysis

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Abstract

Urinary tract infections (UTIs) are one of the most important infectious complications in kidney transplant recipients; hence, antibiotic prophylaxis is warranted. Due to limited information for selection of an appropriate antibiotic for prophylaxis, as well as the varying reports concerning increasing resistance of *Escherichia coli* as the common related pathogen, this systematic review and meta-analysis assess the effect of a combined regimen including fluoroquinolone + co-trimoxazole as prophylaxis in high-risk group patients. PubMed, Cochrane Library, Embase, and Web of Science were used as electronic databases to perform a systematic literature between 2010 and December 2024. A commercially available software program (EndNote X9) was used for electronic title management. Searches were performed with keywords, ("Urinary Tract Infections" OR "urinary tract infection" OR "UTI") AND ("Kidney Transplantation" OR "renal transplant*" OR "kidney transplant*") AND ("Co-Trimoxazole" OR "co-trimoxazole" OR "trimethoprim sulfamethoxazole" OR "TMP-SMX") AND ("Fluoroquinolones" OR "fluoroquinolone*" OR "ciprofloxacin" OR "levofloxacin"). A total of 454 potentially relevant titles and abstracts were found during the electronic and manual search, finally two studies were included. Heterogeneity showed a higher percentage of patients in Group I suffered from urinary infection, compared to Group II. Addition of ciprofloxacin to the standard regimen, co-trimoxazole, was related to a reduced risk of UTI in kidney transplant recipients.

Keywords: *Co-trimoxazole, fluoroquinolones, kidney, renal transplantation, transplantations, urinary tract infection*

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Introduction

Urinary tract infections (UTIs) are the most common infectious complication after kidney transplantation and are associated with hospitalization, graft dysfunction, transplant pyelonephritis, and even increased mortality. The risk of UTI is highest within the first 3 to 6 months posttransplant, a period during which multiple factors coincide, including surgical trauma and manipulation, urethral catheterization and ureteral stenting, and intense immunosuppression. Microbiologically, over 70% of cases are caused by Gram-negative bacteria, with *Escherichia coli (E. coli)* being the predominant pathogen; however, *Klebsiella* spp., *Pseudomonas aeruginosa*, and, in a substantial proportion, *Enterococcus* spp. are involved. The rising trend of antimicrobial resistance, including the increasing prevalence of extended-spectrum beta-lactamases-producing *E. coli* and *Klebsiella* and high resistance of *E. coli* to trimethoprim–sulfamethoxazole (TMP–SMX), has made treatment and

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prevention increasingly complex. In some recipients, Candida species can also be the etiological agent of bacteriuria/candiduria.[1]

Asymptomatic bacteriuria (ASB) is common in kidney transplant recipients; however, randomized controlled trials (RCTs) have demonstrated that routine screening and treatment of ASB in most transplant patients does not reduce the incidence of symptomatic infection or transplant pyelonephritis, and instead increases antibiotic use and the emergence of resistance. Accordingly, the 2019 Infectious Diseases Society of America guideline advises against screening for or treating ASB in patients more than 1 month posttransplant, noting insufficient evidence to either support or oppose such measures in the 1st month. The 2024 European Association of Urology guideline likewise generally does not recommend treatment of ASB in kidney transplant recipients.[2] These conclusions are supported by key RCTs, including those of Origüen *et al*.[3] and Sabé *et al*.,[4] which found that antibiotic treatment of ASB, whether within the first 2 months or during the 1st year posttransplant did not reduce the occurrence of transplant pyelonephritis or symptomatic UTI, but did increase antimicrobial resistance.

In most centers, the accepted standard of care is daily low-dose TMP–SMX for prevention of *Pneumocystis jirovecii* pneumonia, also reducing the risk of UTI and bacteremia. The Kidney Disease Improving Global Outcomes guideline (2009) recommends daily TMP–SMX for at least 6 months for all recipients, highlighting evidence of UTI reduction with this strategy; many centers extend the duration to 6–12 months. For patients intolerant to TMP–SMX, alternatives such as nitrofurantoin, cephalexin, or fluoroquinolones have been proposed, although supporting evidence for UTI prevention in this population is more limited, and concerns regarding safety and resistance are more significant.[5]

Despite routine TMP–SMX, the burden of early UTIs, particularly during the 1st weeks after transplantation and in the presence of a ureteral stent, remains. These early infections are often associated with opportunistic Gram-negative bacilli that are not adequately covered by TMP–SMX. Consequently, some centers have added a short course of a fluoroquinolone during the 1st month to broaden Gram-negative coverage during this high-risk window, coinciding with the presence of catheters/stents and before their removal. A single-center study showed that adding 30 days of ciprofloxacin to TMP–SMX, compared with TMP–SMX alone, reduced UTI incidence for up to 1 year and prolonged the time to the first UTI; however, the proportion of *Enterococcus* in subsequent infections increased, and the authors emphasized the need for definitive RCTs. Short-term fluoroquinolone use has also occasionally been tested for other purposes, such as BK virus suppression, but high-quality trials have found no preventive effect on BK infection.[6]

Besides microbiological rationale and time-related risk, safety and resistance issues must be considered: a classic 1992 trial showed that while ciprofloxacin was as effective as TMP–SMX in preventing UTI, the risk of *Pneumocystis* pneumonia (PCP) was higher in the ciprofloxacin group. Moreover, safety warnings from the U.S. Food and Drug Administration regarding serious adverse effects of fluoroquinolones, including tendinopathy and a rare but significant increased risk of aortic injury, and antimicrobial stewardship concerns about inducing resistance, particularly in *P. aeruginosa*, have led to restricted and targeted use of this class. Therefore, most guidelines continue to recommend TMP–SMX as the first line, with fluoroquinolone addition if used at all, kept short-term and reserved for the highest-risk periods.[7]

Although TMP–SMX remains the cornerstone of posttransplant, early UTIs and the growing burden of antimicrobial resistance remain major clinical challenges. Current evidence on whether adding short-term fluoroquinolone to TMP–SMX, compared with TMP–SMX alone, affects rates of UTI, transplant pyelonephritis, hospitalization, drug-related adverse events, and resistance is scattered and heterogeneous. Some observational studies report benefits, while others highlight safety and resistance concerns. Therefore, this systematic review and meta-analysis, aimed at comparing the efficacy and safety of TMP–SMX versus TMP–SMX plus fluoroquinolone in preventing UTI in kidney transplant recipients, may address an important knowledge gap and support evidence-based decision-making for high-risk posttransplant periods.

Methods

This systematic review and meta-analysis adhered to the PRISMA 2020 guidelines and was registered in PROSPERO (Registration ID: CRD420251129671).

Search strategy

PubMed, Cochrane Library, Embase, and Web of Science were used as electronic databases to perform a systematic literature between 2010 and December 2024. A commercially available software program (Endnote X9) was used for electronic title management. Searches were performed with keywords, (“Urinary Tract Infections” OR “urinary tract infection” OR “UTI”) AND (“Kidney Transplantation” OR “renal transplant*” OR “kidney transplant*”) AND (“Co-Trimoxazole” OR

"co-trimoxazole" OR "trimethoprim sulfamethoxazole" OR "TMP-SMX") AND ("Quinolones" OR "Fluoroquinolones" OR "fluoroquinolone*" OR "ciprofloxacin" OR "levofloxacin"). The present systematic review was performed based on the main consideration of the PRISMA Statement–Preferred Reporting Items for Systematic Reviews and Meta-analysis.[8]

Selection criteria

Inclusion criteria

1. RCTs studies, controlled clinical trials, prospective and retrospective cohort studies
2. In humans
3. Studies comparing co-trimoxazole monotherapy with co-trimoxazole plus a fluoroquinolone for UTI prophylaxis in kidney transplant recipients
4. Only in kidney transplant patients
5. In English.

Exclusion criteria

1. *In vitro* studies, case studies, case reports, and reviews
2. Animal studies
3. Comparison of other antibiotics with FQs used for UTI.

Screening and selection of studies

Two independent and blinded reviewers (M.M. and A.H.) screened titles and abstracts of retrieved articles. Studies meeting the inclusion criteria were assessed in full text by the same blinded reviewers, and disagreements were resolved by discussion.

Data extraction and method of analysis

The subsequent data were extracted from the research: study years, study design, sample size, range and mean of age, drugs, dose, and duration of Rx. Comparison of the effect of co-trimoxazole monotherapy with co-trimoxazole plus a fluoroquinolone used for UTI in kidney transplant patients was analyzed by meta-analysis. Forest plots were assessed using a commercially available software program (Comprehensive Meta-Analysis, Stata. V14).

Risk of bias assessment

Evaluation: the risk of bias: RCTs were surveyed utilizing the Cochrane Collaboration tool for evaluating risk of bias.[9]

Results

A total of 454 potentially relevant titles and abstracts were found during the electronic and manual search. During the first stage of study selection, 174 publications were excluded based on title and abstract. For the second phase, the complete full-text articles of the remaining 11 publications were thoroughly evaluated. A total of 9 papers had to be excluded at this stage because they did not fulfill the inclusion criteria of the present review. Finally, a total of two publications fulfilled the inclusion criteria required for this systematic review [Figure 1]. Table 1 shows individual studies in this meta-analysis.

Two studies (randomized controlled trial) were included, Number of participants in total were 286 that 131 Patients in co-trimoxazole group and 155 patients were in Group II. The main ages of Group I and Group II were 44 and 44.23 years. Group I received co-trimoxazole, and those in Group II received ciprofloxacin plus co-trimoxazole. In Group I, co-trimoxazole was administered with a daily dose of 160/800 mg for 1 (10)–6 (11) months and as standard protocol. In Group II, co-trimoxazole was administered daily for 1 (10)–6 (11) months along with 250 mg ciprofloxacin every 12 h for the first 1 month[10] and 250 mg ciprofloxacin twice daily for 30 days.[11] The patients were followed after renal transplantation and were treated in case of UTI based on the organism causing the infection [Table 1].

Figure 2 illustrates the distribution of UTI events across the two included studies and shows that in both trials, the proportion of patients who experienced at least one UTI episode was higher in the co-trimoxazole alone group than in the co-trimoxazole plus ciprofloxacin group. As depicted in the forest plot [Figure 3], the pooled odds ratio for UTI with co-trimoxazole plus ciprofloxacin versus co-trimoxazole alone was 0.93 (95% confidence interval [CI] 0.30–1.56). This corresponds to an approximately 7% relative reduction in the odds of UTI in favor of the combination regimen; however, the difference was not statistically significant because the CI includes 1.0. Notably, the point estimates of both individual studies were on the side favoring the

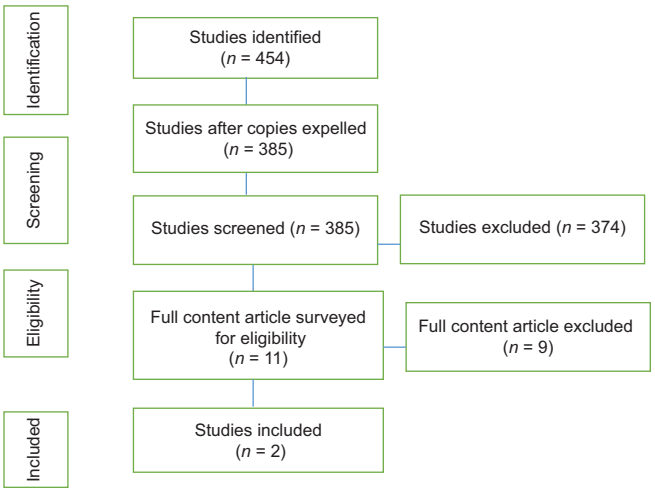


Figure 1: Study attrition diagram

addition of ciprofloxacin, and no study had an opposite direction of effect.

Discussion

The present study was conducted as a systematic review and meta-analysis to assess the effect of adding a short course of fluoroquinolone (ciprofloxacin) to the standard prophylactic regimen of cotrimoxazole in preventing UTIs in kidney transplant recipients. The pooled results of the two included studies (one RCT and one retrospective study) revealed that the incidence of UTI was lower in patients who received cotrimoxazole plus ciprofloxacin compared with cotrimoxazole alone. Although the overall meta-analysis did not demonstrate a statistically significant risk reduction (about 7% decrease with a pooled odds ratio of ≈ 0.93 and a 95% CI of 0.30–1.56, which included 1), the general trend suggested greater efficacy of the combination regimen in reducing UTIs. These findings were consistent with earlier studies; for example, in the randomized trial by Khorvash *et al.* (2016), the incidence of UTI was 32% in the cotrimoxazole-alone group versus only 12% in the combination group[11] (P = 0.026). Similarly, in the retrospective study by Wojciechowski and Chandran (2013), the 1-year posttransplant UTI incidence was 23.6% in the cotrimoxazole group compared with 10.8% in the combination group (P = 0.01).[10]

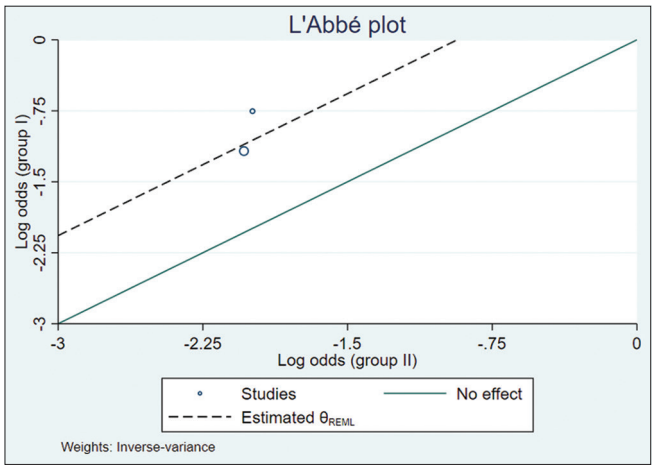


Figure 2: Heterogeneity showed the comparison of urinary tract infections in Group I versus Group II

These results indicate that adding a short course of ciprofloxacin to cotrimoxazole may partly reduce the risk of posttransplant UTIs. However, due to the limited sample size and the small number of studies, these findings should be interpreted with caution, and their clinical significance needs to be evaluated in larger populations.

Our findings build upon previous evidence regarding the overall benefits of antibiotic prophylaxis in kidney transplantation. Cotrimoxazole has long been the

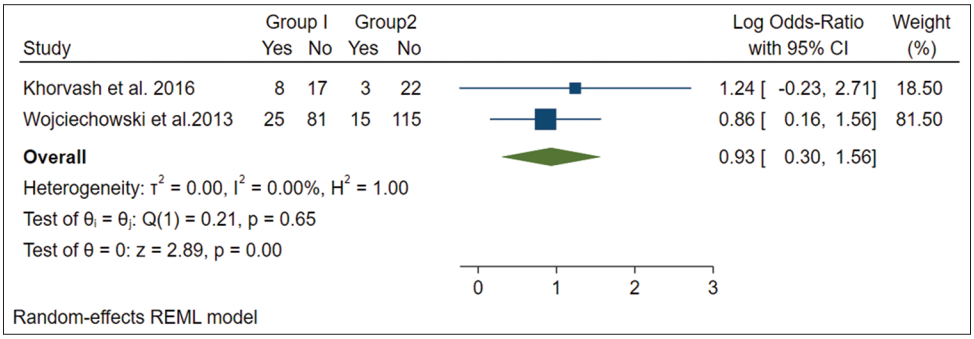


Figure 3: Forest plots showed the comparison of the effect of co-trimoxazole and co-trimoxazole plus ciprofloxacin in urinary tract infection prophylaxis in kidney transplant patients

Table 1: Studies selected for systematic review and meta-analysis

Study, year	Design	Sample size		Mean of age		Group I			Group II		
		Group I	Group II	Group I	Group II	Drugs	Dose (mg)	Duration of Rx	Drugs	Dose	Duration of Rx
Khorvash *et al.*, 2016[11]	RCT	25	25	40.32	41.08	Cotrimoxazole	160/800	Daily for 6 months	Cotrimoxazole + ciprofloxacin	160/800 mg + 250 mg	Daily for 6 months + every 12 h for the first 1 month
Wojciechowski and Chandran, 2013[10]	Retrospective	106	130	47.68	47.38	Cotrimoxazole	160/800	Daily for 30 days	Cotrimoxazole + ciprofloxacin	160/800 mg + 250 mg	Daily for 30 days + twice daily for 30 days

drug of choice for prophylaxis in these patients, and classic studies have shown that this agent can reduce infection incidence. For instance, a systematic review and meta-analysis by Green *et al.* (2011) demonstrated that antibiotic prophylaxis in the first 6 months after transplantation (mainly cotrimoxazole versus placebo or no treatment) reduced bacteriuria (both symptomatic and asymptomatic) by approximately 60% and lowered the risk of sepsis from bacteremia by up to 87%.[12] However, that meta-analysis found no differences in graft survival or overall mortality, and the number of trials was limited.[12] Furthermore, at the time of its publication, no formal guidelines existed for UTI prophylaxis after kidney transplantation. Since then, organ transplantation guidelines have primarily emphasized cotrimoxazole prophylaxis for 3–6 months posttransplant, mainly to prevent *Pneumocystis jirovecii* pneumonia (PCP), although this approach also secondarily reduces UTI risk.[12] In contrast, the routine addition of a second antibiotic, such as a fluoroquinolone, has not yet been adopted as a standard practice. The main reasons include insufficient evidence and concerns over inducing new microbial resistances. In other words, despite case reports from different centers suggesting potential benefits of fluoroquinolones alongside cotrimoxazole, current guidelines have adopted a cautious approach and do not recommend widespread use of such combination regimens. For example, infectious disease societies stress the importance of prudent antibiotic management (antibiotic stewardship) to prevent the emergence of resistant bacteria.[13] Our study represents an effort to fill the existing gap in evidence and to provide information that may contribute to updated guidance on UTI prophylaxis in kidney transplant recipients.

The combination regimen of cotrimoxazole and ciprofloxacin, in terms of mechanism of action, provides broader antibiotic coverage against common UTI pathogens. Cotrimoxazole, through inhibition of the folic acid pathway, is effective against many Gram-negative bacilli (such as *E. coli*) and some Gram-positives; however, the rising resistance of *E. coli* to cotrimoxazole in recent years has limited its effectiveness.[13] By contrast, ciprofloxacin, through inhibition of bacterial gyrase and topoisomerase enzymes, covers a wide range of Gram-negatives, including Pseudomonas and several Gram-positives. The combination of these two drugs likely prevents colonization and infection by organisms resistant to monotherapy through the overlap and complementarity of their spectra. Clinical findings also support this, as in the reviewed studies, the group receiving both antibiotics experienced fewer UTIs and only a small number of UTIs caused by resistant organisms. For instance, Wojciechowski and Chandran reported that although overall UTI cases were fewer in the combination group, a higher proportion of these infections were caused by *Enterococcus* (which is intrinsically resistant to ciprofloxacin) (28.6% vs. 4% in the monotherapy group, $P = 0.047$). This suggests that fluoroquinolones, by suppressing Gram-negative bacteria, may leave space for Gram-positive pathogens such as *Enterococcus*.[10]

Regarding microbial resistance patterns, data from the same study showed no significant difference in the overall rate of isolates resistant to cotrimoxazole (around 75%–80% in both groups) or ciprofloxacin (16.7% vs. 30%; $P = 0.39$) between the two groups. This finding indicates that adding a short course of ciprofloxacin did not necessarily lead to immediate increased resistance in Gram-negative pathogens, possibly because the limited duration of use applied a more controlled selective pressure. Nevertheless, the overall evidence indicates that long-term cotrimoxazole use in transplant patients eventually results in high resistance rates, such that in some studies more than 60% of UTIs occurring during cotrimoxazole prophylaxis were caused by resistant organisms (e.g., resistant *E. coli*). Furthermore, the use of fluoroquinolones as prophylaxis in transplant populations has been associated with increased prevalence of fluoroquinolone-resistant Pseudomonas.[13] From a pharmacological perspective, ciprofloxacin, after oral administration, is well distributed into tissues and secreted into urine, achieving adequate inhibitory concentrations in urine during the 1st month posttransplant – the high-risk period for UTI.[11] Overall, the beneficial mechanism of the combination regimen may be described as providing broader microbial coverage against common UTI pathogens and preventing the overgrowth of organisms resistant to monotherapy. However, this broader spectrum may also negatively affect the patient's natural microbiota. Evidence has shown that fluoroquinolone use induces considerable changes in gut flora, causing what is termed collateral damage to the microbiome; this, in turn, can potentially increase the risk of Clostridium difficile or other opportunistic infections. Therefore, balancing the benefit of expanded antibiotic coverage against the risks of resistance emergence and disruption of the natural flora remains the key consideration in applying this approach.

The results of the present study carry important clinical implications for the management of kidney transplant recipients. UTIs are the most common bacterial infections following kidney transplantation, with an incidence reported in different sources ranging from 20% to 70%.[14] The occurrence of UTI not only

causes patient discomfort and increased clinic visits, but it can also lead to more serious complications such as graft pyelonephritis, bacteremia, and sepsis, and in severe cases may even threaten graft survival. Studies have shown that posttransplant UTI is associated with impaired graft function; for example, in a 1-year follow-up study, patients without UTI had a significantly better mean glomerular filtration rate compared to those with UTI.[15]

Hence, reducing the incidence of UTI may indirectly contribute to preserving better graft function and decreasing recurrent hospitalizations. In this regard, our findings support that adding a short course of ciprofloxacin during the 1st month after transplantation to the standard prophylactic regimen can reduce the occurrence of early posttransplant UTIs and may protect patients from some of the aforementioned consequences.[10] From a clinical perspective, implementing such an approach may be particularly beneficial in high-risk patients; for instance, female recipients due to the higher prevalence of UTI in women, patients with a history of recurrent UTIs or anatomical abnormalities, and those otherwise at elevated risk for UTI may derive greater benefit from intensified prophylaxis.[13] Nevertheless, any modification of the prophylaxis protocol should be undertaken cautiously and with consideration of the consequences of antimicrobial resistance and drug-related adverse effects. Widespread use of fluoroquinolones may select for resistant strains, complicating the treatment of subsequent infections.[13] Moreover, although ciprofloxacin is generally regarded as safe, potential adverse effects such as tendon problems, peripheral neuropathy, and disturbances in cardiac rhythm or blood glucose (particularly in older individuals) should not be overlooked.[13] Thus, clinical practice must always adhere to a careful balance of benefit and risk. Based on current evidence, a short course of fluoroquinolone early after transplantation alongside cotrimoxazole may be considered to reduce UTI, but this decision should be accompanied by close monitoring of the patient's status and the local microbiological profile. The integration of such a change into clinical practice requires further confirmation by larger trials, and should be combined with other UTI-reducing strategies such as timely removal of catheters and ureteral stents within 2–4 weeks after transplantation.[13] Importantly, cotrimoxazole prophylaxis as the gold standard must continue due to its vital role in preventing PCP pneumonia and toxoplasmosis, and the addition of a fluoroquinolone should not be considered a replacement but rather a temporary adjunct in high-risk periods.

Despite these encouraging findings, the present study faces several limitations that must be considered when interpreting the results. First, the number of included studies was very small (two studies), and the overall sample size was limited (a total of 286 patients), the statistical power of the meta-analysis to detect small differences is inadequate. The inclusion of only two studies– one single-center RCT with 50 patients and one single-center retrospective study with 236 patients – renders the results vulnerable to biases inherent in small-scale and nonrandomized designs. Specifically, the trial by Khorvash *et al*.,[11] despite randomization, had a small sample size and may have had insufficient power to assess all outcomes (e.g., differences in mortality or renal function). The study by Wojciechowski and Chandran[10] was retrospective; although the groups were matched for many variables, differences such as the proportion receiving corticosteroids could have acted as confounders affecting the results.[10] Another limitation was the heterogeneity in exact prophylactic regimens between studies; one study administered daily cotrimoxazole for 6 months, while the other reduced cotrimoxazole dosing to three times per week after the 1st month. Although both studies employed approximately 1 month of fluoroquinolone use early posttransplant, this dosing heterogeneity may have influenced the degree of effect observed.

Moreover, both studies only examined the short-term period (1 year or less) after transplantation, and the longer-term effects of adding fluoroquinolones – for example, on preventing late-onset UTIs or improving long-term graft survival– remain unclear. Another important issue is the lack of comprehensive reporting on adverse events and secondary outcomes in the included studies. For instance, neither study monitored the occurrence of Clostridium difficile infections or fungal overgrowth as potential outcomes, and no detailed data were provided on drug-related adverse events such as gastrointestinal or allergic reactions. Therefore, it is impossible to conclude with certainty whether the combination regimen is entirely safe. Furthermore, aspects related to antimicrobial resistance were assessed only based on cultures from symptomatic infections, while changes in the normal microbial flora– such as colonization with resistant bacteria in the gastrointestinal or urinary tract– were not evaluated. This may be significant, as patients receiving broad-spectrum prophylaxis could be predisposed to infections with more resistant organisms in the future.[13] Another limitation is the low external validity; both studies were conducted in single centers (one in Iran and the other in the United States), and patterns of bacterial resistance and

infection epidemiology differ across regions. Therefore, generalizing the results to other countries or centers should be done cautiously. In summary, due to the small sample size, methodological heterogeneity, and lack of long-term and safety data, our study has limitations that underscore the need for further research.

The findings of this systematic review and meta-analysis raise new questions and indicate that more comprehensive studies are required to establish a more definitive guideline. First, conducting large-scale, randomized, multicenter clinical trials is recommended to evaluate the effect of adding fluoroquinolones to standard prophylaxis with adequate statistical power. Such trials could address important questions, including whether the observed reduction in early posttransplant UTIs translates into meaningful improvements in graft survival or reductions in infection-related hospitalizations. Future studies should also systematically assess the safety and microbiological outcomes of this approach; for example, monitoring the incidence of Clostridium difficile, fungal infections, or other adverse events arising from alterations in the microbiota in patients receiving fluoroquinolone prophylaxis is essential. In addition, investigating the pattern of antimicrobial resistance following combined prophylaxis in the long term is of particular importance: does short-term ciprofloxacin use increase the prevalence of resistant organisms in the months or years afterward? The answer to this question may be decisive in determining whether or not to adopt such a regimen in clinical guidelines. Another key issue is defining the optimal duration of prophylaxis. Although both existing studies used a 1-month ciprofloxacin course, longer durations or alternative algorithms, such as initiating fluoroquinolones only if ASB persists, could also be evaluated. Comparative studies may clarify whether a longer course provides greater preventive benefit or merely intensifies resistance. Moreover, research into alternative or complementary strategies is also warranted; for example, the role of other antibiotics such as nitrofurantoin as a urinary tract-specific prophylactic agent, or the incorporation of nonpharmacological measures like cranberry intake, probiotics, or behavioral education to reduce UTI risk alongside standard regimens, should be explored.[12,14] From a clinical optimization perspective, a targeted prophylaxis approach based on individual risk factors could also be assessed; in this way, patients could be stratified at discharge according to sex, history of recurrent UTI, diabetes, use of catheters or stents, and other risk factors, and assigned to tailored preventive regimens. Such personalization may enhance effectiveness while reducing unnecessary antibiotic exposure. Achieving these goals is only possible through the conduct of multiple, high-quality studies. Therefore, we call upon future researchers to carry out larger investigations so that evidence-based recommendations for preventing UTIs in kidney transplant recipients can be made with greater confidence.

Conclusion

The addition of ciprofloxacin to the current regimen, co-trimoxazole, for prophylaxis of UTI in renal transplant patients was related to a reduced risk of it. Although our meta-analysis did not show a statistically significant benefit of adding ciprofloxacin to standard co-trimoxazole prophylaxis, the CIs were wide, and the available data are limited. Given the increasing resistance to current antibiotic prophylaxis regimens, the high prevalence of UTIs in renal transplant recipients, and the limited evidence comparing different prophylactic strategies in this high-risk population, further well-designed studies with larger sample sizes and longer follow-up are needed.

Authors' Contribution

A.H contributed to the conceptualization. M.M and A.H contributed to the methodology, software, and formal analysis. M.M wrote the original draft. M.M reviewed and edited the final draft. A.H, M.M conducted the title and abstract screening, selection, data extraction, and quality assessment process. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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