Review Article

Overview on urinary tract infection, bacterial agents, and antibiotic resistance pattern in renal transplant recipients

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Background: Urinary tract infection (UTI) is a mainly common infection in kidney transplant recipients. This study decided to investigate UTI, bacterial agents, and antibiotic resistance pattern in kidney transplant recipients from Iran. **Materials and Methods:** Search process was conducted for UTI, bacterial agents, and antibiotic resistance pattern in kidney transplant recipients from Iran via electronic databases (Scopus, PubMed, Web of Science, etc.,) with Mesh terms in either Persian and English languages without limited time to May 31, 2020. Data were analyzed by comprehensive meta-analysis software. **Results:** The combined prevalence of UTI in renal transplant recipients was reported by 31.1%. The combined prevalence of Gram-negative bacteria was 69%. The most common pathogens among Gram negatives were *E. coli* followed by *Klebsiella pneumoniae* with frequency 43.4% and 13%, respectively. Subgroup analysis for Gram-positive bacteria showed the combined prevalence of 31%. The most common microorganism among Gram positives belonged to coagulase-negative *Staphylococci* and Enterococci with a prevalence of 10.2% and 9%, respectively. Subgroup meta-analysis of antibiotic resistance for Gram-negative showed the most resistance to cephalexin followed by carbenicillin with a prevalence of 89.1% and 87.3%, respectively. **Conclusion:** Our review showed a noticeable rate of UTI (31.1%) among renal transplant recipients in Iran and a high prevalence of Gram-negative (69%) and Gram-positive (13%) microorganisms. A high resistance rate was seen against almost all antibiotics used for the treatment of UTI. Therefore, empirical prescription of antibiotics should be avoided, and it should be based on data obtained from antibiogram tests.

Key words: Antibiotic resistance, bacteriuria, kidney grafting, renal transplantation, urinary tract infection

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INTRODUCTION

As we know kidney transplantation despite the high cost is clinically effective treatment for the end-step renal disorder,[1] nowadays, it is possible with a profitable kidney transplant increases quality of life in patients and decreases mortality.[2] Posttransplant complications are produced such as dialysis and the altered anatomy of the urogenital tract.[2,3]

The main cause of mortality and morbidity in kidney transplant recipients is bacterial infection.[4] Urinary tract infection (UTI) is mainly a common infection in kidney transplant recipients.[5,6] In original, bacteriuria categorizes into two types: asymptomatic bacteriuria (ASB) and symptomatic UTI.[7] ASB is defined as the growth of bacteria with >10^5 CFU/mL, wherein the patients do not have any symptoms of infection.[8] Based on recent reports, treatment of ASB might not be required and there was no adverse side effect on transplant outcomes.

UTI is defined by the overgrowth of bacteria >10^5 CFU/mL from patients' urine samples alongside with symptoms including dysuria, suprapubic, flank or allograft

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pain, fever, or chills.[8] There are a lot of risk factors for susceptibility to UTI such as acute rejection, female sex, older age, longer durations with a urinary catheter, episodes, and receiving a kidney from a deceased donor.[9]

Organisms that cause UTI post renal transplantation are bacterial, fungal, viral, parasitic, or mycoplasmal.[10] The order of bacterial UTI pathogens in transplant recipients is comparable to that in the nontransplantation population; Gram-negative bacteria are responsible for over 70% of UTI cases.[11,12] The high frequent bacterial agents causing UTI are *Escherichia coli*, *K. pneumoniae*, *Enterococcus* sp., *Enterobacter*, *Pseudomonas aeruginosa*, and *Proteus mirabilis*.[13,14]

In some cases, microorganisms that are not problematic in immunocompromised patients have been involved in posttransplantation UTI.[15] This possibly due to immunosuppressant drugs used in these patients, which accelerates bacterial–urothelial adherence.[16] Hence, resistant bacterial strains can cause the problem to patients.[17]

UTI via the inflammatory cytokine response, free-radical production, CMV reactivation, precipitation of rejection, and pyelonephritis-induced renal scarring can impair graft function.[15] It is debatable that how much UTI can affect transplant function and patient survival. However, many retrospective studies have found no significant association between UTI, transplantation, and patient survival.[18]

Concerning the importance of bacterial UTI in renal transplant recipients, and increasing their antibiotic resistance, this study decided to evaluate UTI, bacterial agents, and antibiotic resistance pattern in renal transplant recipients from Iran through systematic review and meta-analysis.

MATERIALS AND METHODS

Strategy search

Prisma protocol (PRISMA, http://www.prisma-statement.org) was used for searching UTI, the prevalence of microorganisms, and antibiotic resistance pattern in kidney transplant recipients from Iran in both international and national online electronic databases such as Scopus, PubMed, Cochrane Library, Web of Sciences, Iranmedex (www.iranmedex.com), Magiran (www.magiran.com), and Scientific Information Database (www.sid.ir). Mesh terms and text words were urinary tract infection, UTI, kidney transplant, renal transplant, post kidney transplant, antimicrobial drug resistance, and antibiotic resistance pattern. Published studies were searched without time limitation until May 31, 2020.

Inclusion and exclusion criteria

Cross-sectional, cohort, and case–control studies addressing the prevalence of UTI, bacterial pathogens, and antibiotic resistance pattern in renal transplant recipients were enrolled in the current systematic review and meta-analysis. Different types of review articles (systematic, narrative review, and met-analysis), studies with missed data, conferences, meetings, abstracts, and studies published in languages other than English or Persian were excluded. Studies introduced other than kidney transplants were excluded from the study. Of note, two reviewers conducted searches independently.

Assessment of selection bias and quality of selected studies

To achieve this purpose, the criteria given in Critical Appraisal Skills Programmed checklists (www.casp-UK) were used. Hence, 10 questions were asked and if the answer was yes, one point would be considered, and if the answer was no, or if there was any doubt, the score would be 0. At the end, according to the scoring system, strong studies scored above 8, average studies between 5 and 8, and weak studies obtained scores below 4 (file 1).

Data extraction

By use of extract forms, the following data extracted: the first author's name, time of the study, publication year, settings, sample size, prevalence of UTI, Genus, and mean age.

Statistical analysis

Comprehensive meta-analysis software was used for data analysis. The prevalence of UTI, antibiotic resistance, and bacterial agents was calculated by 95% confidence intervals. Due to the existence of heterogeneity among studies, a random effects model was used. I^2 and the Q-statistic tests were used for the assessment of heterogeneity among studies included in the present review. $P < 0.05$ of Q-test and I^2 test >50% was considered statistically significant.

In this study, we evaluated the publication bias visually through the Funnel plot. If the distribution of articles is evenly placed inside the funnel, it indicates that there is no publication bias, and if they placed outside the funnel or there is a heterogeneous and unbalanced distribution inside the funnel, it indicates the presence of bias in the study publication. In addition to the Funnel plot, the statistical Egger's linear regression test was used to further investigate publication bias. According to this test, if the $P < 0.05$, it indicates the existence of publication bias; otherwise, if it is greater than this value, it indicates the absence of publication bias in the studies included.[19] Finally, subgroup analysis was made for bacterial species and antibiotic resistance.

RESULTS

Selection study and features

The selection process is shown in Figure 1. Totally, 819 articles potentially were identified, 18 out of which met inclusion criteria for enrollment in the present systematic review and meta-analysis. Most studies were from Tehran (*N* = 7), followed by Mashhad (*N* = 4). Patients had mean age of 5–87 years [Table 1]. Most studies had cross-sectional design and 2 studies were case control.

Overall effects

According to the findings obtained from the systematic review and meta-analysis which are shown in Figure 2 and Table 2, the combined prevalence of UTI in renal transplant recipients was reported by 31.1% (95% Cl: 24.1–39.1), Z = 4.4, Q = 538, I^2 = 96.8.

Publication bias

Regarding the Funnel plot [Figure 3], because there was a heterogeneous and unbalanced distribution inside the funnel, and studies placed outside the funnel, it indicated the presence of bias in the publication. To further evaluation, the statistical Egger's Linear Regression Test was used; however, the findings showed no publication bias in the studies included, because *P* = 0.29 [Table 2].

Subgroup analysis for Gram-negative bacteria

As listed in Table 2, subgroup analysis showed that the combined prevalence of Gram-negative bacteria was 69% (95% Cl: 23.6–99.5), Z = 11, Q = 201 and I^2 = 94. The most common pathogens among Gram negatives were *E. coli* followed by *K. pneumoniae* with frequency 43.4% (95% Cl: 38.4–50.1), and 13% (95% Cl: 7–19.9), respectively. Furthermore, the least rate belonged to *Acinetobacter baumannii* with a prevalence of 3% (95% Cl: 1.4–5.8).

Subgroup analysis for Gram-positive bacteria

Subgroup analysis for Gram-positive bacteria showed the combined prevalence of 31% (95% Cl: 12.2–48.4), Z = 5.7, Q = 65.1 and I^2 = 90.8. The highest predominant microorganism among Gram positives belonged to coagulase-negative *staphylococci* (CoNS) and Enterococci with a prevalence of 10.2% (95% Cl: 5.4–18.2) and 9% (95% Cl: 4-3.9), respectively.

Subgroup analysis for antibiotic resistance

Subgroup meta-analysis of antibiotic resistance for Gram-negative bacteria showed the most resistance to cephalexin followed by carbenicillin and ceftazidime with the prevalence of 89.1% (58.8, 102), 87.3% (58.8, 99.3), and 86.3% (47.4, 88.6), respectively. The least resistance was observed against imipenem with a resistance rate of 13% [Table 3]. Furthermore, based on the data summarized in Table 4, the highest resistance of Gram-positive bacteria reported against amoxicillin and cephalexin with a resistance rate of 79% (38.1,96) and 74% (33.4,98.91), respectively. The effective antibiotic for treatment of Gram-positive bacteria was reported Polymyxin B (10.6%). Findings of antibiotic resistance for *E. coli* in Table 5 showed the highest resistance against cotrimoxazole and nalidixic acid with a resistance rate of 74.1% and 70%, respectively. As well, the best antibiotics for treatment of UTI caused by *E. coli* were reported imipenem and nitrofurantoin with resistance rates of 13.2% and 19%, respectively.

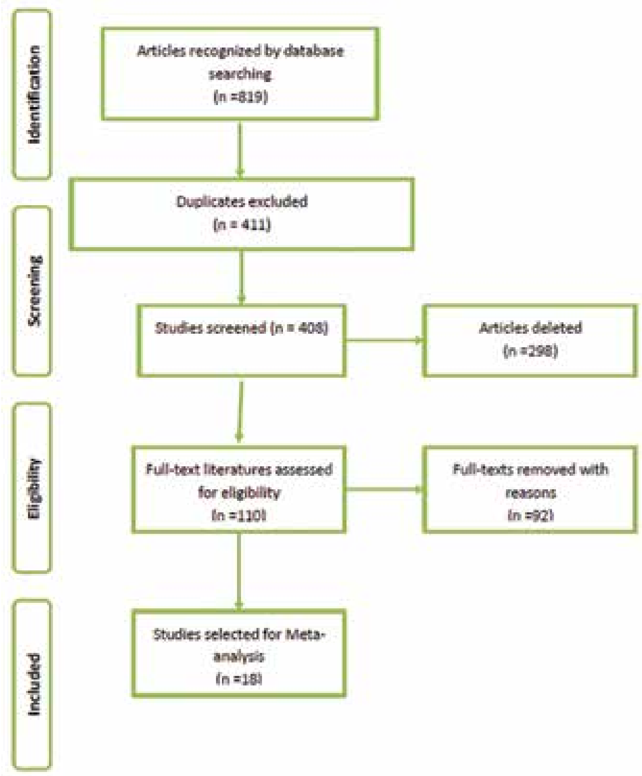

Figure 1: Chart of selection process for included studies

DISCUSSION

In total, UTI is considered as the most common infection and the most possible site of infection that leads to hospitalization of patients with kidney transplantation.[20] The prevalence of UTI in kidney transplant recipients is similar in both developed and developing countries.[5] The prevalence of posttransplant UTI in the kidney transplant recipients varies between 12% and 75%.[21] Of course, in developing countries, this rate may be higher due to epidemiological exposure and lower standards of hygiene.[22] A meta-analysis conducted in 2016 showed that the USA had a significantly higher prevalence of UTIs than European countries (41% vs. 33%).[9]

In the present systematic review and meta-analysis, the combined prevalence of UTI in renal transplant recipients was reported by 31.1%. The combined prevalence of Gram-negative bacteria was 69%. The most common pathogens among Gram negatives were *E. coli* followed by *K. pneumoniae* with frequency 43.4% and 13%, respectively. Furthermore, the least rate belonged to *A. baumannii* with prevalence of 3%. Furthermore, subgroup analysis for Gram-positive bacteria showed the combined prevalence of 31%. The highest predominant microorganism among Gram-positives belonged to CoNS and Enterococci with prevalence 10.2% and 9%, respectively.

The prevalence in Iranian studies included in the current review varied from 4.5% to 67.5%. Our result (31.1% UTI's prevalence) was in line with our studies conducted in other parts of the world such as Turkey,[22] Pakistan,[23] Australia,[24] and the USA.[25] Similar findings in other studies support the concept that UTI still is the most predominant infection postrenal transplantation.[24] The difference in the prevalence of UTI (4.5%–67.5%) in studies included in the present review and other studies from worldwide likely attributed to differences in the definition of UTI, the interval of follow-up, antibiotic prophylaxis used posttransplantation, and inherent differences of the person features among diverse countries.[9]

Similar to our study, others reported the Gram-negative bacteria as the most common organisms isolated from UTI samples of both the nontransplant and transplant

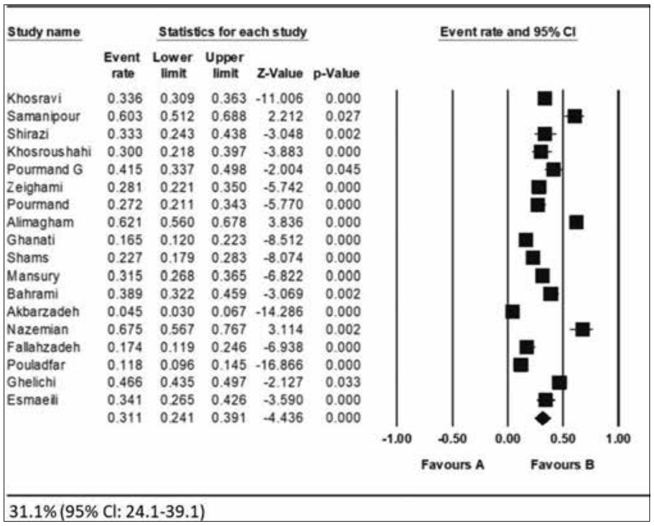

Figure 2: Forest plot of the meta-analysis on prevalence of urinary tract infection among kidney transplant recipients in Iran

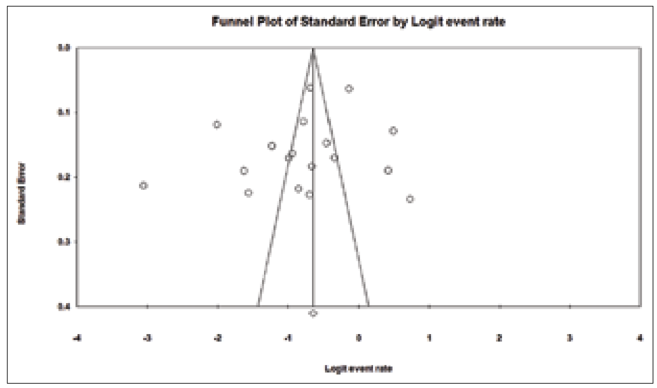

Figure 3: Funnel plot for meta-analysis on prevalence of urinary tract infection among kidney transplant recipients in Iran. Because there is a heterogeneous and unbalanced distribution inside the funnel, and studies placed outside the funnel, it indicates the presence of bias in the study publication

Table 1: Characteristics of enrolled studies for this systematic and meta-analysis

Study	Time of study	Publication	Location	Sample size	UTI prevalence	Gender (%)		Mean age
						Female	Male	
Khosravi *et al.*[44]	2009–2012	2014	Golestan and Ahvaz	1165	391	34.8	65.2	39.6±2
Samanipour *et al.*[45]	2013–2014	2015	Tehran	116	70	30	70	41.3±13.3
Shirazi *et al.*[46]	1991–1996	2005	Tehran	87	29	34.4	65.6	-
Mortazavi *et al.*[47]	1993–2000	2003	Tabriz	100	30	-	-	-
Pourmand *et al.* [48]	2002–2004	2006	Tehran	142	59	-	-	41±14.47
Zeighami *et al.*[49]	-	2008	Tehran	185	52	-	-	-
Pourmand *et al.*[50]	2011–2012	2012	Tehran	173	47	39.3	61.7	40.8±14
Alimagham *et al.*[51]	1993–1997	2002	Tehran	256	159	30	70	20–70
Kian Ghanati *et al.*[52]	2009–2010	2012	Tehran	200	33	-	-	10–70
Shams *et al.*[33]	2012–2014	2016	Mashhad	247	56	40.8	59.2	34.9±13.8
Mansury *et al.*[53]	2013–2015	2017	Mashhad	356	112	42.1	57.9	-
Bahrami *et al.*[54]	2013–15	2017	Iran	193	75	-	-	34.4±12.2
Sorkhi *et al.*[55]	1999–2008	2016	Iran	508	23	36.3	63.7	43.3±13
Nazemian *et al.*[56]	1998–2002	2007	Mashhad	83	56	24	76	50–66
Fallahzadeh *et al.*[57]	1990–2008	2011	Shiraz	138	24	42.7	57.3	13.6±3.5
Pouladfar *et al.*[58]	2012–2013	2015	Shiraz	676	80	50	50	5–87
Ghelichi *et al.*[59]	2001–2011	2018	Iran	991	462	39.8	60.2	-
Esmaeili and Mansour[60]	2009–2010	2013	Hamadan	132	45	48.5	51.5	-

UTI=Urinary tract infection

Table 2: Subgroup meta-analysis for both Gram-positive and negative bacteria

Subgroups	Number of study	Random model			Heterogeneity test		Egger's test		
		Bacteria prevalence (95% CI) (%)	*Z*	*P*	*P*	*Q*	I^2	*t*	*P*
Overall effects (UTI)	18	31.1 (24.1-39.1)	4.4	0.00	0.00	538	96.8	1	0.29
Gram-negative	17	69 (23.6-99.5)	11	0.01	0.001	201	94	0.32	0.002
Gram-positive	16	31 (12.2-48.4)	5.7	0.00	0.00	65.1	90.8	1.2	0.35
Escherichia coli	18	43.4 (38.4-50.1)	3	0.00	0.001	38.1	90.1	0.2	0.11
Entrobacter spp.	8	5.4 (2.2-12.9)	5.8	0.00	45.2	0.00	84.5	5	0.002
Klebsiella	14	13 (7-19.9)	5.3	0.00	0.00	29	78.2	3.6	0.034
Coagulase negative staph	13	10.2 (5.4-18.2)	8.8	0.001	0.00	111	81	0.00	0.13
Staphylococcus aureus	12	5.8 (2.7-13.1)	8.1	0.000	0.000	12	63	1	0.91
Pseudomonas aeruginosa	13	11.3 (7.9-15.8)	12.1	0.011	0.06	16.5	55.2	4	0.03
Streptococcus	12	6 (2.7-17.7)	6.2	0.23	0.01	44.8	92	1.9	0.19
Acinetobacter	10	3 (1.4-5.8)	13.3	0.00	0.08	11.2	60.4	1.5	0.16
Enterococcus spp.	15	9 (4-3.9)	7.1	0.00	0.001	88	98	1.3	0.002

CI=Confidence interval

Table 3: Subgroup meta-analysis of antibiotic resistance pattern for Gram-negative bacteria

Subgroups	Number of study	Random model			Heterogeneity test		Egger's test		
		Resistance rate (95% CI) (%)	*Z*	*P*	*P*	*Q*	I^2	*t*	*P*
Amikacin	11	39 (33.4-40.5)	5.5	0.00	0.32	5.8	92	2.1	0.44
Amoxicillin	11	76 (43.12.-91.7)	2.2	0.01	0.03	5.2	87	11	0.00
Tobramycin	10	75.1 (34.9-111.2)	1.8	0.11	0.002	23	56	0.35	0.43
Kanamycin	10	53 (14.2-61.9)	13	0.07	0.00	8.1	72	1.7	0.46
Erythromycin	10	80.1 (46.8-88.2)	6.1	0.00	0.00	12.1	76	2.4	0.003
Nitrofurantoin	12	41 (28.2-58.2)	1.4	0.00	0.00	72.1	99	0.03	0.5
Cotrimoxazole	15	72 (54.3-91.1)	3.3	0.013	0.00	32.1	84	3.7	0.01
Cephalotin	13	58.2 (52.1-69.6)	4	0.054	0.00	8.3	27.3	0.34	0.33
Gentamicin	13	48 (41-56.8)	0.21	0.00	0.18	17.3	55	0.1	0.26
Ceftriaxon	10	70.1 (55-95.2)	4.6	0.00	0.001	14	72	0.1	0.5
Pipracillin	10	47.2 (14.9-77.2)	1.4	0.9	0.00	19	82.1	0.00	0.0.16
Imipenem	10	13 (4.1-30.2)	1.1	0.00	0.00	32	84	0.3	0.002
Ceftazidime	10	86.3 (47.4-88.6)	1	0.03	0.00	12	77	1	0.39
Nalidixic acid	15	45.3 (9.3,71)	0.7	0.00	0.001	38	85	0.8	0.21
Cefixime	10	56 (40.3-99)	1.1	0.05	0.001	11.5	81	0.3	1
Ciprofloxacin	16	57 (31-72)	0.32	0.6	0.00	43	62	4.2	0.11
Chloramphenicol	13	39.7 (30.4-48.8)	1.7	0.28	0.08	17	47	0.30	0.7
Polymyxin B	10	43.2 (11.2-81.8)	0.00	0.13	0.00	18	82.2	0.00	0.77
Cephalexin	10	89.1 (58.8-102)	8	0.00	0.00	23	80.2	2.5	0.002
Carbenicillin	10	87.3 (58.8-99.3)	8	0.00	0.88	0.33	85.8	1.5	0.004

CI=Confidence interval

patients with the prevalence of 90%.[10,24] We reported *E. coli* followed by *K. pneumonia* as the most prevalent Gram-negative bacteria, as other reports confirm it.[26] In line to our study, a study conducted by Senger *et al*. in 2003, *Enterococcus*, *Staphylococcus*, and *Streptococcus* reported as the highest frequent bacteria.[26] Similarly, Al Midani *et al*. from the UK,[27] Camargo *et al*. from Brazil,[28] Bodro *et al*. from Spain,[29] reported *E. coli* and *K. pneumonia* as the most frequent Gram-negative bacteria. As well, Ediriweera *et al*. from Sri Lanka reported CoNS as the most Gram+,[30] Wang *et al*. from Taiwan,[31] Chuang *et al*. from the USA reported Enterococcus species as the most common Gram-positive bacteria recovered from UTI samples of kidney transplant recipients.[32] All studies mentioned are inconsistent with our findings.

Several studies have confirmed that UTI is related to transplant function failure, particularly in the early posttransplant episode,[6,29,33] but others have not reported such association,[34-36] Additionally, another one found no profit of antibiotic prophylaxis on transplant function in the first 6 months post transplantation.[37] Recently, some studies have shown a rising prevalence of infections caused by Multi-drug-resistant (MDR) strains in both immunocompetent and immunocompromised patients. As several reports presented a high rate of infections are

Table 4: Subgroup meta-analysis of antibiotic resistance for Gram-positive bacteria

Subgroups	Number of study	Random model			Heterogeneity test		Egger's test		
		Resistance rate (95% CI) (%)	*Z*	*P*	*P*	*Q*	I^2	*t*	*P*
Amikacin	11	68 (42.9–83.8)	1.1	0.00	0.00	2	67	0.1	0.22
Nitrofurantoin	11	29.8 (11–78.1)	0.00	0.32	0.2	31	62	0.00	0.4
Erythromycin	10	69 (41–90)	1.7	0.16	0.9	0.5	25	0.76	0.1
Kanamycin	10	73 (43.2–87.8)	1.76	0.17	0.4	12	17	0.58	0.11
Cotrimoxazole	11	44.9 (24.1–65.5)	0.32	0.88	0.4	1.5	0.00	0.66	0.36
Gentamicin	12	65.9 (38.6–75)	11	0.00	0.11	6	78	1.1	0.31
Amoxicillin	11	79 (38.1–96)	1.4	1	0.8	2.8	76	1.4	0.21
Tobramycin	10	62.2 (41.1–80.6)	0.00	0.00	0.01	1	98	0.6	0.5
Cephalexin	10	78 (50–91.2)	1.4	0.01	0.23	0.1	82	4.1	0.37
Carbenicillin	10	74 (33.4–98.91)	0.3	0.001	3.12	0.14	72	0.01	0.43
Chloramphenicol	11	65 (48.6–69.1)	1.2	0.72	0.5	1.6	83	0.01	0.21
Kanamycin	10	70.6 (41.8–88.4)	0.54	0.10	0.00	0.40	74	0.8	0.15
Nalidixic acid	11	47.6 (27.1–86)	0.23	0.00	0.00	0.71	59	4.4	0.12
Tetracycline	11	46.6 (6.17–90.3)	0.03	0.00	0.01	0.2	70.2	3.3	0.01
Polymyxin B	10	10.6 (4.3–33.6)	2.9	0.01	0.02	0.01	64	5.7	0.001

CI=Confidence interval

Table 5: Subgroup meta-analysis of antibiotic resistance for *Escherichia coli* isolates

Subgroups	Number of study	Random model			Heterogeneity test		Egger's test		
		Resistance rate (95% CI) (%)	*Z*	*P*	*P*	*Q*	I^2	*t*	*P*
Nalidixic acid	11	70 (38.4–83.2)	3.2	0.00	0.00	36	85	1	0.6
Amikacin	10	37.4 (29.8.52.3)	3.3	0.05	0.17	11	45	0.73	0.00
Imipenem	12	13.2 (4.1–32.2)	1.1	0.00	30.1	15	63	2.6	0.04
Cephalotin	9	61.6 (58.6–80)	4.5	0.00	0.00	0.01	87	3.5	0.001
Ciprofloxacin	12	59.4 (22.6–85)	0.51	0.59	65.1	0.01	94	7.1	0.39
Tetracycline	11	63 (20–88.3)	0.91	0.73	0.00	32.8	92.1	3	0.22
Gentamicin	13	55 (57.1–57.9)	0.89	0.12	0.00	14	73	0.00	0.01
Nitrofurantoin	11	19 (17.8–60)	14	0.00	0.40	7.1	0.00	2.8	0.00
Cotrimoxazole	13	74.1 (66.3–81.7)	4.2	0.09	0.00	22	59	0.4	0.01
Nalidixic acid	11	68 (33.4–991)	3.2	0.20	0.00	15	83	1	0.23
Chloramphenicol	10	42.4 (22.5–67.1)	0.5	0.10	0.11	173	83	0.03	0.24

CI=Confidence interval

produced by MDR organisms in solid organ recipients, ranging from 6.5% to 56%.[38-41]

In the present review, subgroup meta-analysis of antibiotic resistance for Gram-negative microorganisms showed the most resistance to cephalexin followed by Carbenicillin and Ceftazidime with the prevalence of 89.1%, 87.3%, and 86.3%, respectively. The least resistance was observed against Imipenem with resistance rate of 13%. Furthermore, the highest resistance of Gram-positive bacteria reported against amoxicillin and cephalexin with resistance rate of 79% and 74%, respectively. The effective antibiotic for the treatment of Gram-positive bacteria was reported Polymyxin B (10.6%). Findings of antibiotic resistance for *E. coli* showed the highest resistance against Cotrimoxazole and Nalidixic acid with resistance rate of 74.1% and 70%, respectively. As well, the best antibiotic for treatment of UTI caused by *E. coli* was reported Imipenem and Nitrofurantoin with resistance rate of 13.2% and 19%, respectively.

To our knowledge, ampicillin or amoxicillin were used as the standard treatment for UTI, but various studies from around the world show increased resistance to ampicillin and oxacillin.[42,43] In agreement with their results, our results showed high resistance against oxacillin in both Gram-negative (76%) and Gram-positive microorganisms (79%), respectively.

Taking into account all these considerations, renal transplant recipients are at high risk for infections caused by MDR strains owing to surgical procedure, long stay in intensive care unit, having underlying diseases, and immunocomponent conditions.[41] Therefore, infection control measures have a positive impact on the prevention of UTI after renal transplantation.

Finally, findings from this systematic review and meta-analysis showed that the best antibiotics against Gram-negative bacteria were imipenem. Polymyxin B was an effective antibiotic against Gram-positive microorganisms; also, imipenem and nitrofurantoin can be used as the first and second-line treatments of pathogenic *E. coli* isolated from UTI in kidney transplant recipients.

CONCLUSIONS

Our systematic review and meta-analysis by combining data from previously published studies in Iran showed a noticeable rate of UTI (31.1%) among renal transplant recipients. As well as, a high prevalence of Gram-negative (69%) and Gram-positive (13%) microorganisms was observed, where *E. coli* (43.4%) and CoNS (10.2%) were the most among Gram-negative and Gram-positive bacteria, respectively. A high resistance rate was seen against almost all antibiotics used for the treatment of UTI caused by both Gram-negative and Gram-positive bacteria, too. Hence, arbitrary and long-term treatment and empirical prescription should be avoided. Therefore, the antibiotics prescription should be based on data achieved from antibiotic susceptibility tests.

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Conflicts of interest

There are no conflicts of interest.

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