REVIEW ARTICLE

Nursing Effect Analysis of Urinary Tract Infections in Urology Surgery Patients: a Systematic Review and Meta-analysis

Ailin Shan[1] · Muhammad Hasnain[2] · Ping Liu[3]

Abstract

This meta-analysis aims to identify urinary tract infections (UTIs) in patients with different levels of age groups. For both diagnosis and treatment of UTIs, antibiotics have been widely used in nursing home settings. We also aimed to evaluate the duration of catheterization in UTI patients to reduce catheter-associated complications. We conducted a systematic review that was performed following the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines and recommendations from Cochrane Collaboration. We performed a comprehensive search for published literature in PubMed, ScienceDirect, Taylor & Francis Online, Springer, and Wiley Online databases from 2010 to June 25, 2021. We performed two meta-analysis: the first meta-analysis (meta-analysis I) was performed on data obtained from included studies that compared patients with UTIs (experimental group) and without UTIs (control group); the second meta-analysis (meta-analysis II) was performed to assess the appropriate use of a catheter in UTI patients. All statistical analyses were conducted using the Review Manager 5.4 tool. A total of 15 research articles were included in this systematic review and meta-analysis. Of these, results showed the identification of critical patients with UTIs and without UTIs from nursing resident homes (risk ratio [RR] = 0.80 95% confidence interval CI = 0.69–0.93 $p < 0.0001$). Risk ratio results with random effects (RE) were obtained as RR = 0.69 95% CI = 0.26–1.83, $p = 0.45$, along with heterogeneity I^2 (96%) values. No appropriate prescription of antibiotics in UTIs is practiced among nursing home residents. In addition, pooled results between two groups (short-duration vs. long-duration catheterization) showed RR 0.66 95% CI 0.46–0.93 $p = 0.02$, $I^2 = 56$, that reduced complications associated with CAUTIs. This systematic review and meta-analysis suggested an appropriate use of agents and catheter insertion for a short duration at nursing homes.

Keywords Nursing home residents · Diagnostic and treatment technique · Agents · Antibiotics · Catheter

Introduction

Urinary tract infection (UTI) is a bacterial infection that can affect all age group populations. Bacterial growth of more than 10^5 has been known as solid bacterial growth. Evidence indicates that those patients with this threshold and lower bacterial counts may have urine infections [1].

Urinary infections in males mainly occur due to functional changes in urinary tract obstruction or instrumental procedures. UTI has become a leading reason behind the infection of nursing home residents. Nearly 12% of females and 13% of males have an indwelling urinary catheter upon the time of admission to nursing homes [2].

Women have a threefold higher risk for UTIs than the opposite gender. UTIs have become a challenge regarding the costs and administered antibiotics [3]. The continuous and low dose of antimicrobial prophylaxis can prevent UTIs in women. In addition, cranberry intake seems useful but requires more trials before making specific recommendations [4].

Nearly 50% of patients recruited in a routine check-up at the Stockholm Spinalis "spinal cord injury" (SCI) clinic reported ≥ 1 UTI during the preceding year. Patients with normal voiding had the lowest frequency, and those with the catheter-assisted voiding showed high numbers. Common

✉ Ping Liu
liuping19811130@sina.com

1 Department of Urology, Taizhou Jiangyan Hospital of Chinese Medicine, Taizhou, Jiangsu Province 225500, China

2 Lahore Leads University, Lahore, Punjab 42000, Pakistan

3 Department of Urology, The First Affiliated Hospital of Harbin Medical University Qunli Hospital, Heilongjiang Province, Harbin 150000, China

UTI symptoms and signs have been reported as smelly and cloudy urine, indicating the increased spasticity [5]. To avoid unnecessary antibiotic treatment, clinicians require an understanding of UTIs and their related symptoms.

Sacral neuro-modulation (SNM) is reported effective in refractory UTI dysfunction. The SNM offers a durable and sound solution to functional bladder issues if appropriate for patient selection. In a study conducted in Iraq, female patients' response rate for SNM was better than male patients [6].

The topic of UTIs regarding nursing home residents has remained popular for the last three decades. UTI was a common illness among nursing home residents [7]. Nursing homes' location might be one of the important influencing factors that could influence infecting organisms. Moreover, non-diagnostic criteria used for UTIs in elderly population can compromise the validity of conclusions [8].

The objectives of the systemic review and meta-analysis are as follows:

Nursing home care helps in diagnosing and treating patients after they undergo urology surgeries in hospitals. What are the existing UTIs' diagnosis and treatment approaches used at nursing resident homes? Therefore, we performed this systematic review to know the practical UTI (diagnosing and treating) techniques used at the nursing home.

Methodology

Design

This meta-analysis was conducted according to recommendations from Cochrane Collaboration [9] and PRISMA guidelines [10].

Inclusions and Exclusion Criteria

The inclusion criteria of this meta-analysis are as follows: (1) Each research article has a subject on patients with urinary tract infections. (2) The patients were identified into two groups. Patients in the first group had UTIs while patients in the second group were without UTIs. (3) the first outcome included the diagnosis and treatment strategies resulting from nursing home residents. (4) The second outcome included the CAUTIs with short-duration and long-duration catheterization and their effects on UTI patients. (5) Patients in the selected studies were above 18 years.

The exclusion criteria include the following points: (1) patients with poor life expectancy; (2) letters, editorials, and commentaries; and (3) duplicate studies with the same patients were excluded.

Search Strategy

Literature published in PubMed, ScienceDirect, Taylor & Francis Online, Springer, and Wiley Online from 2010 to September 25, 2021, was searched for relevant studies. Subject headings and variations were combined for the following:

"Nursing effects," "nursing home residents," "nursing homes," "surgery patients," "urinary tract infections," "diagnosis," "treatment," and "catheter-associated urinary tract infections" using Boolean operators. In Table 1, we present the search strategy for PubMed and Taylor & Francis online databases to find the relevant studies.

References of relevant articles and reviews were manually screened to identify the related studies missed by searching the electronic databases.

Study Selection

A referencing package Endnote X9 was used to manage references of studies. After removing the supplicates, two reviewers (AS and MH) independently performed studies' selection and inclusion process in two phases. Titles and abstracts of potentially eligible studies were assessed to remove the irrelevant studies. Next, full-length eligible papers were examined in detail. Any discrepancy was resolved with the consensus of the third reviewer (PL).

Data Extraction

Two researchers (AS and MH) were involved in extracting data from included studies independently. We extracted the main characteristics from studies including study "identification" (ID) (authors/references), study design, study location and setting, study participants, age, UTI type, and associated risk factors (listed in Table 2). Moreover, we extracted more features from included studies as listed in Tables 3 and 4 in "Results." As shown in Table 3, the extracted data includes

Table 1 Database search strategy

Database	Keyword
PubMed	(((nursing effects [Mesh]) AND ((nursing home residents [Mesh]) OR (nursing homes [Mesh]) AND (surgery patients [Mesh]))) AND (((urinary tract infections [Mesh]) AND (diagnosis [Mesh]) OR (treatment [Mesh]) OR (catheter-associated urinary tract infections [Mesh])))
Taylor & Francis Online	['Nursing effects AND nursing home residents OR nursing homes AND surgery patients AND urinary tract infections AND diagnosis OR Treatment OR catheter-associated urinary tract infections']

Table 2 Characteristics of studies regarding UTI treatment and diagnosis at nursing homes

Study ID/reference	Study design	UTI type	Agents	Technique	Nursing home location	Number of residents	Findings/comments
Kuil et al. [12]	Qualitative study	UTI diagnosis	Antimicrobials	Point-of-care testing (POCT)	Dutch nursing homes	18 physicians and nurses	Point-of-care testing (POCT) improves management in nursing homes
Bergman et al. [13]	point-prevalence study	UTI prophylaxis	Methenamine Vitamin C Estrogens Cranberry Trimethoprim Nitrofurantoin	UTI prophylactic prescription	Norwegian nursing homes	1473 residents	The nursing home lacked documented efficacy Agents for UTI prophylaxis were infrequently used
Cherubini et al. [14]	longitudinal observational study	UTI diagnosis	Not specified	Ad hoc questionnaire survey	Italian nursing homes	170	Adequate care and managing chronic disease and poly-pharmacy could be used to reduce hospitalization of nursing home residents
Phillips et al. [15]	Cross-sectional study	Asymptomatic bacteriuria (UTI)	Not specified	Multi-level multivariate analyses	Central Texas	151	About half of the prescribed antibiotics to residents at the nursing home were without documented signs Clinical decision-making in diagnosing the infection must base solely on diagnostic testing
D'Agata et al. [16]	Prospective study	UTI diagnosis	Not specified	Antimicrobial prescription	USA	266 residents	Symptoms and signs that meet the necessary criteria for antimicrobial initiation are absent. Patients with advanced dementia are not reconsidered for UTIs diagnosis and initiation
Handeland et al. [17]	Pilot study	UTI diagnosis	Black chokeberry juice or placebo chokeberry juice	Juice and placebo use	Byhagen, Lunde, Lura, Riska, Rovik, and Åse nursing homes (Norway)	236 residents	The subsequent reduction in antibiotics was observed from juices and placebo

Table 2 (continued)

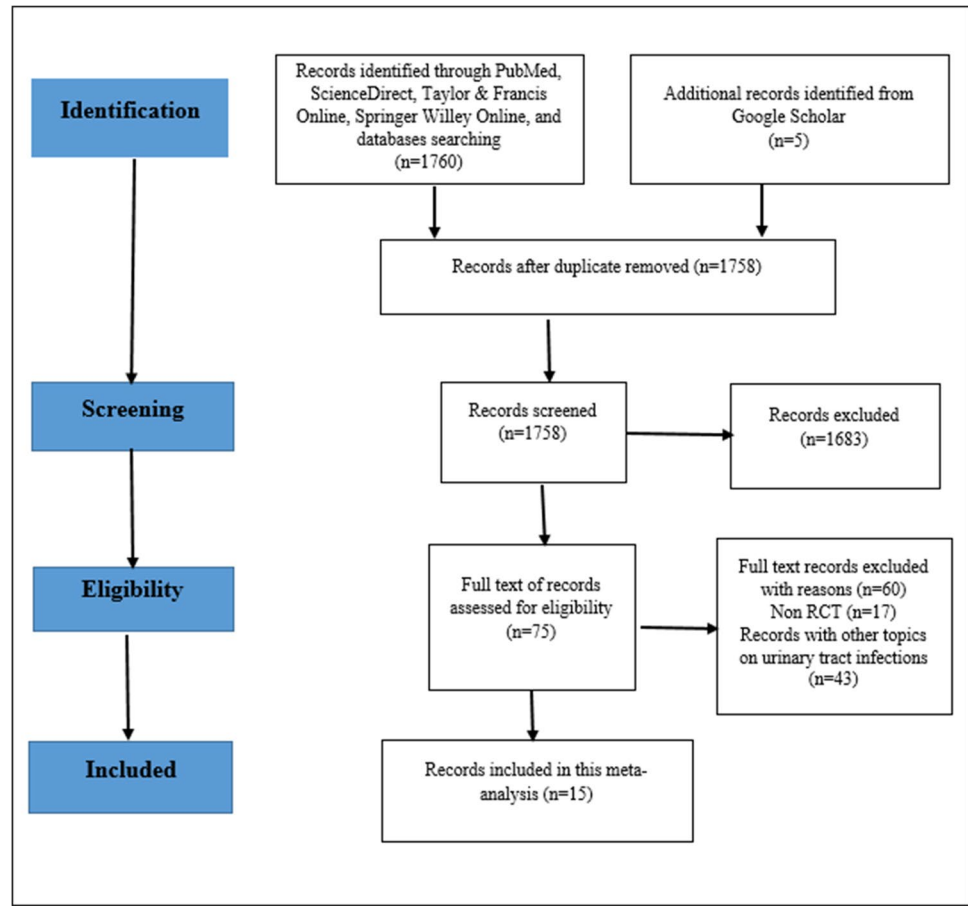| Study ID/reference	Study design	UTI type	Agents	Technique	Nursing home location	Number of residents	Findings/comments
Dufour et al. [18]	Prospective cohort study	UTI treatment	Not specified	Antimicrobial prescription	Boston, Massachusetts nursing homes	110 residents	There was no significant association between antimicrobial treatment and mortality for patients with advanced dementia and UTIs
Eure et al. [19]	Point-prevalence survey	UTI treatment	Prophylaxis Antimicrobials Trimethoprim/sulfamethoxazole	Antibiotic prescription	Four states of USA	1272 residents	Appropriate prescription of antibiotics may reduce UTIs
Rutten et al. [20]	(Cluster randomized controlled trial)	UTI diagnosis	Antibiotics	Physician and nursing staff education	Dutch nursing homes	897 residents	An appropriate antibiotic prescription is crucial for a successful UTI diagnosis
Cooper et al. [21]	Retrospective chart review	UTI design and diagnosis	**Not specified**	Cooper tool	Southeast Michigan	79 residents	An appropriate UTI treatment remained low. Treatment accuracy can reduce unnecessary antibiotic use

Table 3 Studies' characteristics used in the meta-analysis I

Study ID (authors/reference)	Study design	Study location and setting	Study participants	Age (years)	UTI type	Associated risk factor	Follow-ups
Hu et al. [22]	Prospective cohort study	Tainan City, Taiwan	321	65	Catheter-associated UTI	Longer stay in hospitals	Every day
Stenzelius et al. [23]	Prospective cohort study	Skåne University Hospital, Lund Sweden	322	>18	General UTI and febrile UTI	Delay in managing the patients	Not specified
Liu et al. [24]	Prospective and randomized	Chinese People's Liberation Army General Hospital	103	Not specified	Donor Renal Transplantation	UTIs' complications	3 months
Sundén and Wullt [25]	intervention study	Helsingborg Hospital, Lund Sweden	35	Not specified	Asymptomatic bacteriuria	Symptomatic infections	1 month
Wai et al. [26]	Observational study	Southport District General Hospital UK	82	Not specified	General UTI	Severity of sepsis	Not specified

Table 4 Characteristic of included studies about CAUTIs in meta-analysis II

Author, reference	Duration of using a catheter	Problems associated with CAUTIs	Treatment lasted	Outcome measures	Follow-up time
Stenzelius et al. [23]	7–10.5 days	Cranial bleeding, cerebral infection	9 days	The coated catheter had no advantages	Not specified
Liu et al. [24]	1–4 weeks	Urinary leakage and obstruction	Not specified	Adverse catheter outcomes	3 months
Wilde et al. [27]	5–8 days	Catheter blockage	30.44 days	Adverse catheter outcomes	12 months
Barchitta et al. [28]	<7 and >7 days	Sepsis	7 days	Improving the patients with CAUTIs	Not specified
Garbarino et al. [29]	2–5 and 30 days	Cardiovascular and chronic kidney disease	Not specified	Number of prosthetic joint infections (PJIs)	389 days

Fig. 1 Flowchart of studies' search and selection

study ID (authors/references), study design, study location and setting, study participants, age, UTI type, associated risk factors, and follow-ups.

Quality Assessment

This work used the Newcastle–Ottawa scale (NOS), which includes three components: the selection of patients, comparison of studies, and outcome assessment [11]. These components are used to evaluate the quality of included studies. Two authors (MH and PL) performed this task and agreed upon it through the discussion.

Statistical Analysis

All statistical analyses in this study were performed using Review Manager 5.4.1 version. The fixed-effect and random-effect models were used to combine the data extracted from included studies. We calculated the risk ratio (RR) and 95% confidence interval (CI) in the dichotomous data. The heterogeneity between studies was evaluated by using chi-squared and I^2 tests. A p value < 0.10 and $I^2 > 50\%$ showed a substantial statistical heterogeneity. A forest plot represented and evaluated treatment effects in this meta-analysis.

Treatment effects for calculating heterogeneity across the included studies were analyzed. Otherwise, the authors used a fixed-effect model. The sensitivity analysis was conducted to determine the stability and robustness in results in this paper. We performed a subgroup analysis of patients with UTIs and non-UTIs from nursing home residents. In addition, a subgroup analysis between short-duration catheterization vs. long-duration catheterization was performed. A funnel plot was used to assess the publication bias.

Results

In Fig. 1, we illustrate the process of selection, inclusion, and exclusion criteria of studies in this systematic review and meta-analysis.

Search Results

Figure 1 shows the illustration of the search results. Based on the search strategy, 1765 research articles were returned from search keywords. After removing duplicate studies, we excluded 1683 papers by assessing their abstracts and titles. Of the remaining papers, we eliminated 60 studies by
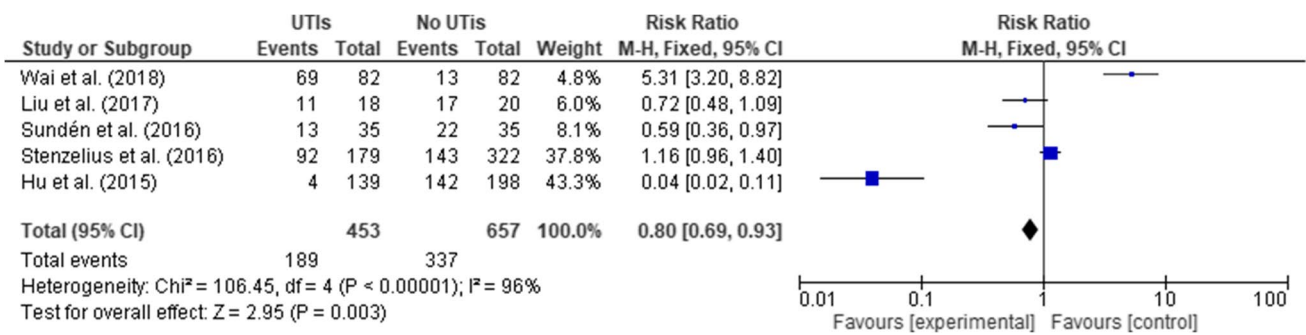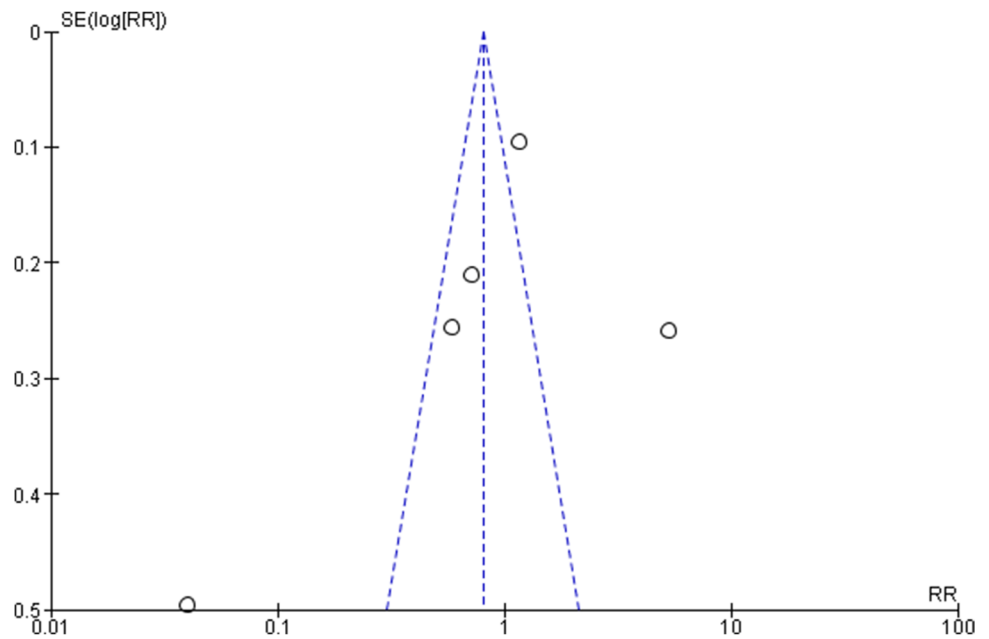
Study or Subgroup	UTIs Events	Total	No UTIs Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Wai et al. (2018)	69	82	13	82	4.8%	5.31 [3.20, 8.82]
Liu et al. (2017)	11	18	17	20	6.0%	0.72 [0.48, 1.09]
Sundén et al. (2016)	13	35	22	35	8.1%	0.59 [0.36, 0.97]
Stenzelius et al. (2016)	92	179	143	322	37.8%	1.16 [0.96, 1.40]
Hu et al. (2015)	4	139	142	198	43.3%	0.04 [0.02, 0.11]
Total (95% CI)		453		657	100.0%	0.80 [0.69, 0.93]
Total events	189		337			

Heterogeneity: Chi² = 106.45, df = 4 (P < 0.00001); I² = 96%
Test for overall effect: Z = 2.95 (P = 0.003)

Fig. 2 Risk ratio with a fixed-effect model in meta-analysis 1

Fig. 3 Funnel plot of meta-analysis I

Study Characteristics

Five thousand five hundred twenty-six patients from 15 studies were included in this systematic review and meta-analysis. One article did not provide the number of patients. Physicians and nurses were reported in that study. A survey was conducted to test the importance of "point-of-care testing" (POCT) as a UTI diagnosing technique at nursing resident homes [12]. Information on the ten included studies in this systematic review is presented in Table 2.

Table 2 shows us the data extracted from ten included studies with 4672 patients in this systemic review. Study designs of included articles are shown in the second column of Table 2. Studies [12, 14, 16, 17, 20, 21] were mainly focused on diagnosing UTIs in patients, while studies [18, 19] investigated the treatment approaches of UTI patients. The rest of the studies [13, 15] assessed UTI prophylaxis and asymptomatic bacteriuria (UTI), as shown in Table 2. There were five studies [15, 16, 18, 19, 21] performed at nursing homes in the USA, two each in Norway [13, 17] and the Netherlands [12, 20]. Study [14] was conducted at nursing homes in Italy. Studies [12, 13, 17, 19, 20] mentioned the agents used to treat patients at nursing homes. All of the included studies reported techniques to diagnose or treat UTI patients at nursing homes. The patients' range in these studies varied between 79 and 1473. Finally, Table 2 shows us the findings of the included studies. In Table 3,
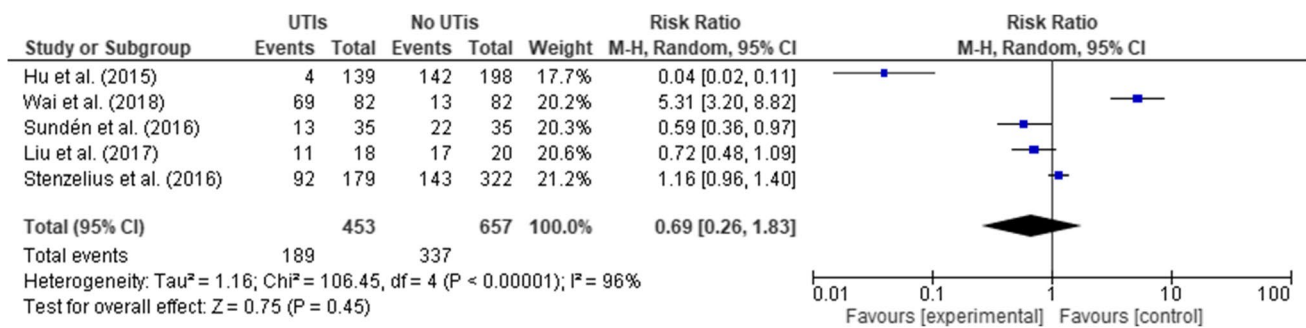
reading them thoroughly. Finally, 15 articles were selected based on the inclusion/exclusion criteria in this study. Among the selected 15 articles, ten studies underwent data extraction (Table 2), while the rest of the articles were examined thoroughly to collect the information (Table 3).

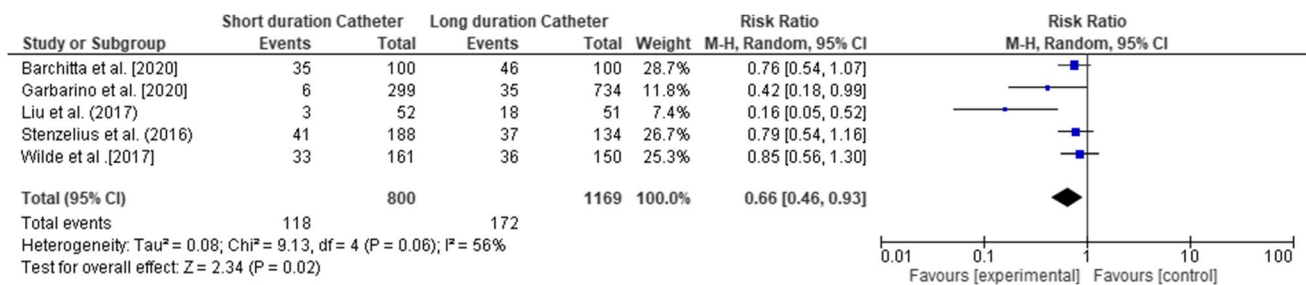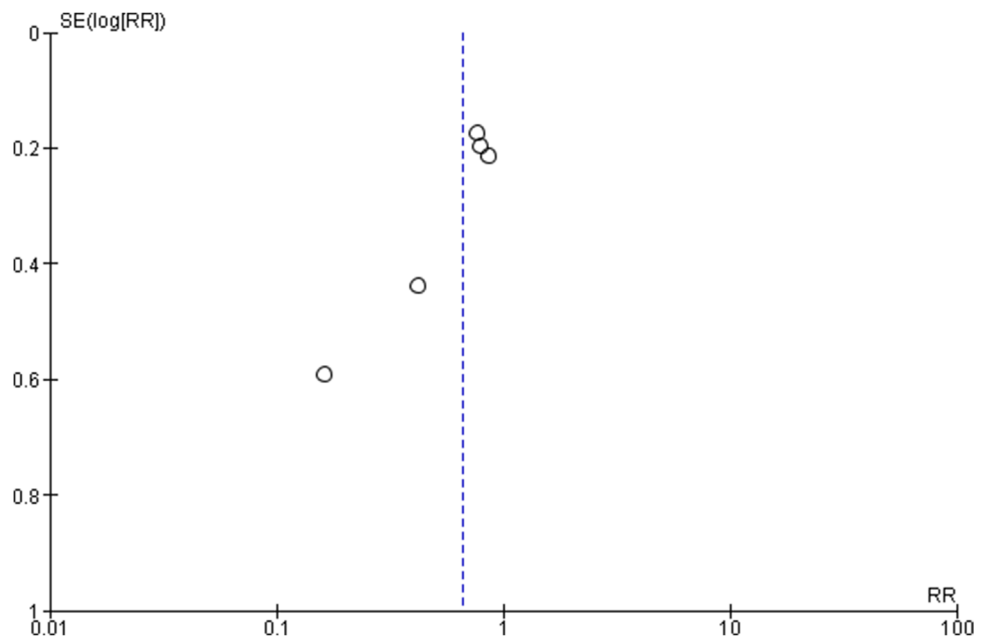**Fig. 4** Risk ratio with a random-effect model in meta-analysis 1

Fig. 5 Risk ratio with the random-effect model in meta-analysis 1I

Fig. 6 Funnel plot of meta-analysis II

we show characteristics of five studies that qualified for the subgroup analysis with UTIs vs. non-UTIs patients from nursing homes.

The results showed the identification of patients with UTIs and without UTIs (0.80, 95% CI = 0.69–0.93, $p < 0.0001$; Fig. 2). A significant heterogeneity ($I^2 = 96\%$)

was achieved from the random-effect model (see Fig. 3). If we deleted the study [23], we did not receive any significant difference in the heterogeneity I^2 value among studies. Sensitivity results also showed stability in results.

Catheter-Associated Urinary Tract Infections (CAUTIS)

Five studies [23, 24, 27–29] reported the events of UTIs in patients at nursing homes (Table 4). All studies showed a trend of lower effects on patients with short-duration vs. long-duration catheterization (Fig. 4). Pooled results demonstrated differences between two groups (short-duration catheterization vs. long-duration catheterization) (RR 0.66 95% CI 0.46–0.93 $p = 0.02$) (Fig. 5). The heterogeneity ($I^2 = 56\%$) among studies was reported, which is considered to be medium.

Figures 4 and 6 represented the funnel plots that indicated no evidence of publication bias in our performed meta-analyses I and II.

Publication Bias

Publication bias of the included studies was examined using patients with UTIs and without UTIs from nursing homes. This was achieved by studying the diagnosis and treatment techniques of patients with UTIs at different nursing home residents. There was no significant publication bias among the included literature (Fig. 3). The figure above shows us heterogeneity and test for overall effect values from the random-effect model.

A standard random-effect model directly models the effect measures, which show a contrast between the two groups. We have observed similar values of heterogeneity $I^2 = 96\%$ from fixed- and random-effect models (see Figs. 3 and 4). The fixed-effect model and random-effect model show that there is a lot of between-study variances.

Discussion

UTI is a common infection, and there are some common approaches presently used in nursing homes. Diagnosis and treatment nursing effects are mainly studied in the literature. The majority of the approaches suggested using the antimicrobial to treat UTI patients at nursing home residents. Thus, there is a lack of other types of practical nursing approaches, which can be proposed to improve the conditions of UTI patients at nursing homes. Findings of a study by Dufour and colleagues revealed no association between patients treated with antimicrobial agents and mortality [18]. Patients with UTIs and dementia treated by antimicrobials had no compelling survival advantages at nursing resident homes.

This systemic review and meta-analysis indicated that UTI patients were given some agents in the severe conditions at nursing resident homes [13, 19]. However, infrequent use and document efficacy remained crucial issues to achieve the desired results at nursing homes. However, the literature also suggested that proper agent use might help reduce UTIs among patients. This is not practiced at nursing homes. At the same time, a study reported that juices and placebo effectively reduced the UTIs among patients [17]. The patients with UTI were offered high phenolic contents, including chlorogenic acids, B-type procyanidins, and anthocyanin daily for a more extended period. As compared to patients treated with antibiotics, the use of juices and placebo remained effective. Therefore, we need to be very careful in treating UTI patients with antibiotics or supplements at nursing homes. This meta-analysis indicates that appropriate treatment of UTIs or appropriate prescription of antibiotics is crucial for proper treatment at nursing homes. Studies [17, 20, 21] supported this claim in the current meta-analysis.

The duration of catheters among patients has been shown as an important risk factor [30]. This meta-analysis demonstrated that the short duration of catheterization has lower adverse impacts on patients than the long duration of catheterization. Short catheterization duration was defined as inserting a catheter for ≤ 7 days in patients at nursing homes. On the other hand, a long duration was termed as the insertion of a catheter for > 7 days among patients at nursing homes. In light of the results and their findings, insertion of a catheter for a short duration reduces complications, including sepsis development, catheter blockage, cranial bleeding, cerebral infection, and chronic diseases. Regarding UTIs and their treatment duration, studies [23] and [28] reported 9- and 7-day durations of treatment, respectively. However, a study [27] reported a 30.44-day longer treatment period for CAUTI patients. This might be due to complications among CAUTI patients or required treatment standards at various nursing homes.

Based on the findings of this meta-analysis, a pragmatic approach can be proposed for the precise use of antibiotics in nursing resident homes. Moreover, nursing staff working at nursing resident homes may get appropriate training and education to prescribe antibiotics to patients. An innovative system may be proposed to document the prescription of each patient at nursing resident homes. In addition, more research trials can be conducted to know the association between two groups (long-term vs. short-term treatment of CAUTI patients) at nursing homes.

Strengths and Limitations

The strengths of this meta-analysis include the following.

In comparison with the existing systematic review and meta-analysis studies, this meta-analysis presented

comprehensive results. We searched the most popular digital libraries, including PubMed, ScienceDirect, Taylor & Francis Online, Springer, and Wiley Online. At the same time, an earlier published meta-analysis includes published data from MEDLINE, EMBASE, and the Cochrane libraries [31]. Recent works only show the effective use of cranberry against UTIs [31, 32]. This meta-analysis identified other agents published in the literature used against the UTIs at nursing homes. We recognize the appropriate use of antibiotics to reduce UTIs at nursing homes, while authors in a meta-analysis did not reveal the risks associated with the help of antibiotics [33]. We identify the appropriate diagnosis and treatment approaches published in the literature. Treatment approaches based on prescription of antibiotics and development of a decision tool to avoid over-prescription of antibiotics were better approaches identified in this paper. An integrated decision tool with the "electronic health records" (EHRs) helps in diagnosing the UTIs in patients.

Methenamine to be used without any limitation in duration of treatment was an important agent. This meta-analysis suggested the use of antibiotics for asymptomatic UTIs for a short duration 1–2 weeks. POCT carries the risk of unnecessary antibiotic treatment for UTI patients that may increase the exposure of side effects and drug interaction. Urine reflux is a common risk factor for prophylactic treatments of UTIs.

Indwelling catheter use has higher complications. For a longer duration of catheterization, the complication percentage is higher than 50% in patients as determined in this meta-analysis. On the other hand, it reduces to 33% in patients with catheterization for a shorter duration.

This meta-analysis has a few limitations as follows.

First, the included studies are prospective, observational, or retrospective studies, which show a low level of evidence. Thus, this meta-analysis lacked the inclusion of randomized controlled trials. Second, patients chosen from different nursing homes of UK, China, Taiwan, European countries, and US states and proposed UTI diagnosis and treatment strategies may differ in their practical use in other parts of the world. This meta-analysis did not include any study undertaken in Africa and Australian sub-continents. Finally, due to the COVID-19 pandemic, a priority by publishing companies is given to research articles on COVID-19 topics. Therefore, research articles on UTIs topic may take less precedence for publication.

Conclusions

This meta-analysis identified the patients with UTIs from different nursing resident homes located in various parts of the world. Patients with UTIs at nursing resident homes require an appropriate and careful use of antibiotics to reduce the infection rate among patients. Nursing homes lacked document efficacy, and nursing staff infrequently used the agents against the UTIs. Even the prescribed antibiotics were documented without valuable signs. This meta-analysis also showed that the short-duration catheterization reduced the complications compared with the prolonged duration catheterization in patients.

Declarations

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