BMJ Open

Methenamine hippurate for the management and prophylaxis of recurrent urinary tract infections: a scoping review protocol

Abhisekh Chatterjee ,[1] Iihan Ali,[1] Franklyn Wong,[1] Andrea M Allen-Tejerina,[2] Nikolaos Chatzikrachtis,[3] Katie McComb,[3] Samuel Bishara,[3] Diane De Caluwe,[4] Nikolaos Zavras,[5] Joseph M Norris,[6] Panagiotis Nikolinakos [3,5]

To cite: Chatterjee A, Ali I, Wong F, *et al*. Methenamine hippurate for the management and prophylaxis of recurrent urinary tract infections: a scoping review protocol. *BMJ Open* 2025;**15**:e100458. doi:10.1136/bmjopen-2025-100458

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2025-100458).

Received 09 February 2025
Accepted 11 April 2025

For numbered affiliations see end of article.

Correspondence to
Abhisekh Chatterjee;
abhisekh.chatterjee20@imperial.ac.uk

ABSTRACT

Introduction Recurrent urinary tract infections (rUTIs) are typically treated using antibiotics. Given the growing issue of antimicrobial resistance, non-antibiotic management options for rUTIs have faced a recent resurgence in popularity. Methenamine hippurate is a urinary antiseptic used as a non-antibiotic prophylactic measure in those with rUTIs. The results of a recent randomised controlled trial showed methenamine hippurate to perform on par with antibiotic prophylaxis in adult women with rUTIs. However, little is known about the efficacy of methenamine hippurate in vulnerable patient populations, such as children, the elderly, patients with indwelling catheters and those with renal tract abnormalities. Moreover, an up-to-date, comprehensive evaluation of the entirety of the literature surrounding methenamine hippurate has yet to be carried out. As such, key trends within the literature, such as common side effects and specific avenues for future research, are difficult to determine. Therefore, we developed the methodology for a scoping review to map the entirety of the existing evidence base for methenamine hippurate.

Methods and analysis The protocol for this scoping review was developed in accordance with the framework set out by Arksey and O'Malley. We will search MEDLINE, Embase, Scopus, the Cochrane Central Register of Controlled Trials and ProQuest Dissertation and Theses from inception until August 2024, with no language restrictions applied. Studies including patients of any age and sex receiving methenamine hippurate treatment, either as a primary or adjunct treatment for rUTIs, will be eligible for inclusion. Interventional studies, such as randomised controlled trials and their protocols, non-randomised clinical trials, cohort studies, case-control studies and observational studies of any design, will be included. Grey literature, systematic reviews and qualitative studies will also be included. Two independent reviewers blinded to each other's decisions will assess the eligibility of articles at each stage using the Covidence review platform. After the relevant data from each study has been extracted, we will report the results of our scoping review using descriptive summary statistics and a narrative thematic analysis.

Ethics and dissemination Due to the nature of the present study, ethical approval was not required for this scoping review. The final manuscript of this scoping review will be published in an international, peer-reviewed journal and the findings of the review presented in relevant national and international conferences.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The methodology for this scoping review was developed in accordance with the frameworks set out by Arksey and O'Malley in 2005 and further expanded on by Levac *et al* in 2010 and the Joanna Briggs Institute in 2021.
⇒ In order to capture the full breadth of the evidence base, we developed database-specific search strategies and did not restrict our searches to any particular language or time period.
⇒ We will not assess the weight (by conducting a meta-analysis, for example) of the identified evidence, as this falls outside of the purview of a scoping review.

INTRODUCTION

Urinary tract infections (UTIs) are one of the most common forms of bacterial infection worldwide.[1] UTIs can be classified as affecting the upper or lower urinary tract.[2] Lower UTIs in female patients can be classified as uncomplicated, provided they occur in the absence of comorbidities or renal tract abnormalities.[2] Lower UTIs in every other patient population, irrespective of existing comorbidities, are considered to be complicated.[3] Upper UTIs, regardless of the population in which they occur, are always considered to be complicated.[2] Approximately 50%–60% of all women will experience a UTI in their lifetime.[4] A recurrent UTI (rUTI) is defined as two or more UTIs in a 6-month period or three or more UTIs within 1 year.[5] Whilst the true prevalence is difficult to determine, it is thought that 20%–30% of women with a UTI will experience a recurrence.[6] In addition to

impairments in quality of life for an individual, rUTIs also exert a significant psychological burden on a patient as well as an economic burden on the broader healthcare system.[6] The role of antibiotics in rUTI management is prominent; acute treatment of each recurrence with antibiotics and prophylactic low-dose daily antibiotic suppression are both common mainstays of treatment.[1] However, given the ever-developing issue of antimicrobial resistance,[7] there is a growing interest in non-antibiotic management options for rUTIs.

One such non-antibiotic management option for rUTIs is methenamine hippurate. Preparations of methenamine, a cyclic hydrocarbon, have been utilised as a urinary antiseptic for decades.[8 9] In the environment of acidic urine, a salt preparation of methenamine degrades to form ammonia and formaldehyde; the latter is thought to act as a bacteriostatic agent by inhibiting bacterial cell division.[10] Methenamine hippurate is often thought to have gone overlooked by most clinicians,[11] with most guidelines providing no strong recommendation regarding the use of methenamine hippurate for long-term rUTI prevention in women.[12] Nonetheless, methenamine hippurate is widely prescribed in some Scandinavian countries,[13] particularly in Norway.[14] Following the resolution of a 4-month drug shortage of methenamine hippurate in Norway, the number of prescriptions for methenamine hippurate rose as prescriptions for UTI antibiotics fell sharply.[15]

Recently, methenamine hippurate has faced a resurgence in popularity. The ALTAR non-inferiority randomised controlled trial (RCT) found methenamine hippurate to be equivalent to antibiotic therapy at reducing the incidence of rUTIs in a large cohort of adult women.[13] Two recent systematic reviews of the literature, similarly focused on adult women with uncomplicated rUTIs, identified that methenamine hippurate performed on par with antibiotic prophylaxis.[16 17] Recent reviews, both systematic reviews and those looking broadly at non-antibiotic treatments for rUTIS,[8 9] have not investigated the efficacy of methenamine hippurate in vulnerable patient populations. rUTIs are a common problem in the elderly, and diagnosis and management can prove to be challenging in the presence of multiple comorbidities, contraindications to antibiotic treatment and the increased risk of *Clostridium difficile* infections due to prolonged antibiotic use.[18–20] Indeed, elderly women are particularly vulnerable to UTIs, with the prevalence of UTIs being almost threefold higher in this population.[5] In children, long-term infection of the urinary tract can have, although rare, negative consequences on kidney function in later life,[21] and long-term prophylactic antibiotic regimens are typically not recommended.[22] Moreover, patients with indwelling catheters are at greater risk for developing catheter-related UTIs.[23 24] It is unclear to what extent the literature has evaluated methenamine hippurate's viability in these vulnerable patient subgroups.

In the existing literature, a Cochrane review of RCTs last updated in 2012 did identify a number of studies that evaluated methenamine hippurate's effectiveness in diverse populations of patients with both complicated and uncomplicated UTIs.[25] Given methenamine hippurate's recent resurgence in popularity, an updated review of the literature is warranted. Moreover, non-randomised studies, cohort studies and institutional experiences have likely gone overlooked by systematic reviews of RCTs[16 17] and reviews of only the most recent evidence.[26 27] As a result, there is difficulty in ascertaining the necessity of systematic reviews focusing on methenamine hippurate's efficacy in the aforementioned subgroups; indeed, it is unclear whether the recent evidence base has evaluated methenamine hippurate's effectiveness in these patients at all. These knowledge gaps are the primary focuses of our scoping review.

Scoping reviews are conducted to identify a breadth of studies within a field of research.[28 29] Scoping reviews can be applicable to any domain, including the implementation of healthcare practices,[30] surgical procedures[31] or the effects of a particular medication,[32 33] and employ a systematic methodology but forego subsequent meta-analyses in favour of characterising the breadth of and trends within the extant literature.[28 29] Scoping reviews are commonly used to identify whether systematic reviews, which typically focus on a specific patient population, are warranted.[34] As such, scoping reviews are perfectly suited to both characterise a broad evidence base and, as a result, to identify gaps that exist. Thus, we identified that a scoping review framework provided a methodologically sound, systematic method to characterise and summarise the evidence surrounding methenamine hippurate. To date, a rigorous, inclusive assessment of methenamine hippurate's evidence base has yet to be undertaken.

We will conduct a scoping review to systematically map the existing evidence base surrounding methenamine hippurate as a treatment for or prophylactic measure against rUTIs. Assessing the literature in this holistic manner will allow for the identification of patient populations that have and have not been evaluated in the literature thus far. Our work will identify avenues for future research into methenamine hippurate's efficacy in these patient subgroups, including focused systematic reviews and novel RCTs. Moreover, we will characterise how methenamine hippurate has been evaluated up until now, including whether it is more commonly used as a standalone medication for prophylaxis, alongside antibiotics or alongside other non-antibiotic treatments for rUTIs. Moreover, no review to date has yet covered in detail whether methenamine hippurate can be used to prevent UTIs postoperatively or to prevent catheter-associated UTIs. By characterising the literature in this rigorous, detailed manner, we seek to provide specific suggestions to guide future research. In this study, we outline the methodological approach of our scoping review in keeping with the guidance originally set out by Arksey and O'Malley[28] and further expanded on by Levac *et al*[35] and the Joanna Briggs Institute.[29] The framework for this protocol outlines our approach to the four stages

of a scoping review[28]: identifying the research questions, identifying relevant studies, study selection and reporting the data. This scoping review protocol was prospectively registered on the Open Science Framework (OSF) (https://doi.org/10.17605/OSF.IO/NWMB8).

METHODS

This protocol was written in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews checklist (PRISMA-ScR)[36] (online supplemental file 1).

Research questions

As outlined by Arksey and O'Malley,[28] the first stage of conducting a scoping review involves identifying the pertinent research questions. Based on our understanding of the current evidence surrounding methenamine hippurate as a management option for rUTIs, we developed the following research questions that our scoping review seeks to address:

1. In what patient populations has the efficacy of methenamine hippurate already been investigated, and, conversely, in what patient demographics is there a lack of research into the efficacy of methenamine hippurate for the management of rUTIs?
2. How effective is methenamine hippurate in managing rUTIs in these patients (as defined by each study's endpoints), and does its efficacy vary between different patient populations?
3. In what manner is methenamine hippurate evaluated? That is, as a standalone prophylactic measure, an adjunct to antibiotic treatment or alongside other non-antibiotic treatments for rUTIs?
4. What dosage of and over what time course is methenamine hippurate commonly given in the extant literature, and does this vary between studies?
5. What are the commonly reported side effects of methenamine hippurate?
6. What are the geographical and temporal trends in research investigating the efficacy of methenamine hippurate? In other words, is methenamine hippurate evidently more popular in certain countries, and is there a reason for this?

Search strategy

In order to identify potentially eligible studies for inclusion in our scoping review, we will conduct a systematic search of five databases: MEDLINE, Embase, Scopus, the Cochrane Central Register of Controlled Trials (CENTRAL) and ProQuest Dissertation and Theses Global. A thorough search strategy for each database was developed using key terms identified from our research questions and Medical Subject Heading (MeSH) terms and was adapted to suit each database accordingly using the appropriate Boolean operators, database-specific MeSH terms and database-specific syntax (online supplemental file 2, table S1). Key terms included but were not limited to 'methenamine hippurate', 'recurrent urinary tract infections', 'rUTIs' and 'urinary tract infections'. The polyglot search translator was used to aid the process of constructing the search strategy. Databases will be searched from inception up until 10 August 2024, and no language filters will be applied. Prior to the final analysis, the searches will be re-run up until the present day, and any additional studies meeting the eligibility criteria will be included. In addition to database searching, citations of relevant articles will be manually exported and included within the screening process. For studies not given in the English language, a suitable translated version will be sought, either from the authors themselves or using Google's inbuilt translation software.

Identification of eligible studies

Identified studies will be assessed for eligibility using the Population, Concept and Context framework set out by Arksey and O'Malley[28] and the Joanna Briggs Institute.[29] With respect to the population, we will include studies investigating patients with rUTIs, with the strict definition of rUTI being defined by each study individually. Owing to the broad nature of our scoping review, we will include studies investigating both adult (>16 years old) and paediatric (<16 years old) patients with both complicated and uncomplicated rUTIs receiving methenamine hippurate for UTI prophylaxis (ie, long term). We will also include studies where methenamine hippurate is used as an adjunct (eg, alongside conventional antibiotics) or as a control arm. As methodology is likely to be heterogeneous between studies, we have no specific exclusion criteria relating to a comparator; this may be a placebo, conventional antibiotic suppression or no treatment at all. Studies investigating methenamine hippurate for UTI prophylaxis, for example, following surgery or in those with long-term catheters (irrespective of whether these patients have a history of rUTIs or not) will also be included. We will exclude studies conducted exclusively in vitro and in non-human participants. Studies in which patients are given methenamine hippurate for any indication other than rUTI management or UTI prophylaxis will be similarly excluded.

With regard to the context, we will include studies conducted in any healthcare or community setting. We will also include grey literature (in the form of conference abstracts) and systematic reviews of the literature (irrespective of whether a subsequent meta-analysis was undertaken). In order to capture the full breadth of the evidence base, qualitative studies investigating patient or clinician perspectives on methenamine hippurate will also be included. Narrative literature reviews, case reports and case series with fewer than five patients and research letters containing no novel research will be excluded. The full details of the inclusion and exclusion criteria are provided in table 1.

Retrieved articles from each database will be exported and uploaded to Covidence, a digital platform built to facilitate and streamline the process of carrying out systematic

Table 1 Inclusion and exclusion criteria for assessing eligibility of studies

	Inclusion criteria	Exclusion criteria
Population	► Male, female and paediatric patients with recurrent urinary tract infections (rUTIs). ► Male, female and paediatric patients at higher risk for UTIs (eg, postoperatively, or with indwelling or long-term catheters) who are eligible for UTI prophylaxis.	► Studies conducted in non-human participants (eg, in vivo research) and in vitro research.
Concept	► Patients given methenamine hippurate for the management of rUTIs. ► Patients at higher risk for UTIs (such as those with long-term catheters, or postoperatively) receiving methenamine hippurate for UTI prophylaxis. ► We will include studies that use methenamine hippurate as a control arm or as an adjunct medication (alongside, eg, conventional antibiotic prophylactic therapy).	► Studies involving patients given methenamine hippurate for any indication other than rUTIs (eg, exclusively asymptomatic bacteriuria) or UTI prophylaxis. ► Studies that focus exclusively on other non-antibiotic treatments for rUTIs, for example, cranberry products or D-mannose not used alongside methenamine hippurate.
Context	► Studies conducted in primary (eg, patients in the community), secondary (eg, hospitalised patients) and tertiary care (eg, specialist centres) settings will be included. ► Studies conducted in ambulatory care settings, pharmacies and nursing homes will also be included. ► Studies must report an outcome measure related to rUTIs; this includes but is not limited to the frequency, duration, the growth of drug-resistant bacteria and adverse side effects. ► Qualitative studies exclusively investigating personal views or satisfaction with a treatment regimen of methenamine hippurate, from either the patient or provider perspective. ► Systematic reviews of the literature regarding methenamine hippurate.	► Narrative (ie, lacking systematic review methodology, including formal database searching and prospective registration in the PROSPERO database) reviews of the literature surrounding methenamine hippurate.
Study type	► Randomised controlled trials (RCTs). ► Protocols for ongoing RCTs. ► Cohort studies. ► Case-control studies. ► Observational studies. ► Non-RCTs. ► Protocols for planned or ongoing trials/studies ► Qualitative studies. ► Systematic reviews (with or without accompanying meta-analyses) of the literature. ► Conference abstracts.	► In vitro studies. ► Case reports and case series <5 patients. ► Letters, editorials and short communications. ► Narrative (ie, non-systematic) reviews of the literatures. ► Rapid reviews.

reviews.[37] First, duplicate articles will be removed. Remaining articles will undergo title and abstract screening as per the eligibility criteria (table 1). This will be undertaken by two independent reviewers (AC, IA, FW, PN) who will be blinded to each other's decisions. A disagreement between reviewers will be resolved either via a third independent reviewer or by discussion among researchers. Included articles will then undergo full-text screening by two independent reviewers, again blinded to each other's decisions, with conflicts resolved by discussion among reviewers or, if this is unsuccessful, by a third reviewer. At the full-text review stage, the specific reason for exclusion will be recorded. The details of the screening process will be reported using a PRISMA flowchart.[29]

Charting the data

Data will be extracted from each included study using a data extraction form. This data extraction form contains key information regarding each study and was developed in line with our PCC framework. This includes but is not limited to information regarding the nature of the study design, the year of publication, whether patients were randomly assigned to a treatment or not, the characteristics of the included patients, the dosage and time course of methenamine hippurate treatment, UTI frequency pre- and post-intervention, outcome measures used and reported side effects (table 2). Data from included qualitative studies and systematic reviews will be extracted using separate data extraction forms (online supplemental file 2, table S2, S3 respectively) owing to their distinct methodology.

This data extraction tool will be implemented into Covidence and initially piloted by two authors (AC, PN) on five included studies to internally assess its validity prior to the commencement of data extraction, in line with recommendations from Levac *et al* in 2010.[35] If needed, the data extraction fields will be expanded on or edited by the senior authors. Once this is complete, data extraction will be undertaken by one reviewer for each study (AC, IA, FW, PN) with a second independent author checking the extracted data against the original study. The data extraction process will be iterative and collaborative,[35] with any disagreements or difficulty in extracting heterogeneous data being resolved through discussion and consideration between the authors. In addition to extracting data from each study, we will also assess the quality of included trials and observational studies. This will be conducted in duplicate for each study (AC, IA, FW, PN),

Table 2 Data extraction fields

Category	Data extraction fields
Study characteristics	► Study citation ► Year of publication ► Country of origin ► Study design ► Treatment allocation randomisation (Y/N) ► Protocol for an ongoing study (Y/N)
Participant characteristics	► Control group characteristics (if applicable) ► Intervention group characteristics ► UTI aetiology control group (if applicable) ► UTI aetiology intervention group ► Control group sample size ► Intervention group sample size ► Follow-up time
Methenamine hippurate regimen	► Control group medication details (including dosage, adjunct therapy, time course) ► Intervention group methenamine hippurate details (including dosage, adjunct therapy, time course)
Outcomes	► Outcome measure(s) utilised ► Control group UTI frequency pre-intervention ► Intervention group UTI frequency pre-intervention ► Control group UTI frequency post intervention ► Intervention group UTI frequency post intervention
Side effects	► Side effects reported (Y/N) ► Details of reported minor side effects ► Details of reported severe side effects ► Minor side effects (individual and overall rate) ► Severe side effects (individual and overall rate)

UTI, urinary tract infection.

with any disagreements being resolved by consensus among reviewers. For RCTs, the Cochrane Risk of Bias 2 tool will be used.[38] For non-randomised trials, the Risk of Bias in non-randomised studies – of interventions (ROBINS-I) tool will be utilised.[39]

Collating, summarising and reporting the results

After charting the data, reporting the results of a scoping review is separated into three phases:[35] 1) descriptive numerical summary analysis and qualitative thematic analysis, 2) reporting the results in line with the research questions and 3) Discussion of the future implications of the findings of the scoping review.

First, the extracted data will be exported as a CSV file to undergo further analysis. Data analysis will be undertaken using a combination of R[40] and Microsoft Excel. Initially, study characteristics will be grouped together (eg, methodological approach, patient characteristics, methenamine hippurate regimen, reported outcomes), tabularised and presented in the final manuscript. Where possible, we will calculate and present simple descriptive summary statistics (eg, the proportion of patients reporting side effects of methenamine hippurate across studies). We will use the extracted data to construct evidence maps and simple descriptive figures that will holistically outline the key trends and patterns within the extant literature surrounding methenamine hippurate. Depending on the nature and intrinsic heterogeneity of the extracted evidence, we may construct bar charts, line graphs, word clouds, network diagrams and conceptual frameworks, all popular methods of data visualisation within scoping reviews.[41] Qualitative thematic analysis will also be undertaken. Key themes between studies will be identified by discussion among the reviewers, and these will be grouped in accordance with the research questions of our scoping review. These themes will be addressed in a narrative manner in the final manuscript, and their implications for future research will be addressed accordingly.

ETHICS AND DISSEMINATION

Due to the nature of the present study, ethical approval was not required for this scoping review. The final manuscript of this scoping review will be published in an international, peer-reviewed journal, and the findings of the review presented in relevant national and international conferences.

Author affiliations
[1]Imperial College School of Medicine, Imperial College London, London, UK
[2]Lister Hospital, East and North Hertfordshire NHS Trust, Stevenage, UK
[3]Department of Urology, West Middlesex University Hospital, Chelsea and Westminster Hospital NHS Foundation Trust, London, UK
[4]Department of Paediatric Surgery and Urology, Chelsea and Westminster Hospital NHS Foundation Trust, London, UK
[5]Department of Pediatric Surgery, National and Kapodistrian University of Athens, Athens, Greece
[6]UCL Division of Surgery & Interventional Science, University College London, London, UK

Contributors AC, JMN and PN were responsible for conceptualisation of the protocol. AC was responsible for the initial draft of the manuscript. IA, AAT, NC, KM, SB, DDC, NZ and PN provided feedback on the manuscript. All authors read and approved the final version of the manuscript. AC is the guarantor of the review.

Funding Funding for the Open Access publication charge for this article was provided by the Imperial Open Access Fund. JMN has received funding from the MRC (UK) and RCSEng.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer-reviewed.

ORCID iDs
Abhisekh Chatterjee http://orcid.org/0009-0002-6835-5900
Panagiotis Nikolinakos http://orcid.org/0000-0001-8427-7223

REFERENCES

1 Peck J, Shepherd JP. Recurrent Urinary Tract Infections: Diagnosis, Treatment, and Prevention. *Obstet Gynecol Clin North Am* 2021;48:501–13.
2 Bono MJ, Leslie SW, Reygaert WC. *Uncomplicated urinary tract infections*. Treasure Island (FL): StatPearls, 2025.
3 Sabih A, Leslie SW. *Complicated urinary tract infections*. Treasure Island (FL): StatPearls, 2024.
4 Bergamin PA, Kiosoglous AJ. Non-surgical management of recurrent urinary tract infections in women. *Transl Androl Urol* 2017;6:S142–52.
5 Zare M, Vehreschild MJGT, Wagenlehner F. Management of uncomplicated recurrent urinary tract infections. *BJU Int* 2022;129:668–78.
6 Wagenlehner F, Wullt B, Ballarini S, *et al*. Social and economic burden of recurrent urinary tract infections and quality of life: a patient web-based study (GESPRIT). *Expert Rev Pharmacoecon Outcomes Res* 2018;18:107–17.
7 Christaki E, Marcou M, Tofarides A. Antimicrobial Resistance in Bacteria: Mechanisms, Evolution, and Persistence. *J Mol Evol* 2020;88:26–40.
8 Sihra N, Goodman A, Zakri R, *et al*. Nonantibiotic prevention and management of recurrent urinary tract infection. *Nat Rev Urol* 2018;15:750–76.
9 Barea BM, Veeratterapillay R, Harding C. Nonantibiotic treatments for urinary cystitis: an update. *Curr Opin Urol* 2020;30:845–52.
10 Gleckman R, Alvarez S, Joubert DW, *et al*. Drug therapy reviews: Methenamine mandelate and methenamine hippurate. *Am J Hosp Pharm* 1979;36:1509–12.
11 Lo TS, Hammer KDP, Zegarra M, *et al*. Methenamine: a forgotten drug for preventing recurrent urinary tract infection in a multidrug resistance era. *Expert Rev Anti Infect Ther* 2014;12:549–54.
12 Kwok M, McGeorge S, Mayer-Coverdale J, *et al*. Guideline of guidelines: management of recurrent urinary tract infections in women. *BJU Int* 2022;130 Suppl 3:11–22.
13 Harding C, Chadwick T, Homer T, *et al*. Methenamine hippurate compared with antibiotic prophylaxis to prevent recurrent urinary tract infections in women: the ALTAR non-inferiority RCT. *Health Technol Assess* 2022;26:1–172.
14 Rui L, Lindbaek M, Gjelstad S. Preventive effect of methenamine in women with recurrent urinary tract infections - a case-control study. *Scand J Prim Health Care* 2022;40:331–8.
15 Heltveit-Olsen SR, Gopinathan U, Blix HS, *et al*. Effect of methenamine hippurate shortage on antibiotic prescribing for urinary tract infections in Norway—an interrupted time series analysis. *J Antimicrob Chemother* 2024;79:1109–17.
16 Kale S, Somani BK. The resurgence of methenamine hippurate in the prevention of recurrent UTIs in women- a systematic review. *Curr Opin Urol* 2023;33:488–96.
17 Bakhit M, Krzyzaniak N, Hilder J, *et al*. Use of methenamine hippurate to prevent urinary tract infections in community adult women: a systematic review and meta-analysis. *Br J Gen Pract* 2021;71:e528–37.
18 Zeng G, Zhu W, Lam W, *et al*. Treatment of urinary tract infections in the old and fragile. *World J Urol* 2020;38:2709–20.
19 Rowe TA, Juthani-Mehta M. Urinary tract infection in older adults. *Aging health* 2013;9.
20 Detweiler K, Mayers D, Fletcher SG. Bacteruria and Urinary Tract Infections in the Elderly. *Urol Clin North Am* 2015;42:561–8.
21 Brandström P, Hansson S. Urinary Tract Infection in Children. *Pediatr Clin North Am* 2022;69:1099–114.
22 Buettcher M, Trueck J, Niederer-Loher A, *et al*. Swiss consensus recommendations on urinary tract infections in children. *Eur J Pediatr* 2021;180:663–74.
23 Slater R. Preventing infection with long-term indwelling urinary catheters. *Br J Community Nurs* 2011;16:72.
24 Neumeier V, Stangl FP, Borer J, *et al*. Indwelling catheter vs intermittent catheterization: is there a difference in UTI susceptibility? *BMC Infect Dis* 2023;23:507.
25 Lee BSB, Bhuta T, Simpson JM, *et al*. Methenamine hippurate for preventing urinary tract infections. *Cochrane Database Syst Rev* 2012;10:CD003265.
26 Li JM, Cosler LE, Harausz EP, *et al*. Methenamine for urinary tract infection prophylaxis: A systematic review. *Pharmacotherapy* 2024;44:197–206.
27 Davidson SM, Brown JN, Nance CB, *et al*. Use of Methenamine for Urinary Tract Infection Prophylaxis: Systematic Review of Recent Evidence. *Int Urogynecol J* 2024;35:483–9.
28 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
29 Peters MDJ, Marnie C, Tricco AC, *et al*. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Implement* 2021;19:3–10.
30 Nkangu M, Obegu P, Asahngwa C, *et al*. Scoping review protocol to understand the conceptualisation, implementation and practices of health promotion within the context of primary healthcare in Africa. *BMJ Open* 2021;11:e049084.
31 Bondzi-Simpson A, Benipal H, Momoh H, *et al*. Exploring the landscape of oesophageal discontinuity procedures and creation of cervical oesophagostomy in the modern era: a scoping review protocol. *BMJ Open* 2024;14:e081153.
32 Su Z, Zeng YP. Dupilumab-Associated Psoriasis and Psoriasiform Manifestations: A Scoping Review. *Dermatology* 2023;239:646–57.
33 Stanescu AMA, Simionescu AA, Florea M, *et al*. Is Metformin a Possible Beneficial Treatment for Psoriasis? A Scoping Review. *JPM* 2021;11:251.
34 Munn Z, Peters MDJ, Stern C, *et al*. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol* 2018;18:143.
35 Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:69.
36 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med* 2018;169:467–73.
37 Covidence. Covidence systematic review software, veritas health innovation, melbourne, australia. Available: https://www.covidence.org/ [Accessed 21 Apr 2025].
38 Sterne JAC, Savović J, Page MJ, *et al*. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019;366:l4898.
39 Sterne JA, Hernán MA, Reeves BC, *et al*. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016;355:i4919.
40 Team RC. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria; 2016. Available: http://wwwR-projectorg
41 South E, Rodgers M. Data visualisation in scoping reviews and evidence maps on health topics: a cross-sectional analysis. *Syst Rev* 2023;12:142.