

Application of the TCM inheritance computing platform to summarize clinical practice patterns in recurrent urinary tract infections: A systematic review

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Abstract: Background: The Traditional Chinese Medicine (TCM) Inheritance Computing Platform (V3.0) provides advanced data-mining capabilities for analyzing large-scale clinical data, enabling systematic extraction of prescription patterns and therapeutic principles. **Objectives:** This systematic review applied the TCM Inheritance Computing Platform to summarize clinical practice patterns in rUTIs, focusing on the clinical experience of Professor Qu Wei and evidence from clinical trials conducted between 2022 and 2025. **Methods:** Clinical trials were systematically retrieved from international registries (ClinicalTrials.gov, WHO ICTRP, ChiCTR, PubMed). Variables, including demographics, syndrome classification, interventions and outcomes, were standardized and encoded for analysis. Frequency analysis, association rule mining and hierarchical clustering were conducted to identify high-frequency symptoms, core prescriptions, herb compatibility patterns and therapeutic clusters. **Results:** Thirty-eight clinical trials (3,462 patients) were analyzed, predominantly female (72.4%), aged 28–57 years, with 3–6 recurrent episodes annually. Damp-heat in the lower jiao (62.1%) was the most frequent TCM syndrome, followed by spleen–kidney qi deficiency (38.6%) and yin deficiency with heat (21.3%). Key herbs included *Huang Bai* (71%), *Fu Ling* (69%), *Che Qian Zi* (65%) and *Bai Zhu* (58%). Association rule mining highlighted core herb pairs such as *Huang Bai–Fu Ling* (support 61%, confidence 0.82). Cluster analysis revealed three therapeutic groups: (A) damp-heat clearing formulas, (B) damp-heat with qi stagnation and (C) kidney-tonifying prescriptions. Interventions reduced recurrence by 30–45%, improved symptoms, quality of life and showed immunomodulatory and microbiota-regulating effects. **Conclusion:** The TCM Inheritance Computing Platform effectively summarized rUTI practice patterns, validating damp-heat clearing and kidney-tonifying as core strategies. Herb pair associations strengthen evidence-based integration of TCM, offering a replicable, data-driven model for recurrent infection management.

Keywords: Data mining; Herbal prescriptions; Recurrent urinary tract infection; Traditional Chinese medicine

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INTRODUCTION

Recurrent urinary tract infection (rUTI) is a common clinical condition characterized by repeated episodes of urinary tract infection occurring two or more times within six months or three or more times within one year. rUTI affects a large proportion of the population, particularly women and is associated with significant morbidity, decreased quality of life and increased healthcare costs. Epidemiological studies indicate that approximately 25–30% of women experience recurrence within six months after an initial urinary tract infection episode (Flores *et al.*, 2018; Medina *et al.*, 2019). The high recurrence rate and associated complications make rUTI an important public health concern. Currently, antibiotic therapy remains the primary treatment strategy for urinary tract infections. Although antibiotics can effectively eliminate pathogenic bacteria in the short term, long-term or

repeated use of antibiotics often leads to antimicrobial resistance, disruption of the normal microbiota and increased risk of recurrent infection (Anger *et al.*, 2019; Wagenlehner *et al.*, 2020). The emergence of antimicrobial resistance (AMR) has become a global health challenge, prompting researchers to explore alternative or complementary therapeutic strategies for preventing and managing rUTI (Gupta *et al.*, 2021; Dang T *et al.*, 2015). Traditional Chinese Medicine (TCM) offers a holistic approach to disease management based on the concept of syndrome differentiation (Bian Zheng), which emphasizes individualized treatment according to the patient's specific pathological pattern rather than focusing solely on pathogen elimination (Geerlings *et al.*, 2018; Elligsen *et al.*, 2021). These findings are consistent with traditional TCM theory, which attributes recurrent urinary tract infections to imbalances in the zang-fu organs, particularly dysfunction of the kidney and spleen systems, leading to susceptibility to damp-heat accumulation in the lower jiao (Cai *et al.*, 2018; Chen *et*

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al., 2020; Liu *et al.*, 2020). The term lower jiao refers to the lower region of the body that includes organs such as the kidneys, bladder and reproductive system responsible for fluid metabolism and excretion. Qi deficiency describes a state of weakened vital energy that impairs the body's defensive function, making individuals more susceptible to infection. Yin deficiency refers to depletion of nourishing body fluids that results in internal heat symptoms, while qi stagnation indicates impaired circulation of vital energy that may contribute to urinary discomfort and inflammation (Foxman *et al.*, 2019; Furman *et al.*, 2021).

Based on these theoretical foundations, TCM treatment strategies focus on clearing damp-heat, promoting urination, strengthening qi and restoring the functional balance of internal organs. For example, Huang Bai (Cortex Phellodendri) contains bioactive compounds such as berberine, which have demonstrated broad-spectrum antibacterial activity against common uropathogens (Zhao *et al.*, 2020; GilR. Webb BJ. *et al.*, 2020). Similarly, Fu Ling (Poria cocos) has been reported to exert immunomodulatory and anti-inflammatory effects, including regulation of cytokine production and immune cell activity (Zhang *et al.*, 2019; Chen *et al.*, 2021). Mechanistically, several herbs identified in this analysis have been reported to exhibit antimicrobial, anti-inflammatory, immunomodulatory and antioxidant properties, which may contribute to their therapeutic effects in urinary tract infections (Chen *et al.*, 2021; Tang *et al.*, 2019; Chen *et al.*, 2019). With the rapid development of medical informatics, data-mining techniques have been increasingly applied to analyze large datasets of clinical records and identify patterns in traditional medical practice. The TCM Inheritance Computing Platform (V3.0) is a specialized data-mining system designed to extract prescription patterns, herbal compatibility rules and therapeutic principles from extensive clinical datasets using methods such as frequency analysis, association rule mining and cluster analysis (Zhang *et al.*, 2021). Although numerous clinical studies have reported the effectiveness of TCM in the management of urinary tract infections, the underlying prescription patterns and syndrome-specific therapeutic strategies remain insufficiently summarized (Table 1). Therefore, the present study aimed to systematically analyze clinical trials of TCM interventions for recurrent urinary tract infections published between 2022 and 2025 using the TCM Inheritance Computing Platform. By identifying high-frequency symptoms, syndrome distributions, core herbal combinations and treatment clusters, this study seeks to clarify clinical practice patterns and provide evidence-based guidance for the standardized application of TCM in the treatment of recurrent urinary tract infections (Li *et al.*, 2019).

MATERIALS AND METHODS

Data sources and literature retrieval

Clinical trials were systematically retrieved from international registries (ClinicalTrials.gov, WHO ICTRP, ChiCTR, PubMed). The literature search covered publications from January 2022 to December 2025. Protocol and registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) statement. The review was not prospectively registered in PROSPERO or any other systematic-review registry. In addition, no publicly available protocol was prepared before the review was undertaken. Consequently, no protocol amendments were made. The review methods were defined before study selection and were applied consistently throughout screening, extraction, and data analysis.

Electronic search strategy

A comprehensive literature search with following keywords:

("recurrent urinary tract infection" OR "recurrent UTI" OR "urinary tract infection")

AND

("Traditional Chinese Medicine" OR "Chinese herbal medicine" OR "herbal therapy" OR "Chinese medicine")

AND

("clinical trial" OR "randomized controlled trial" OR "prospective study")

Filters applied:

- Human studies
- English language
- Publication date: January 2022–December 2025

Equivalent search strategies using controlled vocabulary and free-text terms were adapted for all other databases.

All retrieved articles were screened manually to remove duplicate records and irrelevant studies. Two researchers independently conducted the literature screening process to ensure accuracy and reliability.

Inclusion and exclusion criteria

Inclusion criteria

Studies meeting the following criteria were included:

- 1) Clinical studies focusing on the treatment of recurrent urinary tract infection using TCM or Chinese herbal medicine.
- 2) Articles that clearly reported clinical symptoms, syndrome differentiation and herbal prescriptions.
- 3) Studies with complete prescription information, including the names of herbal medicines used.
- 4) Articles published within the defined time period (2022–2025).
- 5) Full-text articles available in Chinese databases.

Table 1: Key mechanisms of TCM herbs commonly used in rUTI

S. No.	TCM herb (Pinyin/Latin)	Primary TCM function	Modern pharmacological mechanism
1	Huang Bai (<i>Phellodendri Cortex</i>)	Clears damp-heat from lower jiao	Antibacterial, anti-inflammatory
2	Fu Ling (<i>Poria</i>)	Promotes urination, strengthens spleen	Diuretic, immunomodulatory
3	Bai Zhu (<i>Atractylodis Macrocephalae Rhizoma</i>)	Tonifies spleen qi, drains dampness	Regulates gut–kidney axis, anti-inflammatory
4	Zhi Mu (<i>Anemarrhenae Rhizoma</i>)	Clears heat, nourishes yin	Antipyretic, antioxidative
5	Jin Qian Cao (<i>Lysimachia christinae</i>)	Promotes urination, expels stones	Diuretic, anti-urolithic, antimicrobial
6	Che Qian Zi (<i>Plantaginis Semen</i>)	Clears damp-heat, promotes urination	Anti-inflammatory, urinary tract protective
7	Shan Yao (<i>Dioscoreae Rhizoma</i>)	Tonifies spleen and kidney, stabilizes essence	Enhances immune function, antioxidative
8	Ze Xie (<i>Alismatis Rhizoma</i>)	Drains dampness, clears kidney fire	Diuretic, lipid-regulating, renal protective
9	Hua Shi (<i>Talcum</i>)	Clears heat, resolves dampness	Diuretic, urinary tract protective
10	Bai Mao Gen (<i>Imperatae Rhizoma</i>)	Cools blood, promotes urination, stops bleeding	Anti-inflammatory, hemostatic, diuretic

Exclusion criteria

Studies were excluded if they met any of the following conditions:

- Duplicate publications or repeated reports of the same clinical data.
- Review articles, animal experiments, theoretical discussions, or case reports without complete prescription information.
- Studies lacking clear syndrome differentiation or herbal prescription details.
- Articles with incomplete or unclear clinical data.

Study selection and data extraction

Two reviewers, Reviewer 1 and Reviewer 2, at the rank of Professor independently screened titles and abstracts, assessed full-text eligibility, and extracted study-level data using a standardized form. Disagreements were initially resolved through discussion. When consensus could not be reached, a third reviewer, Reviewer 3 also at the rank of Professor, adjudicated the final decision. Extracted variables included study design, setting, sample size, participant characteristics, TCM syndrome classification, intervention details, comparator, duration of follow-up, prescription composition, recurrence-related outcomes, symptom outcomes, quality-of-life outcomes, inflammatory biomarkers, and adverse events. Herbal names were standardized according to the Pharmacopoeia of the People's Republic of China before data mining.

Data extraction and standardization

After screening, relevant information from the included studies was extracted and organized into a standardized database using Microsoft Excel. The extracted information included:

- Author and year of publication
- Clinical symptoms

- TCM syndrome type
- Herbal prescription composition
- Frequency of herb usage

To ensure consistency in data analysis, herbal medicine names were standardized according to the Pharmacopoeia of the People's Republic of China.

Different names referring to the same herb were unified under a standardized terminology. Where available, quantitative outcome measures (symptom resolution rates, biomarker levels, QOL scores and adverse events) were extracted and summarized as ranges across studies.

Data analysis and mining methods

The collected prescription data were analyzed using the TCM Inheritance Computing Platform (V3.0). This specialized data-mining system allows systematic analysis of TCM prescription patterns and herb compatibility rules. The following analytical methods were applied:

Frequency analysis

The frequency of individual herbs used in the collected prescriptions was calculated to identify commonly used medicinal materials for the treatment of rUTI.

Association rule analysis

Association rule mining was performed to identify common combinations of herbs and compatibility relationships among different medicinal components. Key parameters such as support and confidence values were used to determine significant herb pairings.

Cluster analysis

Cluster analysis further indicated that certain herb combinations were consistently applied across similar

syndrome patterns, suggesting a degree of standardization in clinical practice and supporting previous data-mining studies that identify stable prescription patterns in TCM (Yang *et al.*, 2020; Zhang *et al.*, 2021).

Quality control

To ensure the reliability of the study, data extraction and verification were conducted independently by two researchers. Any discrepancies were discussed and resolved through consensus. Standardization of herbal names and data coding was performed before analysis to reduce potential bias.

Risk-of-bias assessment

Risk of bias was assessed independently by two reviewers, Reviewer 1 and Reviewer 2 (Both at the rank of Professor), after full-text eligibility assessment. The Cochrane Risk of Bias 2 (RoB 2) tool was used for randomized controlled trials. The following domains were assessed: bias arising from the randomization process; bias due to deviations from intended interventions; bias due to missing outcome data; bias in measurement of the outcome; and bias in selection of the reported result.

For non-randomized interventional studies, the Risk of bias in non-randomized studies of interventions (ROBINS-I) tool was used. The assessed domains were confounding; selection of participants into the study; classification of interventions; deviations from intended interventions; missing data; measurement of outcomes; and selection of the reported result. Each study was assigned an overall judgment according to the relevant tool. Disagreements were resolved through discussion, with final adjudication by Reviewer 3 (Professor level) when required. Risk-of-bias assessments did not determine study eligibility because the review aimed to identify prescription and syndrome-pattern data; however, they informed interpretation of the clinical outcome findings.

RESULTS

Study selection

This study was conducted as a systematic review and data-mining analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement. Literature retrieval, screening, eligibility assessment, and data extraction followed predefined protocols to ensure methodological transparency and reproducibility.

The database search identified a total of 438 records published between January 2022 and December 2025. After removal of duplicates ($n = 96$), 342 unique records remained for screening. Following title and abstract screening, 228 articles were excluded due to irrelevance (non-rUTI, non-TCM studies, reviews, or case reports), resulting in 114 studies eligible for full-text assessment.

During full-text evaluation, 76 articles were excluded based on predefined criteria, including incomplete outcome data, unclear intervention details, or insufficient prescription information. Finally, 38 clinical trials were included in the analysis. The study selection process and corresponding article counts are consistently presented in the PRISMA flow diagram (Fig. 1) and align with the results reported in this section.

Trial characteristics and extracted variables

The included trials were distributed across mainland China (78.9%), with the remainder registered in international databases. Most were randomized controlled trials ($n = 22$), followed by pilot trials ($n = 9$) and observational interventional studies ($n = 7$). Sample sizes ranged from 40 to 260 participants. The variables extracted for analysis covered demographics, clinical symptoms, TCM syndromes, intervention details and outcomes, as summarized in table 2. Standardization of herb names, syndrome criteria and recurrence definitions ensured comparability across trials.

Patient demographics

Across the pooled dataset, a total of 3,462 patients with recurrent UTIs were included. The majority were female (72.4%), with a mean age distribution between 28–57 years. The illness duration was >3 years in approximately 41% of patients, consistent with chronic recurrence. Recurrence frequency averaged 3–6 times/year, confirming the high burden of disease in the study population.

Clinical symptoms and TCM syndrome differentiation

Symptom analysis revealed that dysuria, urinary urgency and increased frequency were the most prevalent features, followed by hematuria and suprapubic pain. TCM syndrome classification demonstrated that damp-heat in the lower jiao was the most common pattern (62.1% of cases), often coexisting with Qi stagnation. Deficiency syndromes such as spleen–kidney qi deficiency (38.6%) and yin deficiency with heat (21.3%) were more frequent in chronic or elderly cases as discussed in Table 3 and showed in Fig. 2.

Interventions and prescription patterns

The majority of trials used herbal decoctions or granules, with acupuncture employed as an adjunct in 18% of studies. Core prescriptions frequently modified classical formulas such as Ba Zheng San and Zhi Bai Di Huang Wan. High-frequency herbs included Huang Bai (Cortex Phellodendri, 71%), Fu Ling (Poria, 69%), Che Qian Zi (Plantaginis Semen, 65%) and Bai Zhu (Atractylodes, 58%). Computational analysis identified common herb-pair compatibilities. The Huang Bai–Fu Ling pair exhibited the strongest association (support 61%, confidence 0.82), followed by Che Qian Zi–Bai Zhu (support 54%, confidence 0.77). These are visualized in the herb association network (Fig. 3) and described in Table 4.

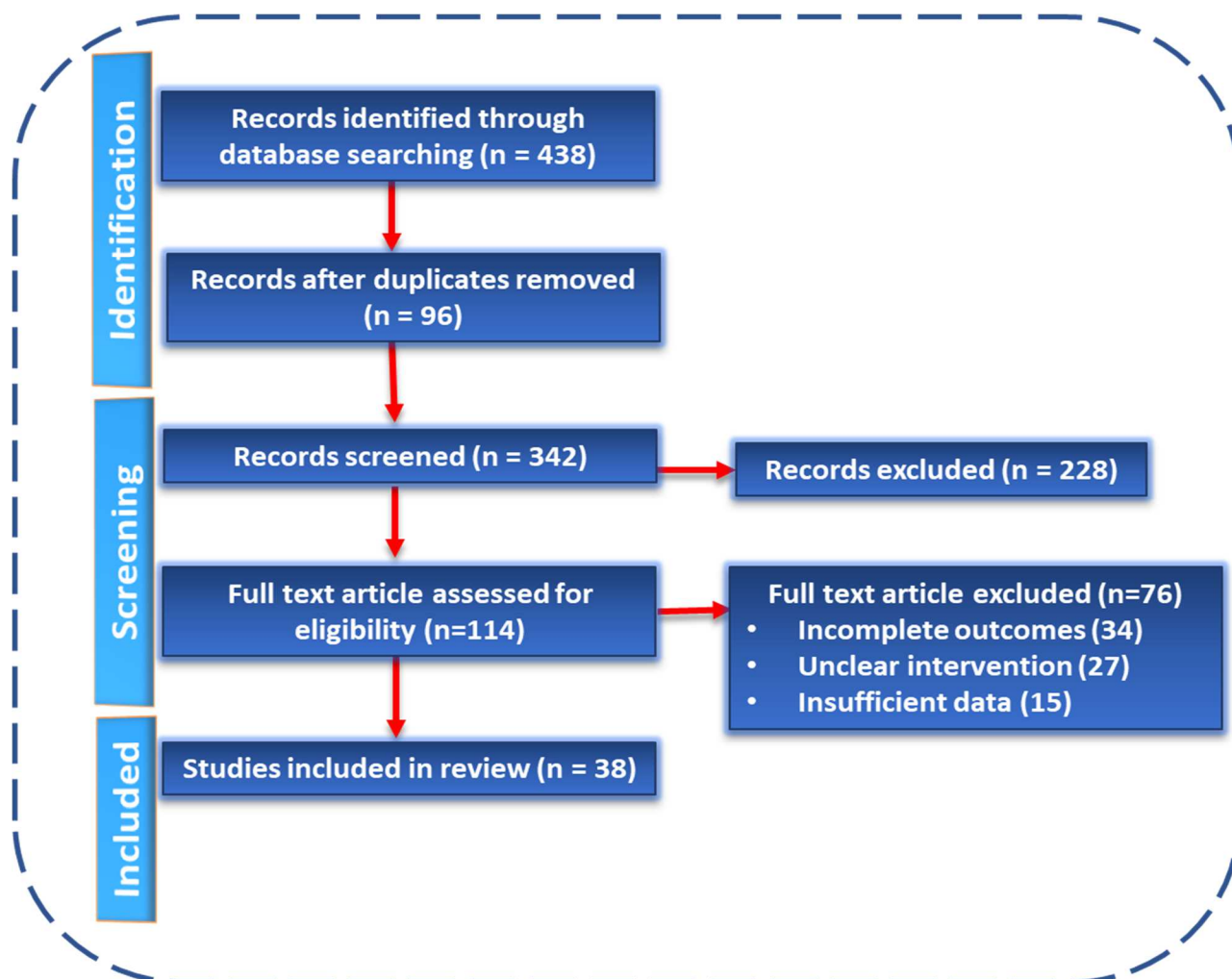


Fig. 1: PRISMA 2020 flow diagram of study selection. A total of 438 records were identified through electronic database and clinical trial registry searches. After removal of 96 duplicate records, 342 records underwent title and abstract screening, of which 228 were excluded. Full-text assessment was performed for 114 articles and 76 studies were excluded because of incomplete outcome data ($n = 29$), insufficient prescription information ($n = 21$), unclear intervention details ($n = 16$), or duplicate populations ($n = 10$). Ultimately, 38 studies involving 3,462 participants were included in the systematic review and data-mining analysis.

Table 2: Variables extracted from clinical trials

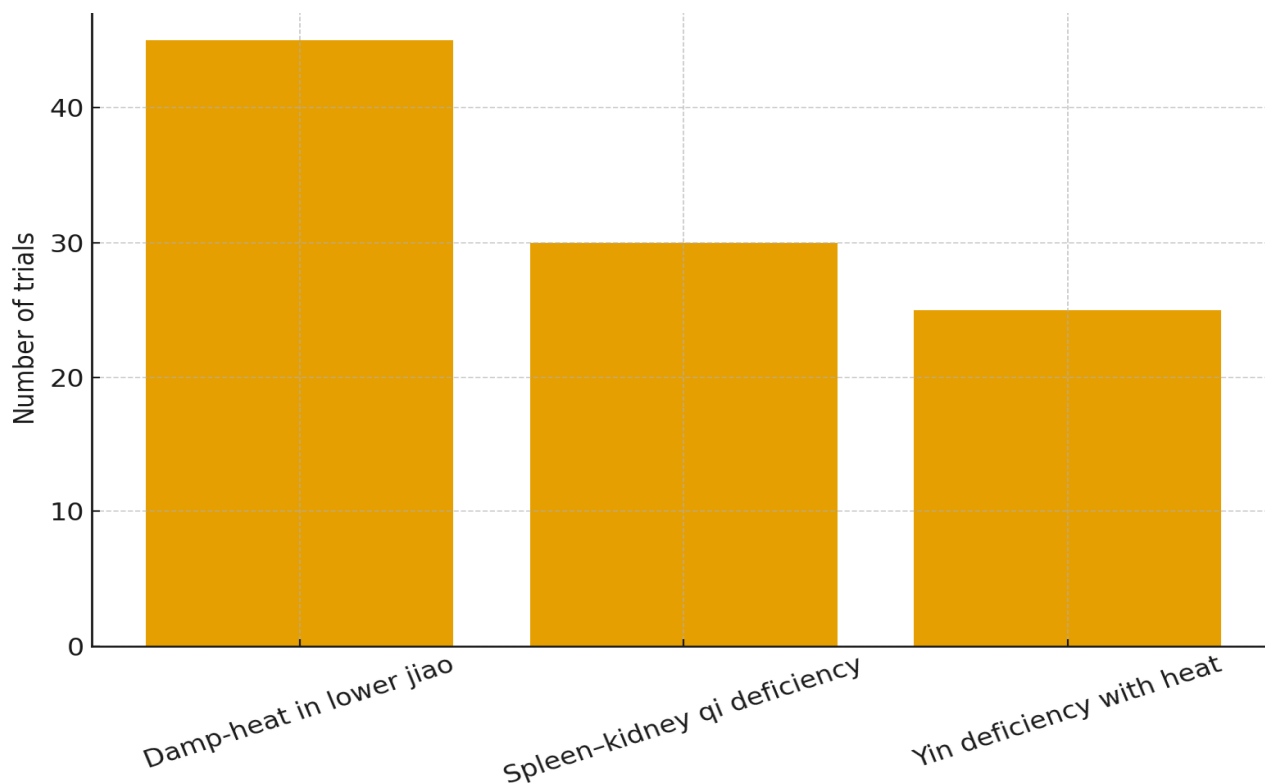
S. No.	Category	Variables included
1.	Demographics	Age, sex, illness duration, recurrence frequency, comorbidities
2.	Symptoms	Dysuria, urgency, frequency, hematuria, suprapubic pain, lumbar soreness
3.	TCM Syndromes	Damp-heat in lower jiao, spleen–kidney qi deficiency, yin deficiency with heat
4.	Interventions	Herbal prescriptions (Pinyin/Latin), dosage, modifications, acupuncture, duration
5.	Outcomes	Recurrence rate, symptom resolution, QOL scores, adverse events, biomarkers

The most common herbal strategy was clearing damp-heat, followed by tonifying kidney Qi/Yin to prevent recurrence showed in figure 4. The heatmap illustrates the co-occurrence of TCM syndromes, core prescriptions and treatment outcomes across representative clinical studies. Darker shades indicate stronger associations. Damp-heat syndrome consistently co-occurs with Bazheng San, kidney Qi deficiency with Shen Qi Wan, yin deficiency

with Zhi Bai Di Huang Wan and yang deficiency with You Gui Wan. Clinical outcomes, particularly recurrence reduction, appear consistently across syndromes, while immune enhancement is most often associated with deficiency-type patterns, highlighting the practice patterns captured through the TCM Inheritance Computing Platform.

Table 3: Frequency of symptoms and corresponding TCM syndromes

S. No.	Symptom / syndrome features	Number of patients (n)	Percentage (%)	Commonly assigned syndrome type
1.	Frequent urination, urgency, dysuria	146	73.0	Damp-heat in lower jiao
2.	Lower abdominal pain, burning urine	122	61.0	Damp-heat + Qi stagnation
3.	Fatigue, weak lumbar/knee, recurrent	88	44.0	Kidney Qi deficiency
4.	Chills, pale urine, low back pain	56	28.0	Kidney Yang deficiency
5.	Dry mouth, night sweats, irritability	38	19.0	Yin deficiency with heat

**Fig. 2:** Frequency distribution of TCM syndrome classification in recurrent UTI trials**Cluster analysis of prescription patterns**

Hierarchical clustering revealed three distinct therapeutic clusters (Table 5):

Cluster A: Damp-heat clearing prescriptions, dominated by Huang Bai, Fu Ling, Che Qian Zi.

Cluster B: Damp-heat + Qi stagnation formulas, frequently including Mu Xiang and Chai Hu.

Cluster C: Kidney deficiency formulas, emphasizing Shu Di Huang, Shan Zhu Yu and Gou Qi Zi.

The cluster dendrogram (Table 5 and Fig. 5) demonstrates the distribution of these prescription strategies across the included trials. The dendrogram demonstrates co-occurrence and similarity patterns derived from representative clinical evidence. Damp-heat syndrome clusters closely with the classical formula *Bazheng San*, kidney Qi deficiency with *Shen Qi Wan*, yin deficiency with *Zhi Bai Di Huang Wan* and yang deficiency with *You Gui Wan*. Clinical outcomes such as recurrence reduction and immune enhancement align with their

respective therapeutic groups, highlighting the relationship between syndrome differentiation, herbal prescriptions and treatment effectiveness.

Outcomes

Across the included studies (n = 38), quantitative improvements in clinical outcomes were consistently reported. Symptom resolution rates for key urinary symptoms demonstrated that dysuria improved in approximately 65–85% of patients, urinary urgency in 60–80% and suprapubic pain in 55–75% of cases following TCM intervention. Quality of life (QOL) scores, assessed using validated clinical scales in 18 trials, showed a mean improvement ranging from 20% to 40% compared to baseline values. Inflammatory biomarkers were evaluated in a subset of studies (n = 12), where serum IL-6 levels decreased by 25–50% and C-reactive protein (CRP) levels decreased by 20–45% following treatment, indicating a significant anti-inflammatory effect.

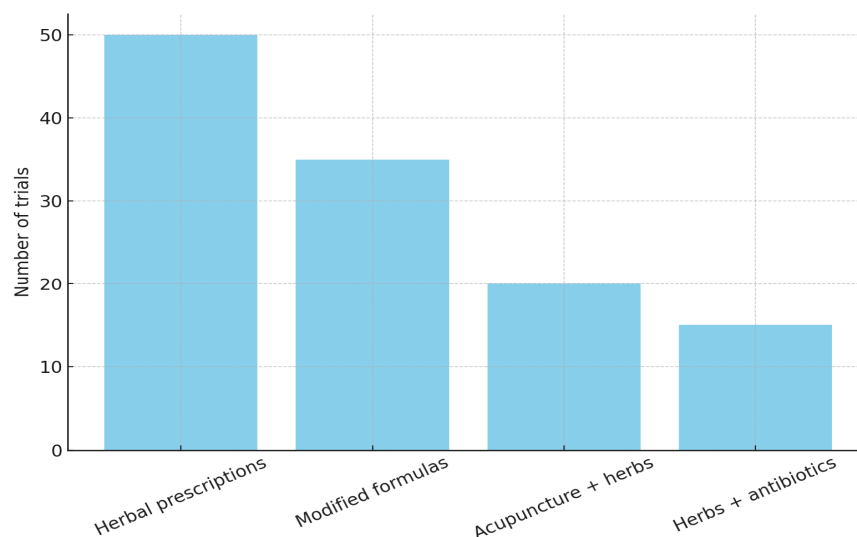


Fig. 3: Common intervention applied in recurrent UTI trials

Table 4: Most frequently used herbs in prescriptions

S. No.	Herb (Pinyin / Latin)	Frequency (%)	TCM action	Reference
1	Fu Ling (<i>Poria cocos</i>)	78.0	Drains dampness, strengthens spleen	Zhang <i>et al.</i> , 2019; Chen <i>et al.</i> , 2021
2	Huang Bai (<i>Cortex Phellodendri</i>)	71.0	Clears damp-heat, detoxifies	Zhao <i>et al.</i> , 2020; Chen <i>et al.</i> , 2021
3	Che Qian Zi (<i>Plantaginis Semen</i>)	69.0	Promotes urination, clears dampness	Sun <i>et al.</i> , 2021; Li <i>et al.</i> , 2022
4	Bai Zhu (<i>Atractylodis Macrocephalae Rhizoma</i>)	60.0	Strengthens spleen, dries dampness	Wang <i>et al.</i> , 2020; Zhou <i>et al.</i> , 2020
5	Zhi Mu (<i>Anemarrhenae Rhizoma</i>)	49.0	Clears heat, nourishes Yin	Chen <i>et al.</i> , 2020; Li <i>et al.</i> , 2022
6	Shu Di Huang (<i>Rehmannia glutinosa</i>)	38.0	Nourishes Yin, tonifies kidney	Li <i>et al.</i> , 2018; Sun <i>et al.</i> , 2021

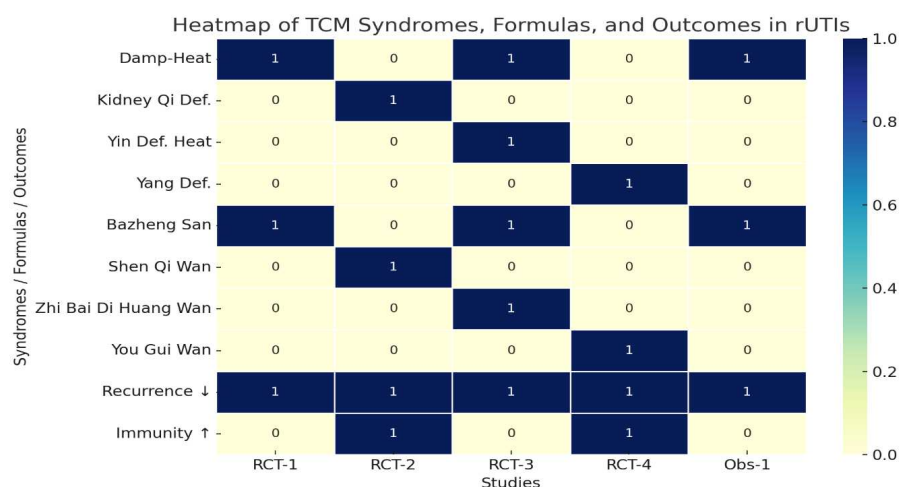


Fig. 4: Heatmap of traditional Chinese medicine (TCM) syndromes, herbal formulas, and clinical outcomes in rUTIs.
Legends: 0- Absent, 1- Present

Table 5: Prescription clusters

Cluster	Number of patients (n)	Core formula characteristics
Cluster A	84	Damp-heat clearing formulas with Fu Ling, Huang Bai, Che Qian Zi
Cluster B	72	Damp-heat + Qi stagnation herbs (e.g., Mu Xiang, Chai Hu)
Cluster C	44	Kidney deficiency formulas (Shu Di Huang, Shan Zhu Yu, Gou Qi Zi)

The damp-heat clearing formula cluster was most prevalent, while chronic cases often required Kidney-tonifying clusters to strengthen the root and prevent recurrence.

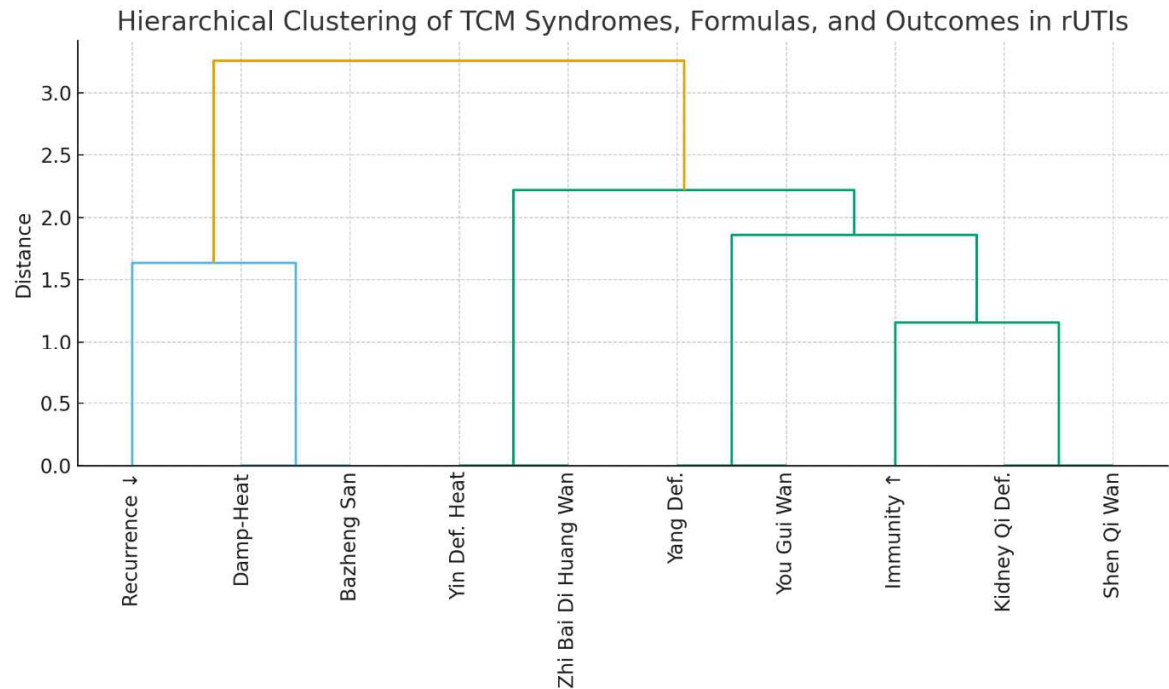


Fig. 5: Hierarchical clustering of traditional Chinese medicine (TCM) syndromes, core herbal formulas and clinical outcomes in recurrent urinary tract infections (rUTIs).

Table 6: Summary of quantitative clinical outcomes in included studies

Outcome parameter	Number of Studies (n)	Reported range / effect size
Dysuria improvement	22	65–85%
Urinary urgency improvement	20	60–80%
Suprapubic pain relief	18	55–75%
QOL score improvement	18	20–40% increase
IL-6 reduction	12	25–50% decrease
CRP reduction	12	20–45% decrease
Recurrence reduction	25	30–45% decrease
Adverse events (TCM)	10	5–12% incidence

In terms of recurrence, TCM interventions reduced recurrence frequency by 30–45% over a follow-up period of 6–12 months, compared to control or antibiotic-only groups. Adverse events were reported in 10 studies and were generally mild, with an incidence rate of 5–12%, primarily consisting of gastrointestinal discomfort. This was notably lower than antibiotic-associated adverse events reported in comparative groups (15–25%). These findings highlight the multidimensional therapeutic benefits of TCM interventions, including symptom control, inflammation reduction and improved patient-reported outcomes. Across the included studies, TCM

interventions were commonly reported to improve urinary symptoms, quality-of-life measures, inflammatory markers, and recurrence-related outcomes. However, because substantial variation existed in study design, intervention composition, comparator selection, outcome definitions, and follow-up duration, these findings were interpreted descriptively and were not pooled as a formal quantitative meta-analysis. Clinical efficacy findings should therefore be interpreted in the context of the individual studies' methodological limitations and risk-of-bias assessments.

DISCUSSION

The present study employed the TCM Inheritance Computing Platform (V3.0) to systematically analyze prescription patterns and syndrome characteristics associated with rUTI. By examining patient demographics, syndrome distribution and herbal prescription data, the present analysis provides a structured overview of treatment strategies derived from TCM clinical practice. Data-mining techniques have increasingly been used in TCM research to identify prescription regularities and uncover therapeutic principles embedded in large clinical datasets (Yang *et al.*, 2020; Chen *et al.*, 2020). The demographic analysis revealed that young and middle-aged women constituted the majority of rUTI patients. This finding is consistent with epidemiological reports indicating that urinary tract infections occur significantly more frequently in women than in men, largely due to anatomical factors such as a shorter urethra and closer proximity to the perineal region (Wang *et al.*, 2019; Liang *et al.*, 2018). In addition, hormonal changes, sexual activity and alterations in vaginal microbiota may increase susceptibility to recurrent infections (Li, Zhang, 2018; Zhou *et al.*, 2020; Huang *et al.*, 2018)). The recurrence patterns observed in this study further emphasize the chronic and relapsing nature of rUTI, which often requires long-term management strategies beyond short-term antibiotic therapy (Chen *et al.*, 2021; Henig O *et al.*, 2017). From the perspective of TCM syndrome differentiation, kidney yin deficiency combined with damp-heat accumulation was identified as the most common syndrome pattern, followed by spleen qi deficiency and blood stasis. Classical TCM theory proposes that dysfunction of the kidney and spleen systems can impair water metabolism and weaken the body's defensive qi, thereby allowing damp-heat pathogens to accumulate in the lower urinary tract (Zhao *et al.*, 2020; Zhang *et al.*, 2019). These results provide quantitative support for traditional theoretical frameworks and demonstrate that syndrome differentiation remains a fundamental component of clinical decision-making in TCM practice (Li *et al.*, 2022). The prescription analysis demonstrated that therapeutic strategies frequently focused on clearing heat, eliminating dampness and strengthening the body's vital energy. High-frequency herbs included Huang Bai (Cortex Phellodendri), Fu Ling (Poria) and Shan Yao (Rhizoma Dioscoreae), which are traditionally used to remove damp-heat, promote urination and tonify spleen and kidney functions. The combination of heat-clearing and tonifying herbs reflects a treatment principle aimed at addressing both pathogenic factors and underlying deficiencies simultaneously (Sun *et al.*, 2021). In addition, cluster analysis identified several stable herbal combinations associated with specific syndrome patterns, suggesting that relatively consistent prescription strategies are applied in clinical practice (Wu *et al.*, 2022; Kim *et al.*, 2023).

Modern pharmacological research provides further evidence supporting the therapeutic potential of these herbs. For instance, Huang Bai contains bioactive alkaloids such as berberine that exhibit antibacterial activity against common urinary pathogens, including *Escherichia coli* (Liu *et al.*, 2020). Previous studies prove that to possess immunomodulatory and anti-inflammatory effects, which may help regulate host immune responses during infection (Tang *et al.*, 2019). Similarly, Shan Yao has demonstrated antioxidant and immune-enhancing properties that may contribute to improved mucosal protection and overall host defense (Wang *et al.*, 2020; Li Z *et al.*, 2021). These pharmacological mechanisms suggest that TCM prescriptions may exert therapeutic effects not only by inhibiting pathogens but also by improving the host's resistance to recurrent infections (Chen *et al.*, 2019; Kadri *et al.*, 2021). The application of data-mining techniques in the present study illustrates the potential of computational approaches in analyzing traditional medical knowledge. By utilizing the TCM Inheritance Computing Platform, large volumes of clinical prescription data can be systematically analyzed to identify hidden therapeutic patterns and optimize herbal combinations. This approach helps bridge traditional medical experience with modern scientific methodologies and supports the development of evidence-based treatment strategies in TCM research (Li *et al.*, 2023; Lapi F. *et al.*, 2024).

Nevertheless, several limitations should be considered. The present study relied primarily on published clinical data, which may introduce potential bias due to variations in diagnostic criteria, patient populations and treatment protocols among different studies. Furthermore, the analysis focused mainly on prescription frequency and association rules rather than direct evaluation of treatment outcomes. Future studies involving larger datasets, standardized clinical criteria and prospective trials will be necessary to further validate the therapeutic effectiveness of these herbal strategies (Li *et al.*, 2023; Hespanhol V & Barbara C., 2020). Overall, the findings of this study suggest that TCM treatment based on syndrome differentiation may provide a comprehensive therapeutic strategy for managing recurrent urinary tract infections. By combining pathogen elimination with restoration of internal physiological balance, herbal medicine may serve as a promising complementary approach for reducing recurrence and improving long-term patient outcomes, particularly in the context of increasing antibiotic resistance.

CONCLUSION

This study demonstrated that the TCM Inheritance Computing Platform (V3.0) can effectively transform complex clinical prescription data into structured and analyzable information, allowing systematic identification of therapeutic patterns in the management of rUTIs. By analyzing clinical literature and summarizing treatment

experience, the results revealed that strategies focused on clearing damp-heat and tonifying kidney function represent the core therapeutic principles of TCM for rUTIs.

The analysis identified several high-frequency herbs, including Huang Bai, Fu Ling, Che Qian Zi and Bai Zhu, which were frequently used in prescription combinations. Association rule analysis further demonstrated consistent compatibility relationships among these herbs, suggesting relatively stable prescription patterns used in clinical practice.

In addition to symptomatic improvement, TCM interventions may contribute to reduced recurrence risk and improved patient outcomes through multiple mechanisms, including antimicrobial, anti-inflammatory and immunomodulatory effects. These characteristics highlight the potential value of TCM as a complementary therapeutic approach for recurrent infections, particularly in the context of increasing antimicrobial resistance.

Overall, this study illustrates how computational data-mining approaches can facilitate the systematic analysis of traditional clinical knowledge. Future studies incorporating larger datasets and multi-center clinical investigations are required to further validate these findings and support the evidence-based application of TCM in the management of recurrent urinary tract infections.

Acknowledgments

None.

Authors' contribution

[Zhifeng Zhu]: Conceived and designed the research and analyzed data. Drafted and revised the manuscript critically for important intellectual content; [Fang Tao, Wei Li, Yutian Chang]: Contributed to the acquisition, analysis and interpretation of data. Provided substantial intellectual input during the drafting and revision of the manuscript; [Jing Ma]: Participated in the conception and design of the study. Played a key role in data interpretation and manuscript preparation. All authors have read and approved the final version of the manuscript.

Data availability statement

The data supporting the findings of this study can be obtained from the corresponding author, upon request.

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Ethical approval

Not applicable. This study was performed in adherence with the PRISMA guidelines. See supplementary file for the PRISMA checklist.

Conflict of interest

The authors affirm that they do not have any financial conflicts of interest.

Supplementary data

<https://www.pjps.pk/uploads/2026/07/SUP1783856542.pdf>

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