Review

Urinary Tract Disorders and Nature-Based Management- A Comprehensive Review

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Abstract

Background: Urinary tract infections (UTIs) are becoming a serious public health issue affecting millions globally. The so-called uropathogens, which include *Escherichia coli*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* are typically responsible for urinary tract infections, which are among the most prevalent infections in the majority of developing countries.
Objectives: The focus of this review paper was to outline natural treatment approaches for treating and curing UTIs.
Methods: To find the relevant publications, databases such as PubMed and Google Scholar were searched. Research articles, case studies, and review papers published between 1999 and 2025 were all included in the search approach.
Results: This study covers the epidemiology, pathogenesis, risk factors, various forms and conditions, and potential natural therapy options for UTIs. *Withania somnifera, Tribulus terrestris, Asparagus racemosus,* and *Azadirachta indica* are a few common medicinal herbs that have been shown to have therapeutic potential for the treatment and management of UTIs. Flowers, fruit, bark, leaves, seeds, and even entire portions of medicinal plants were used to treat urinary tract infections. These parts, or their extracts, are taken orally as a stand-alone preparation or may be combined with other foods or beverages, such as milk, honey, water, juices, black pepper etc.
Conclusion: Herbal remedies are effective both for short-term prophylaxis and at the earliest indication of an infection. Even though herbal remedies show more promise than conventional treatment, further research is needed to fully understand the phytoconstituents and how they work to treat and cure urinary tract infections.

Keywords- Antibiotics; Herbal remedies; Phytoconstituents; Uropathogens; UTI

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INTRODUCTION

One of the most serious public health issues facing both sexes is urinary tract infections (UTIs), although females are more vulnerable because of the variations across urogenital and reproductive physiology, anatomy, and activity.[1] It can affect several sections of the urinary tract system, including the kidneys, bladder, ureter, and urethra, particularly the lower urinary tract system, which includes the bladder and urethra.[1] The urinary system is impacted in various regions, and elderly men and women of all ages are more likely to experience UTI-related morbidity[1]. Pregnancy, poor hygiene, sexual activity, and even prior UTI episodes are some of the risk factors that may explain why some people are more susceptible to UTIs than others.[2] UTIs have become a significant socioeconomic burden because of their high recurrence rate and multi-drug-resistant strains.[3] It is anticipated that around one in two women will get urinary tract infections (UTIs), which are common bacterial illnesses, particularly among women.[4] Lower urinary tract irritative symptoms, such as urgency, dysuria, frequency, and nocturia, are typical signs of a male UTI. If these symptoms are not promptly and effectively treated, they may result in pyelonephritis, or kidney infection.[5]

The majority of UTI cases are caused by Uropathogenic *Escherichia coli* (UPEC), with the remainder being caused by various Gram-positive cocci (such *Staphylococcus saprophyticus, Streptococcus agalactiae* and *Enterococcus faecalis*) and Gram-negative rods (like *Proteus mirabilis* and *Klebsiella pneumoniae*). [4,6] Microorganisms such as *Escherichia coli*, *Klebsiella*, *Enterobacter*, and *Proteus* are responsible for about 95% of UTIs.[7] Among the bacterial species, *Staphylococcus* species make up 10% to 15% of infections, whereas *Escherichia coli* accounts for 80% to 85%.[8]

Every year, governments around the world spend ten million dollars on UTIs.[8] Incorrect or indefinite treatment is the primary cause of these expenses.[9,10] Every year, 150 million people worldwide suffer from urinary tract infections (UTIs), which are among the most prevalent bacterial illnesses.[10, 11, 12] In an estimation, about 60% females and 13% males are suffered from UTI and other related conditions.[13] The number of UTI-related deaths worldwide was regrettably 236,790 in 2019, up 140.18% from 98,590 in 1990.[2] A survey carried out in the United States found that approximately 10.5 million people visit hospitals for urinary tract infections, comprising 2-3 million emergency cases and 0.9% of ambulatory cases.[12] UTIs can cause everything from a minor, self-limiting illness to acute sepsis, and their death rate is between 20 and 40 percent, rising unpredictably with age.[14] UTIs are more common in both sexes, with a female to male ratio of 2:1 in individuals over 70 compared to a 50:1 ratio in the younger population.[14]

After respiratory tract infections, it is the second most prevalent infection.[14] According to estimates, between 40 and 50 percent of women will experience one episode throughout their lifetime, and 20 to 30 percent will experience additional episodes, with the exception of babies and the elderly.[15] It is estimated that between 30% and 50% of women over 50 are impacted by these.[16] According to estimates, 10–60% of women will experience a symptomatic UTI at some point in their lives, and every other woman will have experienced at least one UTI.[16] During the first six to twelve months following their first UTI, up to 30% of infants and children get recurrent infections, and up to 8% of kids will get at least one UTI between the ages of one month to eleven years.[17] Numerous factors, such as age, parity, gravidity, pregnancy, and the presence of other illnesses, are linked to UTIs and can worsen the infection's state.[8] Plants have long been utilized by humans to cure common infectious diseases, and certain traditional medicines are still used today to treat a variety of illnesses.[18] According to the World Health Organization (WHO), almost 80% of developing nations continue to benefit from traditional medicines made from medicinal plants.[19] Numerous secondary metabolites present in medicinal plants, including terpenoids, alkaloids, phenolic compounds, and sulfur-containing compounds, have been shown to exhibit a range of pharmacological actions.[20] Patients with symptomatic UTIs are often offered antibiotics; however, these treatments have the potential to permanently change the normal vaginal and gastrointestinal tract microbiota and to promote the formation of bacteria resistant to several medications.[5] Importantly, the "golden era" of antibiotics is ending, and with it, the need for well-considered substitute therapies.[1] A recent study by the World Health Organization (WHO) found that antibiotic resistance is directly responsible for more than 730,000 deaths annually.[5] The growing prevalence of drug-resistant diseases makes it imperative to use standardized, contemporary analytical techniques to find and separate novel bioactive components from medicinal plants.[21]

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The present review explores the pathogenesis of UTI, it's types, causative organisms and management of UTI. This study mainly focuses on the medicinal plants used for the treatment of UTIs (Figure 1 & 3).

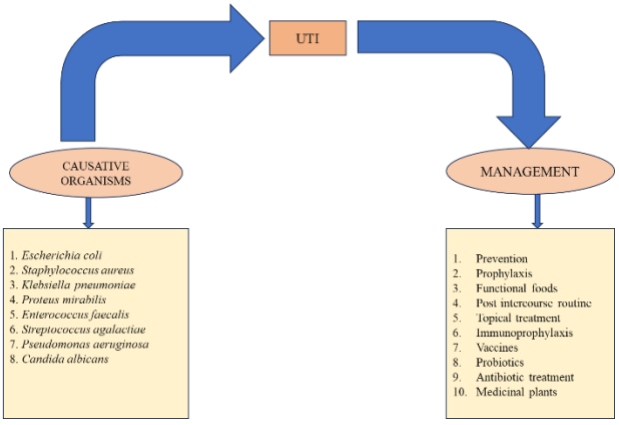

Fig. 1: Causative organisms and management strategies associated with UTIs.

Pathogenesis

Urinary tract infections are four times more common in women than in men, according to adequate and indisputable clinical and scientific data. Microorganisms can enter the renal system by spreading via the urethra, blood, or lymphatic membrane. However, the main cause of UTI is the introduction of microorganisms through the urethra, exceptionally for enteric or intestinal bacteria (such *Escherichia coli* and microorganisms belonging to the Enterobacteriaceae family).[12] Additionally, the risk of infection is increased by bladder catheterization or instrumentation. Within four weeks of catheterization, almost all patients have bacteriuria because of bacterial migration within the mucopurulent gap between the catheter and urethra[4]. Hematogenous infections are caused by some bacteria that cause early infections elsewhere in the body. Additionally, the virulence of UTIs depends on the body's defence mechanisms.[22]

Risk factors associated with UTIs

The following are some risk factors associated with UTI: advanced age, poor diet, heightened immune response, diabetes mellitus, smoking, obesity, concurrent infection in an inaccessible site, lack of risk issue regulation, prolonged clinic visits prior to surgery, preferentially current hospitalization, previous or ongoing genitourinary infection, surgical procedure involving bowel section, colony formation with microbes, persistent drainage, urinary blockade, and urinary stone (Figure 2) .[22]

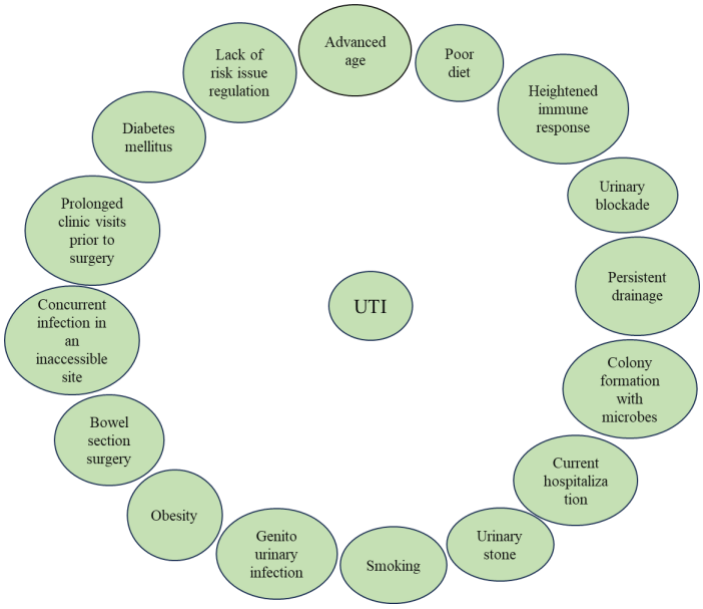

Fig. 2: Risk factors associated with urinary tract infection.

Classification of UTI

Five categories are used to classify urinary tract infections: site, severity, episode, symptoms, and complicating factors. Of these, site and severity are the most crucial (Fig. 3).

Classification based on site

Any area of the urinary tract can become infected, including the kidneys and the ureters (pyelonephritis), the bladder (cystitis), and the urethra (urethritis).[23]

Classification based on severity

When a child has a lower urinary tract infection with some mild symptoms and is able to take fluids and oral treatment, the infection is considered mild. Severe UTIs are identified if they exhibit more severe symptoms like dehydration, recurrent vomiting, or temperature above 39 degrees Celsius.[12]

Classification based on episode

First UTI: an anatomical assessment is advised since this could indicate anatomical problems.

Recurrent UTI: It can be of 3 types: unresolved, persistent infection and re-infection. The initial treatment for an unresolved infection is insufficient to eradicate bacterial growth in the urinary tract. A bacterial recurrence from a location in the urinary tract that

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cannot be removed (such as stones or malfunctioning renal segments) results in a persistent infection. Every episode of re-infection may be brought on by a different set of novel microbes.[24]

Classification based on symptoms

Symptomatic UTI includes irritative voiding symptoms, suprapubic pain, fever and malaise. When uropathogenic bacteria are attenuated by the host or non-virulent bacteria colonize the bladder without causing symptoms, this is known as asymptomatic bacteriuria.[24]

Classification based on complicating factors

An uncomplicated UTI is one that happens in a healthy host who is not pregnant, has no structural or functional abnormalities, or has not had any instruments placed in them (such as a catheter). Every other UTIs is regarded as being complicated.[25] A male UTI is typically seen as being intrinsically complex.[26]

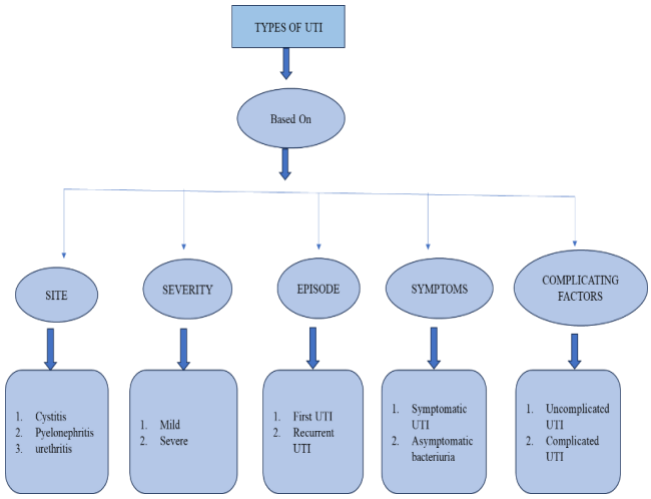

Fig. 3: Types of Urinary tract infection.

Causative organisms of UTI

It takes more than 10^5/mL of bacteria in the urine to cause a UTI. In addition to Gram-positive and Gram-negative bacteria, certain fungi can also cause urinary tract infections, such as, *Escherichia coli, Enterococcus faecalis, Staphylococcus aureus, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumoniae, Candida albicans* etc (Table1).[27]

Escherichia coli

Escherichia coli strains that are uropathogenic are the most frequent pathogens to infect the urinary system. These strains exhibit a variety of virulence characteristics, including adhesins, fimbriae, flagella and biofilms.[28]

Enterococcus faecalis

Enterococcus species have emerged as a major contributor to illnesses linked to healthcare, including UTIs and endocarditis. *Enterococci* infections are a topic of interest because of their capacity to proliferate in harsh settings and their inherent and multiple antibiotic resistance, which presents a special challenge.[29]

Staphylococcus aureus

One of the biggest bacterial problems facing public health today is *Staphylococcus aureus*, which is mostly detected in people who have urinary tract infections. 0.5–6% of UTI infections are caused by *S. aureus*, which has a low fatality rate. According to data, nearly 35% of *S. aureus*-related UTI cases worldwide are symptomatic, and chemotherapy is strongly advised for these individuals.[30] Demonstrative studies have shown that *Staphylococcal* infection can cause UTIs in pregnant and non-pregnant women up to 6.9% and 7.7%, respectively.[31]

Proteus mirabilis

The gram-negative rod-shaped bacterium *Proteus mirabilis* is found in many natural environments and is best known for its urease activity and swarming motility. The primary cause of complicated UTIs, particularly those linked to catheter use, is this bacterium.[32,33]

Pseudomonas aeruginosa

Urinary tract infections are among the many chronic illnesses caused by the multidrug-resistant bacterium *P. aeruginosa*.[34] Because this organism has innate resistance to many antibiotics and can develop additional resistance mechanisms to several antibiotic classes, such as beta-lactams, aminoglycosides, and fluoroquinolones. Infections caused by it are challenging to treat. As a result, there are very few treatment options available for these drug-resistant pseudomonades.[35]

Klebsiella pneumoniae

Klebsiella pneumoniae is one of the bacteria that causes urinary tract infections most often in healthcare settings. It also produces more and more *Klebsiella pneumoniae* carbapenemase (KPCp). In half of the documented cases, the majority of KPCp infections are nosocomial and can result in fatal consequences.[36] It is an important member of the Enterobacteriaceae family, regarded as an opportunistic pathogen that causes a wide range of illnesses and frequently develops drug resistance.[37]

Candida albicans

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When it comes to fungal UTIs, Candida species are the most common. The majority of patients with Candida UTIs are hospitalized, however, they are less frequent in the community.[38]

Table 1: Disease-causing microorganisms and their treatments

Causative Organisms	Diseases	Spreading Method	Treatment	References
Escherichia coli	UTIs, gastroenteritis, neonatal meningitis, serious abdominal cramps, diarrhoea, increase temperature	Consuming contaminated food or water, contact with animal or their environment, person to person contact	Vaccination, probiotics, anti-adhesive therapeutics, phage therapy, microbiota, transplantation, nanomaterials, medicinal plants	39, 40, 27, 41
Enterococcus faecalis	UTIs, intra-abdominal, pelvic, soft tissue infections, bacteremia, endocarditis, meningitis, haematogenous osteomyelitis, septic arthritis pneumonia	Fecal-oral transmission, contaminate objects, wounds, contaminate medical devices	Antibiotic therapy, non-antibiotic prophylactic treatment	29, 42, 43
Staphylococcus aureus	Mastitis, skin problems, UTIs, bacteremia, pneumonia, food poisoning	Contaminated food, person to person transmission, through intra mammary during milking process	Antibiotics, silver nano particles and antibiotics, chemotherapy	44, 30, 31, 5
Proteus mirabilis	CAUTIs, wounds, gastro-intestinal tract infections, bacteremia, sepsis, skin diseases, ear and eye diseases, respiratory tract diseases	Direct contact with infected one, exposure to contaminated surfaces, contaminated food, water and soil, smear infection	Antibiotics, anti-microbial agents, phytochemicals, apitherapy, phage therapy, repurposed drug, nanoparticles	32, 45, 33
Pseudomonas aeruginosa	Lung infection, ear infection, gastro-intestinal tract infection, UTIs, cancer, traumas, sepsis, blood related infections, COVID-19	Contaminated water, soil, person to person, contaminated food, contact with contaminated surfaces	Antibiotics, nanoparticles, phage therapy, gene delivery, development of vaccine	35, 46, 34
Klebsiella pneumoniae	UTIs, pneumonia, surgical wound infections, endocarditis septisemia, necrotizing pneumonia, pyogenic liver abscesses, endogenous endophthalmitis, intra-abdominal infections	Contaminated objects, wounds, person to person	Antibiotic therapy	12, 47, 37, 36
Candida albicans	Oral cavity infection, gastro-intestinal tract infection, skin infection, blood stream infection, UTIs, osteoarticular infections, vaginal infection	Contact with contaminated surface and people, blood stream	Antifungal medications, control blood sugar level, removal of bladder catheter	38, 48, 49

UTI related conditions

Cystitis

Cystitis means inflammation of the bladder and has a variety of causes including infections, chemical irritants, radiotherapy and chemotherapy. Women are much more likely than males to acquire cystitis, and by the time they are 24 years old, around one-third of them will have experienced at least one episode. Cystitis is uncommon

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in men under 50. The primary symptoms are the need to urinate more frequently and urgently than usual, as well as lower abdominal and urinary pain. Frequently, the urine generated is bloody, murky, and foul-smelling.[50]

Recurrent cystitis

Recurrent UTIs, or rUTIs, are defined as occurring at least three times a year or twice in the previous six months. Up to 70% of women will experience rUTI within a year.[51] Recurrent UTIs are linked to substantial morbidity and a decline in quality of life, which has an effect on healthcare costs.[52]

Interstitial cystitis

Interstitial cystitis (IC), also known as bladder pain syndrome (BPS), is characterized by a number of incapacitating systems, including discomfort in the suprapubic area, nocturia, and frequency and urgency of micturition.[53,54] These symptoms usually appear when the bladder is full and go away once the urine has been passed. Along with these symptoms, a common complaint among individuals with IC is pelvic pain, which can come from a variety of viscera, including the rectum, vagina, or urethra.[55]

Pyelonephritis

Pyelonephritis is caused by UTI-causing microorganisms ascending to the kidneys, which can lead to kidney damage, scarring, and eventually impaired kidney function.[56] About 90% of instances of mild pyelonephritis are caused by *Escherichia coli*. Even if other causal organisms are more common in complex cases, *E. coli* still predominates.[57]

Asymptomatic bacteriuria

When bacteria are found in the urine but no symptoms are present, this is known as asymptomatic bacteriuria.[58,59] Although it can affect women of any age, older women with diabetes are more likely to experience it. Every catheterized patient has asymptomatic bacteriuria.[60]

Urethral syndrome

A urethral syndrome occurs when the clinical signs of a urinary tract infection (UTI) are present yet the urine test results are negative for bacteria.[61] A lower urinary tract bacterial infection is the reason for admission for between 25% and 50% of patients.[62] It could have been caused by bacteria, spread by intercourse, or something else entirely, including trauma, drugs, or long-term conditions like diabetes.[63]

Complicated and uncomplicated infection

Complicated urinary tract infections are typically described as occurring in a host with compromised defences or in a patient with a structural or functional defect. The difference between complicated and uncomplicated infections is crucial because, even with medicines that are effective against the pathogen, the response to therapy is frequently unsatisfactory and antimicrobial resistance is more prevalent when complicating factors are present.[64] People with uncomplicated UTIs don't have any structural abnormalities in their urinary tract and also don't have other conditions like diabetes, pregnancy, need a straightforward solution.[65]

Management of UTI

Prevention

If the causes are found and treated quickly, recurrent UTIs can be avoided.[66] Recurrent UTIs can be avoided by treating constipation, enhancing defective elimination syndromes and encouraging patients to drink more water to keep their bladders free of bacteria.[67]

Prophylaxis

Low-dose antibiotic prophylaxis can be used daily or every other day to treat reinfections. A short dose of antibiotics known or postcoital antibiotic prophylaxis is started as soon as symptoms appear. Oestrogens, Lactobacilli, Vitamin C (Ascorbic Acid), cranberry, D-Mannose are the non-antibiotic prophylaxis for Urinary Tract Infections.[1,68]

Functional foods

For a long time, it is believed that eating some particular foods can prevent UTIs. These include things like Echinacea, garlic, antioxidants, and cranberry juice.[69] Cran-berry juice possesses anti-adhering properties that prevent *E. coli* from sticking to the walls of the bladder.[70]

Post intercourse routine

Prophylactic antibiotics alone are insufficient to prevent UTIs in sexually active individuals, according to several research. It has been stated that the infection may be avoided if people take certain medicines after sexual activity. Antibiotics are provided along with spermicidal cream containing nonoxynol-9 to prevent infection.[71]

Topical treatment

In post-menopausal women, topical vaginal oestrogen therapy reduces UTIs by altering the vaginal flora.[72] Certain topical creams, particularly those containing povidone and iodine, are also used to prevent UTIs. These antiseptic lotions are applied locally to reduce inflammatory processes.[1]

Immunoprophylaxis

Due to its great effectiveness and good tolerance, the oral vaccination Uro-vaxom must be included in the

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standard of care for patients suffering from urogenital infections.[73] A lyophilized mixture of membrane proteins from 18 distinct *Escherichia coli* strains is present in Uro-Vaxom. By boosting macrophages, lymphocytes, and the amounts of endogenous IgA/IgG antibodies in circulation, it boosts humoral and cellular immune responses to UTI.[74]

Vaccines

Antigenic elements of common UTI-causing bacteria, like *Escherichia coli*, are present in vaccinations and stimulate both the innate and adaptive immune systems. This activation makes it possible for the bladder to develop an immunoprotected environment. Immunotek's polyvalent whole-cell-based sublingual vaccine, MV140 (Uromune), produces IL-10 cytokines after dendritic cell activation, eliciting a potent T helper 1 cell and T helper 17 cell response. There is insufficient evidence to justify the use of UTI vaccines as an alternative in clinical practice, according to a new systematic review and meta-analysis of the broader body of research on the topic. There were 14 studies in all that looked into Strovac, Uromune, Solco-Urovac, ExPeC4V, and Uro-Vaxom.[75]

Probiotics

One well-reported probiotic for preventing UTIs is Lactobacillus, which can be administered orally or vaginally. The unfavourable environment created by lactobacilli prevents urinary bacteria from surviving in urine.[76] One study conducted in the Netherlands shown that oral administration of *Lactobacillus rhamnosus* GR-1 and *Lactobacillus reuteri* RC-14 restores the vaginal Lactobacilli flora, decreases colonization by potentially harmful bacteria, and stops recurrent UTIs.[77,78]

Antibiotic treatments

For acute uncomplicated cystitis, oral antibiotic treatments consist of ampicillin, cotrimoxazole, trimethoprim, and nitrofurantoin. Medication such as trimethoprim, erythromycin (for gram-positive bacteria), fluoroquinolones, doxycycline, and aminoglycosides are advised for patients with a suspected prostatic infection.[79] Treatment options for cystitis in pregnant women include cephalexin, cefpodoxime, ceftibuten, nitrofurantoin, and amoxicillin.[80] In mild cases of upper urinary tract infections, cephalosporins, ciprofloxacin, cotrimoxazole, ampicillin, or amoxicillin-clavulanate are administered orally.[79] A major worry with antibiotic resistance is the growing use of antibiotics, especially in developing nations. Chronic use of macrolides can also raise the risk of cardiovascular mortality and recurring infections, among other health risks.[81] Thus, new medications are being created, like β-lactam antibiotics combined with carbapenems and cephalosporins.[82]

Medicinal plants

Herbal medicine is a plant-based product that can be taken as an extract or diluted. Herbal remedies are being used more and more frequently worldwide to address a range of medical conditions. The majority of people in poor nations get their healthcare primarily from herbal products. Herbs are mostly used in therapeutic treatments such as Ayurveda, Unani, Homeopathy, Sidha, etc.[83] Since ancient times, people have utilized medicinal plants to cure and manage a variety of illnesses due to their positive effects. Even at the beginning of the twenty-first century, medicinal plants have become more and more well-liked and dependable all over the world because of their low prevalence of side effects, affordability, ease of access, lack of bacterial resistance, and tolerance for UTI sufferers. Additionally, according to WHO data, over 30% of pharmaceutical formulations and 80% of the world's population rely on medicinal plants.[84]

To cure urinary tract infections, people have consumed flowers, leaves, bark, fruit, seeds, and even entire parts of medicinal plants. When taken orally, these ingredients or their extracts can be consumed alone or in combination with other foods or drinks, such as milk, water, juices, black pepper, honey etc. The dosage of natural remedies is also influenced by the patient's age, sex, and present state of health.[85]

Therefore, the present review article highlights natural therapies that are beneficial in managing and treating urinary tract infections. Table 2 lists the common names, families, botanical origins, and functional uses of 26 most widely used plants for the treatment of urinary tract infections.

Table 2: A collection of typical herbs that are used to cure UTIs

Plant Name	Family	Common Name	Plant Parts Used	Method of preparation	Mode of application	References
Curcuma longa L.	Zingiberaceae	Turmeric, Indian-	Roots	Infusion	For two hours, steep 150 g of the roots in 200 ml of water. After	86

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Plant Name	Family	Common Name	Plant Parts Used	Method of preparation	Mode of application	References
		saffron, Haridra, Haldi, Rajani			every meal, this infusion is to be administered.	
Azadirachta indica A. Juss.	Meliaceae	Neem, Indian lilac, Margosa	Bark, leaves and Fruit	Powder	Bark and leaf powder, as well as fresh fruits are taken	1
Ocimum sanctum L.	Lamiaceae	Tulsi, Holy Basil, Kalatulsi	Whole plant	Tisane, decoction, maceration	Decoction, maceration, or infusion of any dried portion or the entire dried plant	87,88
Saraca asoca (Roxb .) W. J. de Wilde	Caesalpinaceae	Ashoka tree	Seed	Powder	Tender coconut is mixed with seed powder and eaten three times a day.	89
Zingiber officinale Rosc.	Zingiberaceae	Ginger, Andrakam, Inchi, Ada	Root	Powder	For 15 days, 500 milliliters of water were mixed with two grams of root powder and eaten overnight.	89
Abutilon indicum (L.) Sweet	Malvaceae	Country mallow, Kanghi, Pedipedica	Leaves, Root	Powder	Root and leaf powder taken orally.	1
Withania somnifera (L.) Duna	Solanaceae	Ashwagandha	Root	Decoction	About 50 g of the root powder should be boiled in 100 ml of water. After meals, take about 50 ml of this concoction three times a day.	86
Ricinus communis L.	Euphorbiaceae	Castor oil plant, Jada	Root	Decoction	Root decoction taken orally to treat UTIs.	90
Aloe vera L.	Asphodelaceae	Aloe vera	Leaves	Maceration and infusion	Leaf extract is used	87
Moringa oleifera Lam.	Moringaceae	Moringa	Leaves	Infusion	Consume raw dried fruit, tea made from dried leaves, and oil is used.	88
Tribulus terrestris L.	Zygophyllaceae	Calthrops, Gokharu	Fruits	Powder	For a week, consume 100 ml of the juice made by combining fruit powder, milk, and honey.	89
Asparagus racemosus Willd.	Liliaceae	Shatavari, Satavar, Satamull	Root	Powder	To prevent blood in the urine and other related urinary issues, the patient is given 5 g of tuberous root powder mixed with 10 g of sugar candy once a day for a month.	91
Cucumis sativus L.	Cucurbitaceae	Cucumber, Timun, Gherkin, Kakudi	Fruit	Raw	The fruits are provided every day and can be eaten raw or mixed into salads.	92
Aegle marmelos L.Corr.	Rutaceae	Bela	Fruit	Juice	Fruit juice is taken orally.	93

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Plant Name	Family	Common Name	Plant Parts Used	Method of preparation	Mode of application	References
Mangifera indica L.	Anacardiaceae	Mango, Amba	Leaves	Powder	Leaves are eaten in powder form for a few days.	85
Allium sativum L.	Alliaceae	Garlic, Lehsan	Bulbs and cloves	Infusion, raw, oil	Raw garlic is used as food. Also its oil and infusion can treat UTI.	94, 88
Aerva lanata (L.) Juss. Ex Schult.	Amaranthaceae	Lopong arak	Root Leaves	Paste Decoction	Five grams of root paste or ten to fifteen milliliters of the plant's decoction are administered twice day for ten days to prevent dysuria. Decoction of leaves and young shoots is used to remove kidney and bladder stones.	91
Achyranthes aspera L.	Amaranthaceae	Apang	Whole plant	Juice	Juice of the plant taken orally.	95
Clitoria ternatea L.	Fabaceae	Butterfly pea, Bluebellvine, Creeper, Aparajita	Seed	Crush	For urinary issues, crushed seeds are taken with either cold or boiled water.	96
Acacia nilotica Delile	Fabaceae	Babul, Gum Arabic tree, Kikar, Sant tree	Leaves, gums, bark, flower	Decoction	10g of gum and two leaves made into a paste with cow's milk. Bark powder is utilized. Drinking a flower decoction can also help treat UTIs.	85, 97
Camellia sinensis L.	Theaceae	Tea	Leaves	Infusion	Dried leaf infusion taken	88
Zea mays L.	Poaceae	Maize, Maka	Seed, corn silk	Raw, decoction	Raw corn seeds are consumed whenever desired. Over the course of a month, one cup of the corn silk decoction is consumed twice daily.	92
Hibiscus rosa-sinensis L.	Malvaceae	Mondoro, Jasum, Mandar	Flower	Decoction, Infusion	Essential oil and flower decoction or infusion used	1, 88
Nigella sativa L.	Ranunculaceae	Kala zira	Seed	Oil, raw	A teaspoon of the oil is taken daily for a month along with a tablespoon of honey and a cup of lukewarm water. Seeds are consumed every day, either raw or mixed into meals.	92
Citrus limon (L.) Osbeck	Rutaceae	Lemon, Lembu	Peel, Fruit	Infusion, juice	One cup of lemon peel infusion is made and administered three times a day for two months. A cup of lemon juice is consumed three times a day for two months, along with a tablespoon of honey and olive oil.	92
Cynodon dactylon (L.) Pers.	Poaceae	Dhoob, Bahama grass	Leaf	Juice	Ten milliliters of leaf juice are taken orally for five days on an empty stomach.	89

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Though little research has been done, it has been reported that phytochemical constituents in herbal medicines used to treat UTIs act as immunomodulators and nutraceuticals, increase the body's oxidant status or provide antioxidant compounds, inhibit microbial attachment, stop the growth or multiplication of microorganisms, and some may even have microtidal properties. The presence of different phytochemicals, such as flavonoids, anthraquinones, alkaloids, glycosides, saponins, sterols, steroids, terpenoids, tannins, phytosterols, triterpenoids, hydrocarbons, etc and numerous other secondary metabolites of medicinal plants are the reasons for their effectiveness.[85] The primary phytochemical ingredients that give them their effects are listed in Table 3.

Table 3: Plant extracts and its components are utilized to treat various UTIs

Plant Name	Extract	Constituents	Diseases	Reference
Curcuma longa L.	Rhizome aqueous, ethanolic and ethyl acetate extracts	Hydroquinine, Quinine, o-acetyl-L serine, Copaene, Neophytadiene, Phytol, acetate, Phytol, 18-Norabietane	Multi-drug resistant bacteria UIT	98
Azadirachta indica A. Juss.	Leaf ethanolic extract	Alkaloids, Glycosides, Triterpenes, Saponins, Tannins, and flavonoids	Uropathogens	99
Ocimum sanctum Linn.	Leaf methanolic and aqueous extract	Flavonoids, cardiac alkaloids, glycosides, steroids, tannins, diterpenes, phenols, saponins, carbohydrates, and proteins	UTI in pregnant women	100
Saraca asoca (Roxb.) W. J. de Wilde	Leaf ethanolic extract	Saponins, flavonoids, steroids and glycosides	UTI pathogens (*E. coli* and *S. aureus*)	101
Zingiber officinale Rosc.	Alcoholic extract (dried rhizome powder)	phenolic compounds, essential oils, tannins, saponins and flavonoids	*E. coli* isolates from UTI	102
Abutilon indicum (L.) Sweet	Stem extracts (ethanolic, methanolic and aqueous)	flavonoids, phenols, steroids, saponins, tannins and glycosides, starch and terpenoids, cardiac glycosides, carbohydrates,	Genitourinary tract infections	103
Withania somnifera (L.)Duna	Fruit extract (Methanol, ethanol, chloroform, ether and petroleum extract)	Saponins, alkaloids, carbohydrate, tannin, flavonoids, glycosides	UTIs	104
Ricinus communis L.	Leaf methanolic extract	Amine, aldehyde, alkanes, and alkyl halide and alkane	UTI causing bacteria	105
Aloe vera L.	Leaf aqueous extract	Cinnamic acids derivatives, anthracene compounds, aloe-emodin and its derivatives, and flavonoids,	UTI causing by Gram - ve bacteria (Achromobacter xylosoxidans 4892, Citrobacter Freundii 426, etc)	106
Moringa oleifera Lam.	Leaf extract (Methanol extract)	Saponins, alkaloids, flavoniods	UTIs	107
Tribulus terrestris L.	Fruit extracts (Ethanol, ether, aqueous, chloroform, petroleum)	Saponins, alkaloids, flavonoids, tannins, teroids, glycosides, tr iterpenoids, anthraquinones, gum, mucilage, coumarin, protein, and amino acids, carbohydrates, starch and reducing sugars	UTIs	108

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Plant Name	Extract	Constituents	Diseases	Reference
Asparagus racemosus Willd.	Root powder	Flavonoids, saponins, tannins	UTI	109
Cucumis sativus L.	Ethanol and aqueous fruit extracts	Cardiac glycosides, terpenoids, carbohydrates, cardenolites and flavonoids	*Escherichia coli, Pseudomonas aeruginosa* etc.	110
Aegle marmelos L.Corr.	Leaf ethanolic and aqueous extract	Skimmianine, Cineol, Citral, Aegeline, Lupeol, Eugenol, Marmesinine, Citronella, Cuminaldehyde	UTI	111
Mangifera indica L.	Leaf extract (methanol, petroleum ether, aqueous)	phenolics, tannins, amino acid, saponins, carbohydrates, proteins, sterols, and glycosides	Pathogens causing UTI	112
Allium sativum L.	Aqueous and ethanol extract	Glycosides, tannin, saponins, flavonoids and alkaloids	*Staphylococcus aureus* and *Escherichia coli*	113
Aerva lanata (L.) Juss. Ex Schult.	Plant methanolic extract	kaempferol, quercetin, isorhamnetin, flavanone, syringic acid narcissin, apigenin, ferulic acid and vanillic acid	Common uropathogens	114
Achyranthes aspera L.	Ethanolic extract seed	Alaloids, saponins, flavonoids	Urolithiasis	115
Clitoria ternatea L.	Plant extract (petroleum ether, acetone, isopropanol)	Alkaloids, protein, carbohydrate, amino acid, alkaloids, tannins and phenolics	Gram -ve bacterium UTI (*Proteus mirabilis*)	116
Acacia nilotica Delile	Seed and leaf methanolic extract	Flavonoids, saponin, tannin, alkaloids and glycosides	*E. coli*	117
Camellia sinensis L.	Leaves ethanolic extract	Tannin	Virulent bacteria UTI	118
Zea mays L.	Corn husk and silk (methanolic and aqueous extract)	flavonoids, steroids, saponins, tannins, terpenoids and cardiac glycosides	Multi-drug resistant bacteria CAUTI (Catheter associated urinary tract infection)	119
Hibiscus rosa-sinensis L.	Leaves alcoholic extract	Alkaloid, saponin, tannin, flavonoid, terpenoid	Recurrent UTI	120
Nigella sativa L.	Plant ethanolic extract	Thymoquinone	UTIs	121
Citrus limon (L.) Osbeck	Peel ethanolic extract	Saponins, flavonoids, glycoside, tannin and steroid	Human pathogenic bacteria UTI	122
Cynodon dactylon (L.) Pers.	Leaf aqueous and ethanolic extract	Alkaloids, tannins, sterols, steroidal saponins, flavonoids, phenols, and glycoside sugars	UTI	111

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DISCUSSION

Urinary tract infections (UTIs) make almost 25% of all illnesses and are among the most prevalent bacterial infections worldwide. Numerous organisms can cause UTIs, but the most prevalent ones are *Pseudomonas aeruginosa*, *Escherichia coli*, *Candida albicans*, *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Staphylococcus aureus*, and *Staphylococcus saprophyticus*.[85] Although UTI is one of the most dangerous general medical conditions that affect both sexes, females are more vulnerable due to differences in their urogenital and conceptual life structures, physiology, and lifestyle.[7] Chronic conditions like diabetes, kidney failure, long-term corticosteroid therapy, and use of immune-suppressive medications for autoimmune disorders can also increase the incidence of UTIs. Other risk factors include tumours, stones in the kidneys, ureter, bladder, and repeated pregnancies, as well as obstructions in the urinary tract system brought on by enlarged prostates.[1] Medicinal plants have been a vital part of human society since the dawn of civilization, helping to combat illnesses. In order to lower expenses, improve treatment efficacy, and eradicate UTI patients' adverse effects, medicinal herbs have become very famous and popular.[94]

Sahena Ferdosh documented the pharmacological characteristics and bioactive substances of five plant species that are historically used in Guam for the treatment of urinary tract conditions, including *E. hirta* and *P. amarus*. Very little information has been published regarding *P. serratifolia*'s pharmacological activity and phytochemical screening. Other species that have been reported to be useful against the E. coli strains that cause the majority of UTIs include *E. hirta*, *P. amarus*, *U. lobata*, and *P. guajava*.[20] The ethnobotanical studies on medicinal plants used to treat urinary tract infections were gathered from the 16 regions of the Philippines, according to Mariel C. Magtalas et al. Numerous phytochemicals which have been demonstrated to be bioactive against bacterial uropathogens by mechanisms like synthesis of cell wall inhibition, bacterial metabolism disruption, bacterial infection attenuation, and antibiotic modulation were found in the most frequently mentioned ethnomedicinal plants in this review, including *C. nucifera* L.[2] Lovepreet Kaur lists a few widely accessible plants that can be utilized to treat or prevent UTIs.[10] Satyanshu Kumar et. al discussed the antibacterial properties of 15 Indian medicinal plants against uropathogenic bacteria.[123] According to Susmita Chakrabarty et al., three tropical plants- *Psidium guajava*, *Syzygium cumini*, and *Punica granatum* have antibacterial qualities that could be used as antibacterial agents against four isolated multi-drug resistance bacteria: *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus*.[124] Venkata documented the effectiveness of a few of these traditional plants and their vital significance in treating urinary tract infections in the general public.[125] Ziphozethu M. Ndlazi et al., reported the antibacterial and immunomodulatory qualities of six chosen ethnomedicinal plants that are utilized by traditional healers in the KwaZulu-Natal, South Africa, area as a remedy for urinary tract infections.[126] Sharif et al. states the therapeutic potential benefits of *Cydonia oblonga* extracts for treating urinary tract infections through anti-urease and antibacterial properties.[127]

The main benefit of these herbal remedies is that bacteria are not resistant to them. These herbal remedies can be used to address the issue of resistance that arises from the usage of conventional treatment. Since medicinal plants have a variety of phytochemical elements that are primarily responsible for their positive effects as well as their synergistic effects, microbial resistance to herbal medicine has not yet been documented. Only the plant components and usage instructions are covered in this review article. Further research is required to validate the phytoconstituents that treat urinary tract infections. To eradicate the harmful microorganisms, further molecular research is therefore needed, as well as technology to determine how phytoconstituents work.

CONCLUSION

UTIs are a major health issue for people worldwide. Therefore, timely treatment intervention and accurate diagnosis are essential. The use of traditional herbs is crucial for nursing and treating UTIs since they strengthen the body's natural defenses. Medicinal herbs reduce inflammation, promote healthy kidney function, and alleviate symptoms with less side effects. However, the dosage, herbal combination, and duration of treatment must be accurately documented for their legitimate medication. This study established the wide ethnomedical usage of 26 plants for the treatment of urinary tract infections (UTIs), which are a major source of morbidity in several developing countries. But further research is required to validate the safety and effectiveness of these plant-based medicines in treating urinary tract infections, including pharmaceutical and toxicological studies. Therapeutic potential screening of medicinal plants is required to determine all possible

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bioactive chemicals that are responsible for pharmacological activity and their processes. More studies at the molecular level need to be conducted as well. Furthermore, the stereochemistry and structural elucidation of compounds extracted from robust plants should be highly advantageous for the creation of novel UTI therapies.

Declarations

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