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RECURRENT URINARY TRACT INFECTIONS: CHALLENGES IN MANAGEMENT AND STRATEGIES FOR RECURRENCE PREVENTION - A REVIEW ARTICLE

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ABSTRACT

Urinary tract infection (UTI) is one of the most common infectious diseases among adults and is caused by the presence of microorganisms in the urinary tract. Bacteria from the group of uropathogenic *Escherichia coli* strains, known as UPEC, play a central role in the etiology of these infections.

Epidemiological data indicate that nearly half of all women worldwide will experience at least one UTI in their lifetime, and a significant proportion will struggle with recurrent infections. This problem is particularly prevalent among young, sexually active women, as well as those of menopausal age, which may be partially explained by age-related impairments in immune function.

Currently, one of the major challenges in contemporary clinical practice is the increasing antibiotic resistance among UTI-causing bacteria. Specialists emphasize that targeted therapy, along with non-antibiotic or alternative methods, is essential in addressing this problem and preventing recurrent UTIs.

The following overview assesses the effectiveness of the most common methods of preventing recurrent urinary tract infections, based on recent publications. These approaches include both non-pharmacological methods such as adequate hydration, proper hygiene, and appropriate contraception, as well as pharmacological methods including antibiotic therapy, D-mannose supplementation, and vaginal estrogen therapy. Each method is based on a different mechanism of action, from mechanical removal of bacteria and competitive inhibition of bacterial adhesion to stimulation of immune defenses. Despite differing pathways, all these mechanisms share a single overarching goal: to prevent urinary tract infection.

KEYWORDS

Urinary Tract Infection, Recurrent Urinary Tract Infection, UTI, *Escherichia Coli*, UPEC, Prevention, Prophylaxis, Antibiotic Resistance, Immunotherapy, D-Mannose

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Methodology

This article is a review. The data used in the article was obtained from available peer-reviewed scientific articles and reports published in reputable journals and databases. We used online databases and journals such as PubMed, BJU International, Springer Natural Link, The Journal of Urology, Urology Practice, IDSA Journals, and BMJ Open. The article also draws on the current positions of the Polish Urological Association from 2024 and the Recommendations for the diagnosis, treatment and prevention of urinary tract infections in adults from 2015. The review selected clinical trials, review articles, guidelines and reports on urinary tract infections published between 2010 and 2025 in English and Polish.

Introduction

1. Definitions

The urinary tract is one of the most common sites of infection in individuals of all ages and genders, regardless of immune status [1,2,3].

Urinary tract infection (UTI) is defined as an inflammatory clinical condition caused by the presence of microorganisms in the urinary tract, accompanied by symptoms [2,4]. Recurrent urinary tract infection (rUTI) is defined according to the commonly accepted definition as the occurrence of at least two episodes of symptomatic UTI within 6 months, or 3 infections within the last 12 months [1,2,4,5,6].

2. Epidemiology

According to epidemiological data, urinary tract infections account for nearly 50% (or 40%, depending on the source) of hospital-acquired infections and 10-20% of community-acquired infections [1,2,3].

Studies show that 50-60% of women experience at least one UTI episode in their lifetime, with 40% to 50% of those who have already had one episode experiencing it again, and almost half of these women may experience recurrent urinary tract infections (from 3-5% to as much as 20%). In addition, more urinary tract infections occur among women in highly developed countries; according to experts, up to 10% of them will experience at least one episode of UTI per year. Among men, the incidence of UTIs reaches 12-14% over their lifetime and is significantly lower than in women. In the neonatal period, infections are more common in boys (about 60% of UTIs), but from 2-3 months of age, this trend reverses in favour of women [1,3,4,7].

The peak incidence occurs among women aged 18–24 (according to other sources, the age group is expanded to 16–35), which is most likely related to the highest sexual activity in this age group, which is considered the main risk factor for UTI. Recurrent UTIs also affect young, sexually active women more often, even if no specific anatomical or physiological abnormalities can be diagnosed [2,3,5].

In women aged 35–65, UTI incidence decreases, but rises again after menopause. According to the data, menopausal women are particularly vulnerable to UTIs, with rates reaching up to 20% compared with 7% in the general population.

Among elderly men, 10% suffer from UTIs. The narrowing difference in incidence between elderly women and men is attributed partly to prostate enlargement, which disrupts urine flow. In addition, patients aged 65+ experience a natural decrease in immune system activity and a higher incidence of comorbidities such as diabetes and hormonal changes, which may be associated with more frequent complications related to inflammation in this age group [2,3,5].

3. Pathogenesis and Etiology

Regardless of the characteristics of the group of patients at risk of UTI infection, its most common etiological factor is uropathogenic *Escherichia coli* (UPEC) [8]. In women, the proximity of the urethra and the anal area facilitates the migration of bacteria from the faecal reservoir (UPEC strains are present in the human digestive tract) to the urinary bladder. The anatomically shorter urethra in females compared to males further facilitates the passage of pathogens into the urinary bladder. It is said that 95% of all UTIs are caused by pathogens passing from the urethra to the bladder [5,9].

Interestingly, uropathogenic *E. coli* strains are able to migrate to the periurethral area after prior contamination with intestinal flora due to their ability to express many virulence factors, and their ability to adhere to host epithelial cells, including umbrella cells (also known as surface cells), intermediate cells and basal cells, is considered to be of key importance in causing UTI [8,10].

The most important role in this process is played by type 1 and 2 fimbriae, Dr fimbriae adhesins, S fimbriae and F1C fimbriae, which have the ability to recognise receptors in the kidneys. These factors support the formation of biofilms that prevents, among other things, the penetration of antibiotics. Attempting to understand the specific mechanisms of biofilm formation and spread is crucial for the development of new therapies to prevent colonisation, such as biofilm inhibitors, anti-adhesion molecules, and molecules that induce bacterial dispersion [8].

UPEC also form so-called intracellular bacterial communities, protecting themselves from the host's defence mechanisms and remaining dormant in the urothelial epithelium of the bladder (study on mouse models). This phenomenon may be responsible for chronic and recurrent UTIs [2,4,5,8].

Furthermore, Uropathogenic strains of *E. coli* secrete lipoprotein - α -haemolysin and CNF1 - a necrotising cytotoxic factor 1, which is responsible for severe forms of UTI, including pyelonephritis [2].

Other pathogens present in the faecal reservoir are also responsible for causing UTIs, including *Klebsiella pneumoniae* (the second most common intestinal bacillus causing UTIs) [2], *Proteus mirabilis* and other Enterobacteriaceae, which also exhibit a range of adhesive activities to host epithelial cells. *Klebsiella pneumoniae*, equipped with an envelope with anti-phagocytic properties, lipopolysaccharides and fimbriae, exhibits increasing virulence through the aforementioned adhesive mechanisms, and thus resistance to most antibiotics used [2,5].

In addition, the presence of *Gardnerella vaginalis*, a natural component of the vaginal and bladder flora, may be responsible for recurrent UTIs. *G. vaginalis* causes epithelial exfoliation, which facilitates the invasion of uropathogenic *E. coli* into the deeper layers of the urogenital tract, where they remain dormant and may be responsible for episodes of recurrent inflammation [5].

4. Risk Factors

Studies show that sexual activity, especially among young women, is a risk factor for UTIs, probably due to increased colonisation of the vagina and bladder by UPEC [4,11,12]. It is therefore crucial to ask patients about their sexual practices, as avoiding activities considered to be risk factors for urinary tract infections can

prevent their recurrence [4,13]. Experts say that spermicidal contraceptives are a risk factor for recurrent urinary tract infections, especially nonoxynol-9, which is toxic to *Lactobacillus* species but does not inhibit *E. coli*, promoting overgrowth of UPEC in the vaginal environment [4,14].

A weakened immune system during menopause is particularly significant in recurrent urinary tract infections. The vagina of women of reproductive age is mostly colonized by *Lactobacillus* species, which metabolize glycogen secreted by vaginal epithelial cells into lactic acid, which is responsible for maintaining the proper pH of the vagina. This maintains the protective function of the vaginal microbiome, preventing dysbiosis and infections [6,15,16]. *Lactobacillus* is also responsible for preventing pathogens from adhering to the vaginal epithelium [6,17]. Studies show that the bladder microbiome is also characterized by a large number of *Lactobacilli* bacteria. It can be hypothesized that the presence of these bacteria in the bladder may also have a protective effect against susceptibility to UTIs [5,18]. During menopause, estrogen levels drop, leading to a decrease in glycogen levels in vaginal epithelial cells and, consequently, to a decrease in lactic acid production by *Lactobacillus* bacteria. This increases the pH of the vagina, making it more susceptible to infections [6].

5. Symptoms

The classic symptoms of lower urinary tract infection are polyuria and dysuria, which is a highly specific symptom with over 90% accuracy in young women [7], pain in the urethra and lower abdomen during urination, urinary urgency, as well as a feeling of incomplete bladder emptying [6].

Patients often report other symptoms, such as unpleasant urine odor, hematuria, and systemic symptoms such as fever, tachycardia, and chills, which may be signs of inflammation in the upper urinary tract—pyelonephritis [6].

It is also important to ask about symptoms affecting the genital organs, as conditions such as vaginal discharge in women, testicular pain in men, or purulent discharge from the urethra may accompany UTIs. In addition, information should be obtained about potential past sexually transmitted diseases, comorbidities, previous UTIs, and treatment used [2].

6. The problem of antibiotic resistance and its impact on therapeutic decisions

One of the most significant current challenges in UTI management is the growing antibiotic resistance among causative bacteria, particularly the emergence of carbapenem-resistant *Enterobacteriaceae*, which poses a serious global public health threat [2,8].

Resistance resulting from chromosomal mutations spreads rapidly among bacteria. Resistance acquired through conjugation, transformation, or transduction also plays a critical role. These processes render a bacterial cell that was previously sensitive to antibiotics multi-resistant. This mechanism is driven by the use of multiple antibiotics. A leading example is the extended-spectrum beta-lactamases, or ESBLs, cited in the guidelines of the Polish Urological Association [2]. They confer resistance to most penicillins and all cephalosporins. In addition, ESBL-encoding genes are located on plasmids, which facilitates their exchange between different species and exacerbates the epidemiological problem. Specialists face a major therapeutic challenge, where the use of combination therapy will be crucial in the treatment of UTIs, as resistance to single preparations will only tend to increase [2].

Restricting the use of broad-spectrum antibiotics and choosing targeted therapies may also be key to improving the current treatment situation [7]. Additionally, the use of non-antibiotic and alternative methods are gaining importance in both treatment and prevention of recurrent UTIs [4].

Results And Methods

Strategies for Recurrence Prevention

1. Non-Pharmacological Interventions

Despite numerous studies confirming the effectiveness of antibiotic therapy in preventing UTIs, many publications suggest prevention based on a step-by-step approach, i.e. first avoiding risk factors and actions not directly related to microorganisms.

- Hydration

The role of hydration in preventing UTIs has been the subject of numerous studies, although most of them were published more than 20 years ago and their results are sometimes contradictory. One study involving 791 women aged 22-73 reported a 2.21-fold increase in the risk of urinary tract infections in women who voluntarily restricted their fluid intake compared to women who did not. However, this study omitted many important elements such as urine osmolality and average fluid intake. Further research into the modification of urinary pH or osmolality as prophylaxis against UTIs is warranted [19].

Despite much conflicting data, many urological guidelines seem to recommend increased fluid intake and more frequent urination (before bedtime and after intercourse).

- Spermicides

One of the key natural defence mechanisms is the presence of microorganisms in the vaginal and urethral areas, mainly *Lactobacillus*. These organisms are able to bind to vaginal epithelial cells, preventing UTI. Changes resulting in the loss of normally protective *Lactobacillus* spp. bacteria appear to increase the risk of rUTI [20,21].

There is strong evidence that spermicidal contraceptives (coated condoms, cervical caps) are a risk factor for recurrent UTIs. The main ingredient in spermicides (nonoxynol-9) is toxic to the *Lactobacilli* bacteria naturally present in the vagina, but not to *E. coli* bacteria, which is the main cause of UTIs. A study of premenopausal women found a significant increase in *E. coli* colonisation in the vagina in 75 women using condoms with spermicides. (from 15% at baseline to 48% at week 1; $P=0.001$) [22].

In a nested case-control study of sexually active premenopausal women with and without UTI, those exclusively using condoms coated with nonoxynol-9 ($n=23$) had an OR for developing UTI of 2.2 (95% CI 1.0-4.8), and those using exclusively nonspermicidal condoms ($n=8$) had an OR of 1.6 (95% CI 0.6-4.5) [23].

- Hygiene

As with adequate hydration, most scientific studies on the relationship between hygiene and UTIs were conducted 20-30 years ago. Nevertheless, since a large proportion of the bacteria that cause UTIs originate in the digestive system, many societies recommend maintaining good hygiene, including proper wiping (from front to back), avoiding constipation and wearing breathable underwear.

2. Pharmacological Interventions

- Long-term antibiotic therapy

The first of the discussed methods of pharmacological preventing recurrent urinary tract infections is direct antimicrobial action. There are several antibiotic administration regimens, i.e. continuous (usually for 3-6 months or even years), after sexual intercourse or when symptoms of UTI occur.

- Continuous antibiotic therapy

Many studies indicate the significant effectiveness of continuous antibiotic prophylaxis of recurrent UTI in preventing recurrence. On the other hand, long-term administration of drugs increases the risk of adverse effects such as gastrointestinal disorders or increased bacterial resistance to antibiotics.

A meta-analysis of 23 studies confirms the efficacy of continuous antibiotic prophylaxis compared to placebo, with an NNT of only 1.81 (95% CI, 1.67-2.17), although it should be noted that prophylaxis lasting >12 months has not been studied under controlled conditions. Direct comparisons of antibiotics have been published mainly for nitrofurantoin, although they did not show a significant difference in recurrence, making nitrofurantoin, norfloxacin and trimethoprim-sulfamethoxazole essentially interchangeable options. However, the authors of the study point out that some of the studies date back to the 1970s, which may reflect lower reporting standards and lower study quality [24].

Another meta-analysis compared the effects of long-term antibiotic therapy with non-antibiotic therapy in women over 65 years of age. Three randomised trials compared long-term antibiotic use with vaginal oestrogens ($n=150$), oral lactic acid bacteria ($n=238$) and D-mannose powder ($n=94$) in postmenopausal women. Long-term antibiotic use reduced the risk of UTI recurrence by 24% (three trials, $n=482$; pooled risk ratio (RR) 0.76; 95% CI 0.61 to 0.95, number needed to treat=8.5). No statistically significant increase in the

risk of adverse events was observed (mild adverse events: pooled RR 1.52; 95% CI 0.76 to 3.03; serious adverse events: pooled RR 0.90, 95% CI 0.31 to 2.66) [25].

Continuous UTI prophylaxis regimens include: fosfomycin trometamol (3 g every 10 days), trimethoprim (100 mg once daily), cephalexin (125 mg or 250 mg), cefaclor (250 mg daily) and furazidone (50 mg daily) (there are no reliable clinical data confirming their efficacy) [3].

- **After intercourse**

Taking the drug after intercourse seems to be better accepted by patients due to the smaller number of tablets taken, especially when the symptoms are closely related to sexual activity. Medications used in the prevention of UTIs include: co-trimoxazole (240-480 mg), cephalexin (250 mg), cefaclor (250 mg) and furazidone (50 mg) (there is no reliable clinical data confirming its effectiveness) [2,3,26].

3. Supplementation (D-mannose, cranberry)

- **D-mannose**

D-mannose is a monosaccharide isomer of glucose and participates in the glycosylation of certain proteins. After absorption from the gastrointestinal tract, it is excreted in the urine, where, upon reaching the appropriate concentration, it binds to the FimH protein on the flagella of *E. coli* bacteria, preventing them from adhering to the uroplakin receptor on the urothelial epithelium. Competitive inhibition is considered one of the potential mechanisms for preventing UTI recurrence [27,28]. D-mannose is commonly sold as a dietary supplement. In addition, it can also be found in fruits such as oranges/apples or in the form of galactomannans in coffee beans or fenugreek, but this form of administration is considered to have too low bioavailability [29]. Studies show that approximately 20-35% of D-mannose ends up in urine, where it has the potential to block the adhesion of pathogenic *E. coli* to the epithelial cells of the urinary tract [30]. The role of D-mannose in the treatment of acute UTI and the prevention of its recurrence has been evaluated in numerous clinical trials.

In one study conducted by L Domenici et al., patients were given D-mannose twice daily for 3 days, then once daily for 10 days in acute urinary tract infection, followed by prophylactic treatment for 6 months. Promising results were obtained as a prophylactic agent (4.5% vs. 33.3% recurrence in treated and untreated patients, respectively). The authors suggest that D-mannose may be an effective adjunct to UTI treatment and an effective prophylactic agent, but further studies are needed to confirm this [31].

Another study conducted by Kranjčec et al. investigated the effects of D-mannose and nitrofurantoin in adult women with UTI and a tendency to recurrence. After initial treatment with antibiotics, 308 women with a history of recurrent urinary tract infections were randomly assigned to three groups (D-mannose, nitrofurantoin, placebo). The results showed that patients in the D-mannose and nitrofurantoin groups had a significantly lower risk of UTI recurrence during prophylactic therapy compared to the placebo group (no prophylaxis) (RR 0.239 and 0.335, $P < 0.0001$) [32].

- **Cranberry**

Cranberry in various forms has been used in medicine for hundreds of years to treat various conditions, including urinary tract infections. Over the years, many theories have emerged regarding the effect of cranberry on the urinary tract infection process. Initially, it was suggested that their prophylactic properties result from lowering the pH of urine, which prevents the growth of bacteria in the urinary tract. Currently, the most commonly cited reason is the presence of proanthocyanidins in cranberries, which inhibit the adhesion of bacteria to the cells of the urinary tract epithelium [33].

A 2023 publication, which is an update of a review first published in 1998, assessed the effectiveness of cranberry products in preventing urinary tract infections in people susceptible to infection. The study included randomised controlled trials of cranberry products compared to placebo, evaluating 50 studies (8,857 participants). Taking cranberries in the form of juice, tablets or capsules reduced the number of urinary tract infections in women with recurrent UTIs and in people susceptible to UTIs after interventions such as bladder radiotherapy. However, the results remained uncertain for older men and women in care facilities, and adults with neuromuscular bladder dysfunction. The authors indicate that cranberry products may help prevent urinary tract infections, but further evaluation in well-designed, prospective RCTs is necessary [33].

Another review by Dolores Gonzalez de Llano et al. evaluated clinical studies providing significant evidence for the use of cranberry products as a complete or partial alternative to antibiotics in UTIs, but it was observed that efficacy depends on individual characteristics and/or the specific case. These differences were attributed to different cranberry products and doses, but also to individual host genetics and immune systems. The authors point out that despite recent discoveries regarding the anti-adhesive effect of cranberries, there may also be other mechanisms influencing the differences in results [34].

Another meta-analysis on the effect of cranberries on urinary tract infections was conducted by Jia-Yue Xia and colleagues. The meta-analysis ultimately included 28 studies. Cranberry-containing products varied significantly in terms of form, manufacturer, daily dose and frequency of dosing (daily doses ranged from 0.4 g to 194.4 g). According to all twenty-three studies included, the estimated weighted risk ratio significantly reduced the risk of recurrent UTIs with cranberry intervention compared to placebo or control (RR = 0.70, 95% CI: 0.59 ~ 0.83; P<0.01).

The results of the meta-analysis revealed a 30% reduction in the risk of developing UTIs in susceptible populations who consumed cranberry products compared to those who did not. However, due to certain limitations of the studies included in this review, these conclusions should be interpreted with caution and further high-quality studies with a sufficiently large sample size are necessary [35].

4. Local Estrogen Therapy in Postmenopausal Women

Urinary tract infections arise as a result of an imbalance between protective processes and bacterial virulence. Estrogen plays a key role in modulating natural defence processes against UTIs. These mechanisms are moderately understood, but it is believed that circulating oestrogens in premenopausal women promote the colonisation of the vagina by *Lactobacillus* bacteria. It has also been shown that increased oestrogen levels in the vagina increase the percentage of glycogen-producing epithelial cells. The conversion of glycogen by *Lactobacillus* bacteria into lactic acid, hydrogen peroxide and antibacterial peptides maintains a low vaginal pH (pH<4.5) and inhibits the growth of uropathogens [36]. An increase in vaginal pH after menopause causes a decrease in the number of lactobacilli and an increase in vaginal colonisation by intestinal organisms (e.g. *E. coli*). Local oestrogen supplementation during menopause can at least partially reverse these changes.

A multicentre retrospective review was conducted involving 5,638 women with a mean age of 70.4 (+11.9 years), a body mass index of 28.5 (+6.3) kg/m² and a baseline urinary tract infection rate of 3.9 (+1.3). The mean urinary tract infection rate in the year following prescription of the drug decreased to 1.8 (P<.001) from 3.9 in the previous year, a reduction of 51.9%. Significant predictors of urinary tract infection after prescribing the drug were age 75 to 84 years, increased frequency of UTIs at baseline, urinary incontinence (1.14; 1.07-1.21), urinary retention (1.21; 1.10-1.33), and diabetes (1.14; 1.07-1.21) [37].

Another multicentre, randomised trial compared vaginal oestrogen (administered via a ring or cream) with placebo. Postmenopausal women with documented UTI were randomised to receive vaginal oestrogen (ring or cream) or placebo in a 1:1:1 ratio. The analysis showed that fewer women treated with vaginal oestrogen had a urinary tract infection within 6 months compared with placebo (11/18 vs 16/17, respectively; P= 0.041). The researchers concluded that commonly prescribed forms of vaginal oestrogen in combination with modern dosing regimens prevent urinary tract infections in postmenopausal women with an active diagnosis of rUTI [38].

5. Immunoprophylaxis and Emerging Therapies

One of the newer ideas for treating and preventing recurrent urinary tract infections is the use of special immunostimulants. However, effective development is hampered by several factors: the lack of natural immunity in people after UTI, the diversity of pathogens causing urinary tract infections, and the risk of a pathological immune response to colonising bacteria in the intestines. Despite these limitations, several preparations are available on the market and many others are in the pre-clinical/clinical research phase.

It is believed that the main effect of vaccination is to stimulate the immune system, mainly T and B lymphocytes, and the subsequent release of specific IgA antibodies that provide immunoprotection.

- Uro-Vaxom (OM-89)

Uro-Vaxom is a well-known immunostimulant, an extract from 18 selected strains of *E. coli*, which, when administered orally, increases resistance to infection and enhances the effect of antibacterial drugs. Uro-Vaxom boosts both innate and acquired immunity by activating TLR receptors and increasing the release of bactericidal agents (nitric oxide) [39]. Studies have also shown that this drug enhances the production of IgA and IgG antibodies not only against *E. coli* strains but also against other bacteria that cause UTIs [40].

Bauer and colleagues conducted a multicentre, double-blind study involving a total of 453 patients, 231 in the study group and 222 in the placebo group. Patients were given 600 mg of the drug daily for 90 days, followed by 600 mg for the first 10 days of months 7, 8 and 9. The mean incidence of urinary tract infections after initiation of treatment was significantly lower in the study group than in the placebo group (0.84 vs 1.28; p<0.003), corresponding to a 34% reduction in urinary tract infections in patients treated with OM-89. The safety profile of OM-89 was good and consistent with that reported in previous studies [41].

In 2010, a prospective multicentre study was conducted involving 34 patients (women) with a mean age of 56.4 years (+34-75) treated for 3 months with one 600 mg Uro-Vaxom capsule. The number of recurrences was significantly lower during the 6-month observation period than in the 6 months preceding the study (0.35 vs. 4.26, $p < 0.001$). During the observation period (6 months after discontinuation of treatment), 28 patients (82.4%) had no recurrences, and 4 (11.8%) experienced one recurrence [42].

Another retrospective analysis included 79 patients with recurrent UTI treated with Uro-Vaxom 600 mg daily for 90 days. The parameter assessed was the number of UTI infections in the 12 months prior to treatment compared to the 12 months after treatment. A significant decrease in the average number of urinary tract infections in the year following the start of treatment was observed compared to the previous year – 3.14 vs 1.53 ($p < 0.05$), respectively [43].

A systematic review was conducted covering 8 RCT studies involving 674 patients in the OM-89 group and 677 patients in the placebo group. The analysis showed a lower percentage of symptomatic urinary tract infections in the study group compared to placebo (OR 0.48; 95% CI 0.23-0.97; $P < 0.01$; $I^2 = 81\%$). Similarly, bacteriuria at both 3 and 6 months after treatment was less frequent in patients treated with OM-89 compared to placebo (OR 0.23; 95% CI 0.10-0.53; $P = 0.03$) and (OR 0.45; 95% CI 0.23-0.89; $P = 0.02$), respectively). However, the authors point to a trend suggesting that the difference in efficacy between OM-89 and placebo has decreased in more recent studies [44].

Clinical trials also include other preparations, such as the ExPEC4V vaccine administered as an intramuscular injection or Solco-Urovac. Strovac (also known as Solco-Urovac) contains ten heat-killed strains of uropathogens (6 UPEC serotypes, *P. vulgaris*, *K. pneumoniae*, *Morganella morganii* and *E. faecalis*) administered intramuscularly. This product was subsequently replaced by a vaginal preparation known as the Urovac vaginal vaccine due to adverse effects [45,46].

However, the results of the analyses are not that accurate, and they were not conducted on a sufficiently large group of respondents to draw clear and correct conclusions.

Conclusions

In summary, urinary tract infections remain one of the most significant problems in modern medicine, which, despite the development of new technologies and drugs, continues to be very important. This review has shown that there are many ways to prevent urinary tract infections, ranging from lifestyle changes and behavioural changes through the use of appropriate supplementation to immunostimulants.

The method of prevention used should depend on the characteristics, symptoms, age of the patient and the potential cause of recurrent infections.

This shows that we are dealing with a multidisciplinary problem that requires multiple actions. Many publications and guidelines clearly recommend starting prevention with lifestyle changes and adequate hydration, which is consistent with the study described above [19]. This demonstrates the need for patient education as one of the first elements of prevention.

In this review, we have also cited numerous publications on D-mannose supplementation, according to which there is evidence of its effectiveness. However, researchers point out (as in the case of cranberries) that more research is needed.

The problem of recurrent urinary tract infections is particularly important in postmenopausal women due to the loss of the natural protective effect of oestrogens. Numerous studies and analyses cited indicate that the use of vaginal oestrogen preparations improves quality of life and reduces the frequency of recurrence.

More and more studies are also focusing on immunoprophylaxis of urinary tract infections. Uro-Vaxom, described in the review, has been available on the market for at least several decades, and many studies indicate its definite effectiveness, as we have cited in this article. However, it is important to note the latest meta-analysis, which has observed a certain downward trend in the effectiveness of this drug, which only requires us to look for new ways to combat urinary tract infections [44].

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