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URINARY TRACT INFECTIONS AND A REVIEW OF COMMON HERBS (CRANBERRY, D-MANNOSE, UVA URSI, AND GOLDENSEAL) AND STUDENTS' KNOWLEDGE AND PERSPECTIVES

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ABSTRACT

Introduction: Urinary tract infections (UTIs) represent a significant burden on public health, frequently recurring and often prompting patients to explore non-antibiotic therapies. Among these, natural remedies such as cranberry (Vaccinium macrocarpon), D-mannose, Uva Ursi (Arctostaphylos uva-ursi), and Goldenseal (Hydrastis canadensis) have garnered attention for their potential antimicrobial and preventative properties. Despite widespread public interest, there is limited data on healthcare professionals' preparedness to counsel on these alternatives. **Methods:** This cross-sectional study assessed pharmacy students' knowledge of the safety profiles, contraindications, and monitoring requirements associated with these agents, while also exploring persistent misconceptions related to UTI epidemiology. **Results**: The data indicated strong baseline knowledge, with 88.57% correctly identifying the therapeutic roles of cranberries and Uva Ursi, and 80% recognizing the benefits of D-mannose and Goldenseal. However, 37.14% of participants incorrectly believed UTIs affect only women, underscoring a persistent epidemiological misconception. While over 85% of respondents expressed confidence in the effectiveness of these remedies, statistical analyses revealed no significant correlation between knowledge or opinion scores and demographic variables. **Conclusion:** These findings highlight both strengths and gaps in pharmacy students' understanding of natural UTI treatments. The results support the need for more

robust curricular integration of evidence-based guidance on herbal and dietary supplements, particularly in light of growing patient interest and ongoing concerns about antibiotic resistance.

KEYWORDS: Urinary Tract Infection; Survey, Pharmacy, cranberry (Vaccinium macrocarpon), D-mannose, Uva Ursi (Arctostaphylos uva-ursi), and Goldenseal (Hydrastis canadensis)

BACKGROUND

UTIs occur when pathogenic microorganisms, most commonly Escherichia coli (E. coli), colonize the urinary tract, leading to localized inflammation and infection. The pathogenesis of UTIs primarily involves bacterial adhesion to the urothelial lining, facilitated by fimbriae and adhesins, which allow the pathogens to resist urinary flow and evade the host immune response. Once adhered, bacteria can ascend the urinary tract, progressing from the urethra to the bladder (cystitis) and, in more severe cases, to the kidneys (pyelonephritis). Host factors such as urinary stasis, incomplete bladder emptying, and anatomical abnormalities can predispose individuals to recurrent infections.

In women, the shorter urethra and proximity to the rectum increase susceptibility. While UTIs are often associated with female anatomy, they can also affect men, particularly those with underlying urological conditions or catheter use, though this is less commonly recognized. UTIs elicit a host immune response marked by symptoms like dysuria and urgency. While innate defenses are crucial, recurrence may result from incomplete treatment, biofilm formation, or bacterial persistence. Variability in susceptibility, shaped by genetic and environmental factors, underscores the need for preventive approaches, including natural remedies that inhibit early bacterial adhesion.

UTIs are among the most common bacterial infections globally, with an estimated 150 million cases occurring annually. In the United States alone, UTIs account for nearly 10 million healthcare visits per year and represent a leading cause of antibiotic prescriptions. While women are disproportionately affected, nearly 50–60% experiencing at least one UTI in their lifetime, men, children, and the elderly are also susceptible, particularly in the presence of comorbidities or indwelling catheters. Recurrent UTIs, defined as two or more episodes within six months or three within a year, affect up to 30% of women following an initial infection.

The impact of UTIs extends beyond individual morbidity, contributing to substantial healthcare costs, antibiotic resistance, and reduced quality of life. Patients frequently experience pain, discomfort, and disruption of daily activities, while recurrent infections may lead to psychological stress and diminished work productivity. From a public health perspective, the widespread use of antibiotics for UTIs contributes to the growing threat of antimicrobial resistance, underscoring the urgency of exploring safe, evidence-based alternatives, including natural preventive therapies.

REVIEW OF SELECTED HERBS

D-Mannose

D-mannose is a naturally occurring simple sugar found in various fruits, including cranberries, apples, and oranges. It is closely related to glucose but is metabolized differently by the human body. Historically, D-mannose has been used as a dietary supplement to support urinary tract health, particularly in preventing recurrent UTIs. Its mechanism involves inhibiting the adhesion of E. coli, the most common cause of UTIs, to the bladder wall, thereby aiding in bacterial elimination through urination. Today, D-mannose is commonly used to reduce UTI frequency and as a non-antibiotic alternative in patients seeking preventive strategies. It is typically sold in powder, capsule, or tablet form and is widely available over the counter in pharmacies, health food stores, and online (Wagenlehner, Lorenz, Ewald, & Gerke, 2022).

A randomized, controlled trial conducted by Lenger et al. (2020) evaluated the efficacy of D-mannose in preventing recurrent UTIs in women. The study included 308 adult women with a history of recurrent UTIs and compared three groups: one receiving daily D-mannose powder, one receiving nitrofurantoin (an antibiotic), and a control group receiving no preventive treatment. Over a 6-month period, the recurrence rate in the D-mannose group was significantly lower (15%) compared to the control group (60%) and was comparable to the antibiotic group (20%) ($p < 0.001$). Furthermore, the D-mannose group experienced fewer adverse effects than those receiving nitrofurantoin (Lenger et al., 2020). However, due to limited clinical studies suggesting that its long-term effects are not well explored, the National Institutes of Health (NIH) has called for larger, high-quality studies to confirm its long-term benefits.

Cranberries

Cranberry, also known as *Vaccinium macrocarpon*, is a fruit native to North America and has long been used as a natural remedy for UTIs. Its therapeutic effect is primarily attributed to its high content of proanthocyanidins (PACs), which inhibit the adhesion of E. coli to uroepithelial cells, thereby reducing the likelihood of bacterial colonization in the urinary tract. This anti-adhesive property underlies its common use in the prevention, rather than treatment, of recurrent UTIs, particularly in women (Singh & Jain, 2020).

Despite widespread use, the clinical effectiveness of cranberries remains a subject of ongoing research. A 2023 randomized controlled trial by Vostalova et al. enrolled 209 premenopausal women with a history of recurrent UTIs. Participants received either a high-PAC cranberry extract (37 mg PACs/day) or a placebo for 24 weeks. The study found a statistically significant reduction in the number of UTI episodes in the cranberry group compared to placebo ($p = 0.038$), with fewer patients requiring antibiotics and fewer reporting moderate-to-severe symptoms (Vostalova et al., 2023). No severe adverse effects were observed, indicating a favorable safety profile.

Goldenseal

Goldenseal, *Hydrastis canadensis*, is a perennial herb native to North America, traditionally utilized by Indigenous peoples for various ailments, including digestive disorders, skin diseases, and infections. The plant's medicinal properties are primarily attributed to its isoquinoline alkaloids, notably berberine, hydrastine, and canadine (Vostalova et al., 2023). Among these, berberine has garnered significant attention for its broad-spectrum antimicrobial activity.

In vitro studies have demonstrated Berberine’s efficacy against a range of pathogens, including E. coli, a predominant causative agent of UTIs. Berberine exerts its antibacterial effects by inhibiting bacterial DNA replication, disrupting cell wall synthesis, and impairing protein function. Notably, it also interferes with the adhesion of uropathogenic E. coli to uroepithelial cells, a critical step in the pathogenesis of UTIs. Furthermore, research indicates that goldenseal extracts may enhance the antimicrobial activity of berberine through the inhibition of bacterial efflux pumps. These pumps are mechanisms by which bacteria expel antimicrobial agents, contributing to antibiotic resistance. By inhibiting these pumps, goldenseal compounds can potentiate the efficacy of berberine and other antibiotics (Geetha, Roy, & Lakshmi, 2011).

Despite promising in vitro results, clinical evidence supporting goldenseal's efficacy in treating UTIs remains limited. The bioavailability of berberine when administered orally is relatively low, which may affect its therapeutic potential. Additionally, concerns have been raised regarding the safety profile of goldenseal, particularly with long-term use or high dosages, due to potential hepatotoxicity and interactions with cytochrome P450 enzymes.

In conclusion, while goldenseal exhibits notable antimicrobial properties in laboratory settings, further clinical research is necessary to establish its safety and efficacy in the treatment of UTIs. Healthcare professionals should exercise caution and consider existing evidence when recommending goldenseal as a therapeutic option.

Uva Ursi

Uva Ursi (Arctostaphylos uva-ursi), commonly known as bearberry, is a low-growing evergreen shrub native to Europe, Asia, and North America. Traditionally, its leaves have been used in herbal medicine to address urinary tract ailments, owing to their content of arbutin, a glycoside that, upon hydrolysis, yields hydroquinone with antimicrobial properties. The leaves also contain tannins, which may exert astringent effects on mucous membranes, potentially reducing inflammation and combating infection (Mount Sinai Health System, n.d.).

Modern clinical investigations have explored Uva Ursi's efficacy in managing uncomplicated UTIs. The ATAFUTI trial, a randomized, placebo-controlled study involving 382 women aged 18–70 with symptoms of lower UTI, assessed the impact of Uva Ursi extract and ibuprofen as alternative treatments (Moore et al., 2019). Participants received either Uva Ursi, ibuprofen, both, or placebos, alongside a delayed antibiotic prescription. The study found no significant difference in symptom severity between Uva Ursi and placebo groups during days 2–4. Additionally, Uva Ursi did not significantly reduce antibiotic consumption compared to placebo. However, ibuprofen advice led to a notable reduction in antibiotic use without increasing complications.

Another study examined the prophylactic effect of Uva Ursi extract (UVA-E) in women with recurrent cystitis (Stanisavljević, Nikolić, Stojanović, & Petrović, 2005). In this double-blind, randomized trial, 57 women with a history of recurrent UTIs received either UVA-E or placebo over a period. The results indicated that UVA-E significantly reduced the recurrence rate of UTIs compared to placebo, suggesting its potential as a preventive agent.

Despite these findings, concerns about Uva Ursi's safety profile persist. The hydroquinone derived from arbutin can be toxic, particularly with prolonged use, potentially leading to liver damage. Consequently, Uva Ursi is recommended only for short-term use under medical supervision (National Center for Biotechnology Information, n.d.). It is contraindicated in pregnant or breastfeeding women, children, and individuals with kidney or liver conditions .
In summary, while Uva Ursi has demonstrated some efficacy in reducing UTI recurrence, its role in acute treatment remains inconclusive. Its potential benefits must be weighed against safety concerns, underscoring the need for further research to establish standardized dosing regimens and to fully elucidate its therapeutic profile.

LITERATURE GAP, STUDY OBJECTIVES AND IMPACT

Healthcare professionals' knowledge and opinions on the use of natural herbs for treating UTIs vary, influenced by factors such as clinical experience, cultural context, and the availability of scientific evidence. A qualitative study involving general practitioners (GPs) in the UK revealed that while some clinicians are open to herbal therapies for recurrent UTIs, many express caution due to limited clinical evidence and concerns about safety and efficacy (Howe et al., 2022). These GPs often rely on antibiotics as the standard treatment but acknowledge the need for alternative options amid rising antibiotic resistance.

In contrast, a review focusing on clinicians' knowledge and attitudes towards antibiotic prescribing for UTIs found that healthcare professionals often have poor levels of knowledge regarding appropriate antibiotic use (Stuart et al., 2023). This gap may extend to alternative treatments, including herbal remedies, highlighting the need for broader education on all potential options.

Additionally, a study examining patients' beliefs and attitudes toward antibiotics and herbal products indicated that a significant portion of patients consider plant-based products effective. This perception may influence healthcare professionals to consider or discuss herbal options with patients, especially when patients express a preference for natural remedies (Jovanovic Tadic et al., 2023).

Overall, while there is a growing interest in herbal therapies for UTIs among both patients and some healthcare providers, the integration of such treatments into clinical practice is hindered by the lack of robust scientific evidence and standardized guidelines. Healthcare

professionals' opinions are shaped by the current evidence base, patient preferences, and the imperative to ensure safe and effective care.

Therefore, the objective of this study was to evaluate pharmacy students' understanding of the efficacy, safety risks, contraindications, and monitoring requirements associated with these natural products. The study also aimed to assess whether students could recognize potential herb-drug interactions and apply this knowledge to patient care.

METHODS

This cross-sectional study surveyed first-professional year pharmacy students to assess their knowledge and perceptions of natural remedies, such as cranberry, D-mannose, Uva Ursi, and Goldenseal, which are used for UTI prevention and treatment. The survey included three sections: demographics, knowledge-based true/false questions, and opinion-based statements measured on a 4-point Likert scale (1 = strongly disagree to 4 = strongly agree). A score above 2.5 was interpreted as agreement.

Demographic data collected included gender, educational background, prior state of residence, work experience type, and duration. A total of 39 students participated, most of whom had a four-year degree and pharmacy-related work experience. Participants answered five knowledge questions on the clinical use, safety, and mechanisms of natural UTI treatments, and five opinion statements gauging their attitudes.

Descriptive statistics, including percentages, means, and standard deviations, were used to analyze responses. Relationships between demographic variables and responses were assessed, with no statistically significant associations found ($p > 0.05$). The results were used to identify knowledge gaps and inform educational needs in pharmacy training.

RESULTS

Table 1 delineates the demographic composition of the study participants (N=39), encompassing gender, education level, and professional experience. The majority were female (74.63%) and held a four-year degree (66.67%), with over half (54.05%) having pharmacy-related work experience. Notably, 41.03% possessed more than three years of professional exposure, underscoring a highly educated and experienced cohort. These characteristics provide critical context for assessing participants' familiarity with natural UTI treatments and the potential influence of their backgrounds on knowledge and perceptions.

Table 1: Sociodemographic Characteristics of Participants (N=46).

Variables		*N= 39* (%)
Gender	Male	10 (25.64%)
	Female	29 (74.63%)
	Non-Binary/Third Gender	0 (0.0%)
	Prefer not to say	0 (0.0%)
Education (Highest level attended)	2 Year College	2 (5.13%)
	4 Years/BS/BA	26 (66.67%)
	MSC/MA or Higher	7 (17.95%)
	Other	4 (10.25%)
Work experience	Never Worked	2 (5.13%)
	Worked in Healthcare Related Jobs	9 (24.32%)
	Worked in Pharmacy Related Jobs	20 (54.05%)
	Other	8 (21.62%)
If you have worked, for how many years?	< 1 Year	12 (30.77%)
	1 - 3 Years	9 (23.0%)
	> 3 Years	16 (41.03%)

Knowledge Based Questions

The survey results provide valuable insight into participants' understanding of natural remedies for UTIs (Table 2). A majority of respondents (80%) correctly identified D-mannose as an agent capable of preventing bacterial adhesion in the urinary tract, indicating strong awareness of its preventive role. Additionally, 88.57% of participants accurately acknowledged the potential health benefits of cranberries, including their ability to help prevent UTIs and other conditions such as stomach cancer and heart disease. This high response rate reflects a solid grasp of cranberry's multifaceted therapeutic properties.

Participants also demonstrated significant awareness regarding Uva Ursi, with 88.57% recognizing its contraindications in pregnant or hypertensive individuals. Similarly, 80% correctly identified Goldenseal as a natural antibiotic commonly promoted for immune support and gastrointestinal relief. These responses suggest that most students had a working knowledge of the intended uses and risks associated with these natural remedies.

However, only 62.86% of participants correctly rejected the misconception that UTIs affect only women. This indicates a notable gap in epidemiological understanding, as a substantial portion of respondents either endorsed or were uncertain about this inaccurate belief. This gender-related misconception, despite the cohort's overall strong educational background and pharmacy-related work experience, underscores a critical area for targeted educational intervention.

Overall, while the correctness rates for most questions were relatively high, the persistence of fundamental misconceptions regarding UTI susceptibility suggests that pharmacy curricula may need to place greater emphasis on the epidemiology of UTIs and the role of natural agents in both prevention and treatment. This would ensure a more comprehensive and clinically accurate foundation for future healthcare professionals.

Table 2: Knowledge-based questions.

Variables	Correct Answer	Participants with Correct Answer N (%)
Question 1: D-mannose can prevent certain kinds of bacteria from sticking to the walls of the urinary tract and causing	True	28 (80%)
Question 2: Only women can get a UTIs	False	22 (62.86%)
Question 3: Cranberries are a good source of certain vitamins and minerals, as well as several unique plant compounds that may help prevent UTIs, stomach cancer, and heart disease.	True	31 (88.57%)
Question 4: Women who are pregnant or breastfeeding, and people with high blood pressure, should not take Uva Ursi.	True	31 (88.57%)
Question 5: Goldenseal is sold to help with digestion, soothe an upset stomach, and kill bacteria. It is considered a natural antibiotic and is often combined with echinacea and promoted as strengthening the immune system.	True	28 (80%)
AVERAGE		**80%**

Opinion Based Questions

The opinion-based portion of the survey revealed generally favorable attitudes toward natural remedies for UTIs, with varying degrees of agreement across different treatments and safety concerns (Table 3). Belief in the efficacy of cranberries as a preventive option for UTIs was particularly strong, with 51.43% of participants strongly agreeing and 38.88% agreeing, resulting in a high mean Likert score of 1.74. This suggests broad support for cranberry supplementation as a commonly accepted, non-antibiotic intervention among pharmacy students.

Similarly, participants overwhelmingly agreed that Uva Ursi should be used with caution in pregnant or breastfeeding women, with a combined agreement of 91.43% and a mean score of 1.77. This reflects a well-informed understanding of herb-specific contraindications and the potential for maternal-fetal harm, indicating that students are aware of safety concerns surrounding natural products.

Confidence in D-mannose's role in preventing bacterial adhesion was also evident, with 85.72% expressing agreement or strong agreement, and a mean score of 1.97. This affirms

students' belief in its preventive utility for recurrent UTIs and supports its growing use in clinical practice as a non-antibiotic alternative.

Opinions regarding Goldenseal, while still favorable, showed slightly more variation. A total of 82.85% agreed or strongly agreed with its antibacterial potential, yet a higher proportion of neutral or skeptical responses contributed to a slightly higher mean Likert score of 2.00. This suggests some uncertainty about the evidence supporting Goldenseal, possibly reflecting limited exposure to its clinical use or concerns about safety and standardization.

Notably, the statement affirming that both men and women can develop UTIs revealed a critical insight: although 88.58% agreed or strongly agreed, 11.47% disagreed or were unsure. The mean score of 1.71 highlights that, while the majority understood the non-gender-specific nature of UTIs, a small but important subset of students still held misconceptions, aligning with findings from the knowledge-based section and underscoring the need for targeted education.

Overall, the opinion-based data reflect a largely positive perception of natural UTI treatments, alongside an awareness of clinical precautions. However, areas of lingering skepticism, particularly around less-studied remedies like Goldenseal, and persistent misconceptions regarding UTI epidemiology indicate opportunities for curricular reinforcement and deeper integration of evidence-based herbal medicine into pharmacy education.

Table 3: Opinion-based questions.

Variables	Agree *N* (%)	Disagree *N* (%)	Mean ± SD
1: I believe that natural remedies like cranberries have the potential to prevent urinary tract infections.	32 (90.3%)	3 (8.61%)	1.74 ± 1.02
2: I believe that women who are pregnant should be cautioned about using remedies like Uva Ursi while pregnant or breastfeeding.	32 (91.43%)	3 (8.61%)	1.77 ± 0.93
3: I believe that D-mannose can prevent certain kinds of bacteria from sticking to the walls of the urinary tract and causing infection.	30 (85.72%)	5 (14.33%)	1.97 ± 1.03
4: I believe that remedies like Goldenseal have the ability to kill bacteria in the body and help cure urinary tract infections.	29 (82.85%	6 (17.19%)	2.00 ± 1.10
5: I believe that both men and women can develop urinary tract infections.	31 (88.59)	4 (11.47%)	1.71 ± 1.03

DISCUSSION

The findings of this study suggest a high level of awareness among pharmacy students regarding natural remedies used for the prevention and management of UTIs. Across the knowledge-based questions, participants answered correctly at notably high rates. For instance, 88.57% of respondents correctly identified the benefits of cranberries and Uva Ursi, while 80% accurately recognized the role of D-mannose in preventing bacterial adhesion and the antibacterial properties of Goldenseal. These results indicate that most students have a solid foundational understanding of the mechanisms and therapeutic potential of these natural products.

Despite this general knowledge, a key misconception emerged: only 62.86% of students correctly identified that UTIs can affect both men and women. This means that over one-third of respondents either misunderstood or were unaware of the epidemiological reality that UTIs are not exclusive to female patients. This misconception persisted despite the high overall accuracy on other knowledge items, suggesting that targeted instruction is still needed regarding the full demographic scope of UTI susceptibility.

Responses to opinion-based questions further illustrated participants' confidence in the clinical potential of these remedies. More than 90% of students expressed belief in cranberries' ability to prevent UTIs, and 85.72% supported D-mannose's preventative mechanism. Additionally, 91.43% of respondents acknowledged the importance of caution when using Uva Ursi during pregnancy or in hypertensive patients, indicating a strong awareness of safety considerations. While Goldenseal also received generally positive feedback, with 82.85% in agreement about its antibacterial properties, slightly higher variability in responses suggests that students may be less certain about its safety or efficacy, potentially due to its less frequent use or limited clinical evidence.

These findings are consistent with broader literature examining healthcare professionals' knowledge and attitudes toward non-conventional therapies for UTIs. A systematic review by Mwape et al. (2024) assessed clinicians' understanding of antibiotic prescribing practices and highlighted substantial variability in their knowledge, particularly regarding alternative treatment options. The authors found that while many healthcare providers are aware of the risks associated with antibiotic overuse, there remains limited confidence in recommending or counseling patients on non-antibiotic interventions such as natural remedies (Mwape, Schmidtke, & Brown, 2024). This parallels the present study's findings, which suggest that

even among pharmacy students, misconceptions and gaps persist despite a generally high level of awareness. The convergence of both studies underscores the need for more structured education and clinical training focused on evidence-based complementary therapies, especially in light of global efforts to combat antimicrobial resistance and promote holistic, patient-centered care.

This study is not without limitations. The sample size was relatively small (N=39), limiting the generalizability of the findings to a broader population. Additionally, the participant pool consisted primarily of students with pharmacy-related experience, which may have influenced their baseline knowledge. The survey did not include detailed correlation analyses between demographic factors such as age, gender, or educational background and response accuracy. Future research should include a more diverse and representative sample and incorporate clinical outcomes to validate the practical implications of student knowledge on patient care.

CONCLUSION

This study explored pharmacy students' knowledge and perceptions regarding the use of natural remedies—cranberry, D-mannose, Uva Ursi, and Goldenseal—in the prevention and management of UTIs. The majority of participants demonstrated strong foundational understanding, with approximately 80–88% accurately identifying the therapeutic properties and safety considerations of these agents. Opinion-based responses further revealed widespread confidence in their efficacy and appropriate use, particularly in relation to D-mannose and cranberry for UTI prevention and cautionary use of Uva Ursi during pregnancy. However, a persistent misconception, that UTIs primarily affect women, was noted among over one-third of participants, highlighting a critical area for educational intervention.

While participants showed a high level of awareness overall, the findings suggest the need for enhanced curricular emphasis on the epidemiology of UTIs and the pharmacological and safety profiles of commonly used herbal remedies. This includes a deeper focus on herb-drug interactions, monitoring requirements, and patient counseling techniques.

Overall, this study contributes to the growing body of literature emphasizing the importance of integrating evidence-based natural product education into pharmacy training. Doing so may better prepare future pharmacists to provide informed, safe, and patient-centered

recommendations regarding natural remedies in the context of rising interest in alternative therapies and the global challenge of antibiotic resistance.

Ethics Approval and Consent to Participate: This study was approved by the institutional Investigational Review Board and was conducted in accordance with ethical standards. As the survey contained no identifiers, formal ethics approval was deemed unnecessary. All participants provided informed consent to participate.

Consent for Publication: Participants provided consent for the publication of findings from this study. The survey did not include any personal identifiers.

Availability of Data and Materials: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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