International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	LIFESTYLE, DIETARY, AND BEHAVIORAL DETERMINANTS OF LOWER URINARY TRACT SYMPTOMS (LUTS): INTEGRATING CLINICAL EVIDENCE WITH DIGITAL HEALTH AND EMERGING TECHNOLOGIES
DOI	https://doi.org/10.31435/ijitss.2(50).2026.5502
RECEIVED	21 March 2026
ACCEPTED	13 June 2026
PUBLISHED	22 June 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

LIFESTYLE, DIETARY, AND BEHAVIORAL DETERMINANTS OF LOWER URINARY TRACT SYMPTOMS (LUTS): INTEGRATING CLINICAL EVIDENCE WITH DIGITAL HEALTH AND EMERGING TECHNOLOGIES

Weronika Szczeblewska *(Corresponding Author, Email: weronika27273@gmail.com)*
Independent Public Provincial Integrated Hospital in Szczecin, Szczecin, Poland
ORCID ID: 0009-0007-3956-622X

Filip Kopacki
University Clinical Hospital no. 2, Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0005-7897-8222

Daniel Jaskot
Independent Public Provincial Integrated Hospital in Szczecin, Szczecin, Poland
ORCID ID: 0009-0004-8678-9838

Jakub Świech
University Clinical Hospital no. 2, Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0001-1732-4162

Marta Kamrowska
University Clinical Hospital no. 2, Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0001-1570-0144

Katarzyna Apanasewicz
J. Strus Multidisciplinary Municipal Hospital in Poznań, Poland
ORCID ID: 0009-0001-0765-5398

Jakub Marzec
University Clinical Hospital no. 1 of Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0007-8336-7260

Natalia Kita
University Clinical Hospital no. 2, Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0001-2277-6198

Natalia Sztenc
Pomeranian Medical University, Szczecin, West Pomerania, Poland
ORCID ID: 0009-0006-4307-7958

Patrycja Broniszewska
University Clinical Hospital no. 2, Pomeranian Medical University in Szczecin, Poland
ORCID ID: 0009-0000-6577-307X

ABSTRACT

Lower urinary tract symptoms (LUTS) are highly prevalent and multifactorial conditions that significantly impair quality of life and contribute to substantial healthcare burden. Their etiology involves complex interactions between physiological, behavioral, and environmental factors.

This narrative review aims to synthesize current evidence on the role of lifestyle, dietary, social, and behavioral determinants in the prevention and management of LUTS. A structured literature search was conducted using PubMed, Scopus, and Web of Science, including observational studies, randomized controlled trials, and recent systematic reviews.

The available evidence indicates that modifiable factors such as obesity, physical inactivity, smoking, and dietary habits play a significant role in the development and progression of LUTS. Fluid intake patterns, caffeine and alcohol consumption, and overall dietary composition influence symptom severity, particularly storage symptoms. In addition, psychosocial determinants—including stress, socioeconomic status, and health literacy—affect symptom perception, healthcare-seeking behavior, and treatment adherence.

Recent advances in digital health and artificial intelligence offer new opportunities for improving LUTS management through real-time monitoring, personalized interventions, and data-driven clinical decision-making.

In conclusion, LUTS management should adopt a multidisciplinary and patient-centered approach integrating lifestyle modification, behavioral interventions, and emerging technologies to improve clinical outcomes and long-term patient care.

KEYWORDS

LUTS, Lifestyle Factors, Dietary Patterns, Behavioral Determinants, Digital Health, Artificial Intelligence

CITATION

Weronika Szczeblewska, Filip Kopacki, Daniel Jaskot, Jakub Świech, Marta Kamrowska, Katarzyna Apanasewicz, Jakub Marzec, Natalia Kita, Natalia Sztenc, Patrycja Broniszewska. (2026) Lifestyle, Dietary, and Behavioral Determinants of Lower Urinary Tract Symptoms (LUTS): Integrating Clinical Evidence with Digital Health and Emerging Technologies. *International Journal of Innovative Technologies in Social Science*. 2(50). doi: 10.31435/ijitss.2(50).2026.5502

1. Introduction

Lower urinary tract symptoms (LUTS) encompass a broad spectrum of storage, voiding, and post-micturition symptoms that significantly impair quality of life and daily functioning. These symptoms include urinary frequency, urgency, nocturia, hesitancy, weak urinary stream, and incomplete bladder emptying, and may occur independently of a clearly identifiable underlying disease (Abrams et al., 2003). LUTS are frequently associated with conditions such as benign prostatic hyperplasia (BPH), overactive bladder (OAB), urinary incontinence, and neurogenic bladder dysfunction; however, their occurrence in otherwise healthy individuals increasingly supports a multifactorial and systemic etiology (European Association of Urology [EAU], 2023).

The global burden of LUTS is substantial, affecting a large proportion of the adult population. Epidemiological evidence suggests that up to 60% of adults experience at least one LUTS, with prevalence increasing markedly with age (Irwin et al., 2006; Coyne et al., 2008; Coyne et al., 2013). Population-based studies also highlight persistent gaps in treatment-seeking behavior across different demographic groups (Sexton et al., 2011).

Importantly, LUTS are no longer viewed solely as age-related conditions but rather as complex syndromes influenced by an interplay of metabolic, environmental, and behavioral factors. Increasing evidence highlights the role of modifiable risk factors—including obesity, physical inactivity, and dietary habits—as well as comorbidities such as diabetes and cardiovascular disease in the development and progression of LUTS (Parsons et al., 2011; Lin et al., 2015; Bradley et al., 2017). Recent reviews suggest that lifestyle and behavioral factors play an increasingly recognized role in the pathogenesis and management of LUTS, reinforcing the need for integrative and preventive approaches.

The pathophysiology of LUTS is multifaceted and involves interactions between bladder function, neural regulation, hormonal influences, and pelvic floor dynamics. Functional disturbances such as detrusor

overactivity, impaired bladder compliance, and altered sensory signaling play a central role in symptom development (Osman et al., 2016; Scarneciu et al., 2021). Moreover, emerging evidence suggests that lifestyle-related factors may modulate these mechanisms through pathways involving chronic inflammation, metabolic dysregulation, and autonomic nervous system imbalance (Lai et al., 2015; Yuan et al., 2021).

Traditionally, the management of LUTS has focused on pharmacological and surgical interventions, including alpha-blockers, antimuscarinic agents, and minimally invasive procedures. While these approaches may provide symptomatic relief, they are often associated with adverse effects, suboptimal long-term adherence, and variable therapeutic outcomes. Consequently, there is growing interest in non-pharmacological strategies, particularly lifestyle and dietary modifications, which represent cost-effective, accessible, and potentially impactful approaches to both prevention and management (Skokan & Newman, 2016; Dumoulin et al., 2018).

In recent years, increasing attention has been directed toward the role of social and behavioral determinants in LUTS. Psychosocial stress, socioeconomic status, health literacy, and barriers to healthcare access have been shown to influence symptom perception, healthcare-seeking behavior, and adherence to treatment (Shaw et al., 2001; Rubach et al., 2019; Nouri et al., 2020). These findings underscore the importance of adopting a holistic, patient-centered framework that extends beyond purely biomedical models of care.

Furthermore, advances in digital health technologies and artificial intelligence are beginning to transform the field of urology. Mobile health applications, wearable devices, and telemonitoring systems offer novel opportunities for continuous symptom tracking, behavioral intervention support, and personalized treatment strategies (Rosa et al., 2021; Topol, 2019; Rajkomar et al., 2019). Recent studies also highlight the growing role of digital tools in improving patient engagement and facilitating remote management of chronic urological conditions (Piwek et al., 2016).

Despite growing recognition of these factors, there remains a lack of integrative frameworks that comprehensively address the interaction between lifestyle, dietary, social, and technological determinants in LUTS. Most existing studies focus on isolated risk factors rather than adopting a multidimensional perspective.

Therefore, this review aims to provide a comprehensive synthesis of current evidence on lifestyle and dietary determinants of LUTS, with a particular emphasis on modifiable risk factors. Additionally, the review explores the role of social, behavioral, and emerging technological influences in the prevention and management of LUTS, highlighting opportunities for improving patient outcomes through multidisciplinary and integrative approaches.

2. Methods

This review was conducted using a structured narrative approach to provide a comprehensive and integrative synthesis of the available evidence on lifestyle and dietary determinants of lower urinary tract symptoms (LUTS).

A systematic literature search was performed using three major electronic databases: PubMed, Scopus, and Web of Science. These databases were selected due to their extensive coverage of biomedical, clinical, and interdisciplinary research. The search included studies published up to January 2026, with a primary focus on literature from the last 10–15 years.

Search terms included combinations of keywords and Medical Subject Headings (MeSH), such as “lower urinary tract symptoms,” “LUTS,” “lifestyle,” “diet,” “obesity,” “physical activity,” “fluid intake,” “behavioral determinants,” and “digital health.” Boolean operators (AND, OR) were applied to refine the search strategy.

Eligible studies included observational designs (cross-sectional, cohort, and case-control studies) as well as interventional studies, including randomized controlled trials and quasi-experimental research. In addition, systematic reviews, meta-analyses, and clinical guidelines were included to ensure a comprehensive and evidence-based synthesis.

Inclusion criteria were defined as follows: (1) studies examining associations between lifestyle or dietary factors and LUTS; (2) adult populations; (3) peer-reviewed publications; and (4) studies reporting clinically relevant outcomes, including symptom severity, quality of life, or treatment response. Exclusion criteria comprised non-English publications, pediatric populations, conference abstracts without full-text availability, and studies lacking sufficient methodological quality.

The study selection process involved an initial screening of titles and abstracts, followed by full-text evaluation of potentially eligible articles. Data were extracted and analyzed qualitatively, with a focus on

identifying key thematic domains, including modifiable lifestyle factors, dietary patterns, psychosocial determinants, and emerging technological influences.

Due to the nature of this review, no formal meta-analysis was conducted. Instead, findings were synthesized thematically to identify consistent patterns, emerging trends, and gaps in the literature.

3. Epidemiology and Burden of LUTS

Lower urinary tract symptoms (LUTS) constitute a substantial public health concern, with wide-ranging clinical, psychosocial, and economic implications. Epidemiological studies demonstrate that the prevalence of LUTS increases with age, affecting both men and women across diverse populations worldwide (Irwin et al., 2011; Coyne et al., 2009; Coyne et al., 2013). Large population-based analyses suggest that up to 60–70% of adults report at least one LUTS, with prevalence rising markedly in individuals over 40 years of age (Irwin et al., 2011). Recent systematic reviews further corroborate the high prevalence of LUTS and highlight persistent underreporting and gaps in treatment-seeking behavior (Sexton et al., 2011).

Sex-related differences in symptom presentation have been consistently reported. Men are more frequently affected by voiding symptoms, such as hesitancy, weak urinary stream, and incomplete bladder emptying, often associated with benign prostatic hyperplasia (BPH). In contrast, women more commonly experience storage symptoms, including urinary urgency, frequency, and urinary incontinence, with epidemiological studies indicating a higher prevalence of incontinence among women (Milsom et al., 2014; EAU, 2023). Despite these differences, LUTS in both sexes share overlapping pathophysiological mechanisms and significantly impact quality of life.

The burden of LUTS extends beyond physical manifestations and has profound implications for daily functioning and well-being. Nocturia, one of the most bothersome symptoms, is strongly associated with sleep fragmentation, leading to daytime fatigue, impaired cognitive performance, and increased risk of falls, particularly among older adults (Hashim & Abrams, 2007; Kupelian et al., 2012). Sleep disruption is also linked to metabolic and cardiovascular consequences, further compounding the health burden of LUTS.

Individuals with LUTS frequently experience psychological distress, including anxiety, depression, embarrassment, and social withdrawal. These effects may be exacerbated by the chronic, unpredictable nature of symptoms and social stigma (Coyne et al., 2008; Chess-Williams et al., 2021). Reduced participation in social, occupational, and physical activities further contributes to diminished quality of life.

From a socioeconomic perspective, LUTS impose a substantial burden on healthcare systems worldwide. Direct costs include physician visits, diagnostic evaluations, pharmacological treatments, continence products, and surgical interventions, while indirect costs arise from reduced work productivity, absenteeism, and early retirement due to symptom severity (Irwin et al., 2006). In high-income countries, the economic burden of LUTS and related conditions, such as overactive bladder, is estimated to reach billions of dollars annually, emphasizing the importance of effective prevention and management strategies.

Moreover, the aging population and increasing prevalence of lifestyle-related risk factors, including obesity and sedentary behavior, are expected to further escalate the global burden of LUTS. This underscores the need for comprehensive approaches that integrate clinical management with strategies targeting modifiable lifestyle and behavioral determinants.

4. Lifestyle Determinants of LUTS

4.1 Obesity and Metabolic Syndrome

Obesity is one of the most consistently identified and well-established modifiable risk factors for lower urinary tract symptoms (LUTS). A large body of epidemiological and clinical evidence demonstrates a strong association between increased body mass index (BMI) and both the prevalence and severity of LUTS in men and women (Parsons et al., 2011;Lin et al., 2015). This relationship appears to be dose-dependent, with higher BMI values correlating with greater symptom burden and increased risk of disease progression.

Several pathophysiological mechanisms have been proposed to explain the association between obesity and LUTS. Increased intra-abdominal pressure related to excess body weight may exert mechanical stress on the bladder and pelvic floor, contributing to impaired bladder function and reduced pelvic support. This mechanism is particularly relevant in the development of stress urinary incontinence in women (Subak et al., 2009).

Beyond mechanical factors, obesity is closely associated with metabolic and inflammatory alterations. Adipose tissue functions as an active endocrine organ, releasing pro-inflammatory cytokines and adipokines that contribute to systemic low-grade inflammation. Emerging evidence suggests that metabolic and

inflammatory pathways, including those associated with vitamin D deficiency, may influence bladder function, detrusor activity, and urothelial signaling (Kupelian et al., 2009; Yuan et al., 2021).

Metabolic syndrome—characterized by insulin resistance, hypertension, dyslipidemia, and central obesity—has also been strongly associated with LUTS. Individuals with metabolic syndrome demonstrate a significantly higher prevalence of both storage and voiding symptoms (Kupelian et al., 2009; Lin et al., 2015). Proposed mechanisms include autonomic nervous system dysregulation, endothelial dysfunction, pelvic ischemia, and smooth muscle alterations within the lower urinary tract (Kupelian et al., 2009).

In addition, insulin resistance and hyperglycemia may impair bladder function through their effects on peripheral neuropathy and microvascular damage. These processes may lead to altered bladder sensation and contractility, contributing to both overactive bladder symptoms and impaired bladder emptying.

Importantly, growing clinical evidence indicates that obesity-related LUTS are at least partially reversible. Interventional studies, including randomized controlled trials, have demonstrated that weight reduction achieved through lifestyle modification—such as dietary changes and increased physical activity—can significantly improve LUTS severity and quality of life. Even moderate weight loss has been associated with a reduction in urinary incontinence episodes, particularly among overweight and obese women (Subak et al., 2009). These findings support the inclusion of weight management as a first-line component of conservative LUTS management strategies.

Collectively, the evidence underscores the importance of integrating lifestyle-based interventions into LUTS care. Targeting obesity and metabolic syndrome not only addresses key underlying pathophysiological mechanisms but also represents a non-invasive, cost-effective, and scalable approach to improving patient outcomes.

4.2 Physical Activity

Physical activity plays a significant protective role in the prevention and management of lower urinary tract symptoms (LUTS) through multiple physiological and behavioral mechanisms. Regular exercise is associated with improved cardiovascular function, enhanced metabolic regulation, and reduced systemic inflammation, all of which contribute to improved bladder function and lower urinary tract health (Parsons et al., 2008; Parsons et al., 2011).

Epidemiological studies indicate that individuals engaging in moderate to high levels of physical activity exhibit a lower prevalence of LUTS compared to sedentary individuals. This association appears particularly strong for storage symptoms, including urinary urgency, incontinence, and nocturia (Parsons et al., 2008; Parsons et al., 2011). Physical activity may exert beneficial effects through improvements in insulin sensitivity, reduction in adiposity, and enhanced pelvic blood flow, thereby supporting normal bladder and urethral function.

In addition to general physical activity, targeted pelvic floor muscle training (PFMT) represents a well-established and evidence-based intervention for LUTS, particularly in women with urinary incontinence. PFMT strengthens pelvic floor musculature, improves urethral closure mechanisms, and enhances neuromuscular control, leading to clinically significant reductions in symptom severity (Dumoulin et al., 2018). Recent systematic reviews continue to support PFMT as a first-line intervention for stress urinary incontinence and as an effective adjunct therapy for other LUTS (Dumoulin et al., 2018; Bø & Nygaard, 2020).

Conversely, sedentary behavior has been associated with an increased risk of LUTS and poorer urological outcomes. Prolonged sitting and low levels of physical activity contribute to weight gain, metabolic dysfunction, and reduced pelvic floor strength, all of which are recognized risk factors for LUTS (Parsons et al., 2008). In addition, sedentary lifestyles may impair vascular function, potentially leading to pelvic ischemia and subsequent bladder dysfunction.

However, not all forms of physical activity confer uniform benefits. High-impact activities, such as running, jumping, and intensive fitness training, may increase intra-abdominal pressure and impose strain on the pelvic floor. In women—particularly those with pre-existing pelvic floor dysfunction or postpartum changes—such activities may exacerbate symptoms of urinary incontinence (Bø & Nygaard, 2020).

Therefore, individualized exercise recommendations are essential. A balanced approach incorporating moderate aerobic activity, resistance training, and pelvic floor exercises is likely to provide optimal benefits while minimizing potential risks. Tailoring physical activity interventions to patient-specific characteristics—including age, sex, comorbidities, and baseline pelvic floor function—is critical for effective LUTS management.

Overall, promoting regular and appropriately structured physical activity represents an important, non-invasive strategy for reducing LUTS risk and improving symptom control. Integrating exercise-based interventions into comprehensive lifestyle modification programs may further enhance both urological outcomes and overall health.

4.3 Smoking

Smoking has been increasingly recognized as a significant modifiable risk factor in the development and progression of lower urinary tract symptoms (LUTS). Multiple biological mechanisms may explain this association, including endothelial dysfunction, oxidative stress, and chronic systemic inflammation, all of which negatively affect lower urinary tract function (Rohrmann et al., 2005; Yuan et al., 2021).

Tobacco smoke contains numerous toxic compounds that contribute to vascular damage and impaired microcirculation. Reduced pelvic blood flow, including to the bladder and prostate, may result in tissue hypoxia and functional impairment, contributing to both storage and voiding symptoms. In addition, smoking-induced oxidative stress may alter detrusor muscle activity and urothelial signaling, thereby exacerbating LUTS.

Another important mechanism linking smoking to LUTS is chronic cough, commonly observed in long-term smokers. Repeated increases in intra-abdominal pressure may weaken pelvic floor structures and contribute to stress urinary incontinence, particularly in women (Bø & Nygaard, 2020). Over time, this mechanical strain may impair urethral support and worsen symptom severity.

Recent epidemiological studies and systematic reviews indicate that smoking is associated with an increased risk of LUTS in both men and women (Noh et al., 2020). Smokers are more likely to report urinary urgency, frequency, nocturia, and reduced urinary flow compared to non-smokers. This relationship appears to be dose-dependent, with greater symptom severity observed among heavy and long-term smokers.

Furthermore, smoking is strongly associated with comorbid conditions such as cardiovascular disease, diabetes, and chronic respiratory disorders, which may indirectly contribute to LUTS through vascular and neurological mechanisms (Yuan et al., 2021). These overlapping pathways highlight the systemic nature of LUTS and their close relationship with overall metabolic and vascular health.

Importantly, smoking cessation may lead to improvements in LUTS and overall urological health. Although the degree of reversibility may vary depending on cumulative exposure, cessation remains a key component of lifestyle modification strategies in patients with LUTS.

Given its widespread health effects and modifiable nature, smoking status should be routinely assessed in individuals presenting with LUTS. Integrating smoking cessation interventions into urological care may provide benefits beyond symptom control, contributing to improved long-term health outcomes.

5. Dietary Factors

Dietary factors represent an important and modifiable group of determinants in the prevention and management of lower urinary tract symptoms (LUTS). Increasing evidence highlights the role of fluid intake behaviors, stimulant consumption, dietary patterns, and micronutrient status in influencing urinary symptoms. These factors may influence bladder function both directly—through modulation of urine production, bladder irritation, smooth muscle activity, and autonomic regulation—and indirectly via their effects on obesity, metabolic dysfunction, and systemic inflammation (Bradley et al., 2017).

Although dietary interventions are commonly recommended in clinical practice, the strength of evidence varies across specific exposures. Some associations, particularly those involving fluid intake patterns and caffeine consumption, are relatively well established, whereas others—such as the role of specific micronutrients—remain less conclusive. Nevertheless, dietary assessment should be considered an essential component of LUTS evaluation, given that these factors are modifiable and amenable to low-cost behavioral interventions. Recent reviews indicate that dietary patterns and fluid intake behaviors are important, yet often underrecognized, contributors to LUTS, particularly through their interaction with metabolic and inflammatory pathways.

5.1 Fluid Intake

Fluid intake plays a complex and sometimes paradoxical role in the management of LUTS. Excessive fluid consumption may exacerbate urinary frequency, urgency, and nocturia by increasing urine production and bladder filling, thereby intensifying storage symptoms. Conversely, insufficient fluid intake may lead to highly concentrated urine, which can irritate the bladder mucosa, worsen urgency, and potentially increase the risk of urinary tract infections in susceptible individuals (Bradley et al., 2017).

Current evidence suggests that optimal fluid management should avoid both excessive restriction and overconsumption. Instead, individualized strategies are recommended, taking into account symptom profile, comorbidities, daily activity patterns, and environmental factors. For example, patients with nocturia may benefit from reducing evening fluid intake, whereas those experiencing bladder irritation related to concentrated urine may require more evenly distributed hydration throughout the day.

Clinical guidelines indicate that fluid modification may be particularly relevant in patients with overactive bladder (OAB). Moderate reductions in fluid intake (approximately 20–25%) have been associated with improvements in urgency and frequency, although effects on urinary incontinence are less consistent (EAU, 2023). Importantly, evidence suggests that fluid management strategies are most effective when tailored to individual patient characteristics rather than applied uniformly.

Education regarding both the timing and volume of fluid intake is therefore essential. Patients should be advised not only on total fluid consumption but also on drinking patterns and beverage types, and how these relate to their specific symptoms. In clinical practice, bladder diaries and fluid logs represent valuable tools for identifying maladaptive behaviors and supporting individualized management strategies (EAU, 2023).

5.2 Caffeine and Alcohol

Caffeine is one of the most frequently discussed dietary factors in relation to lower urinary tract symptoms (LUTS) and is widely considered a potential bladder irritant. Due to its stimulant and mild diuretic properties, caffeine intake has been associated with increased urinary urgency, frequency, and nocturia in susceptible individuals. Recent observational studies and systematic analyses suggest that higher caffeine consumption may be associated with worsening of storage symptoms, although findings remain heterogeneous and appear to be influenced by dose, sex, and baseline symptom severity (Bradley et al., 2017; Gleason et al., 2013; Le Berre et al., 2020).

The mechanisms by which caffeine may exacerbate LUTS include increased urine production, enhanced detrusor overactivity, and heightened bladder sensory signaling. Caffeine may also reduce functional bladder capacity, leading to more frequent voiding and urgency. These effects support clinical recommendations to reduce caffeine intake, particularly in patients with overactive bladder or urgency-predominant LUTS.

Alcohol consumption may similarly influence LUTS through multiple physiological and behavioral pathways. Its diuretic effect promotes increased urine production, particularly during the evening and nighttime, thereby contributing to nocturia. In addition, alcohol disrupts sleep architecture, which may worsen perceived symptom burden and overall quality of life.

Emerging epidemiological evidence suggests that alcohol intake may be associated with increased urinary frequency and nocturia, although the relationship appears to vary depending on consumption patterns and population characteristics (Markland et al., 2011; Noh et al., 2020). Some studies indicate that moderate alcohol intake may not significantly worsen LUTS, whereas heavy consumption is more consistently associated with symptom exacerbation.

From a clinical perspective, moderation or reduction of caffeine and alcohol intake is generally recommended in patients with LUTS, particularly when a temporal association between intake and symptom exacerbation is observed. However, complete elimination is not always necessary. Individualized, symptom-guided modification strategies are likely to be more effective and sustainable in long-term management.

Importantly, variability in individual response suggests that personalized dietary recommendations are essential, as not all patients experience symptom worsening with caffeine or alcohol exposure.

5.3 Dietary Patterns

Emerging evidence suggests that overall dietary patterns may influence the risk and severity of lower urinary tract symptoms (LUTS) more substantially than individual nutrients alone. Diets rich in fruits, vegetables, legumes, whole grains, and unsaturated fats—such as the Mediterranean diet—have been associated with reduced systemic inflammation, improved metabolic function, and enhanced vascular health, all of which may contribute to better lower urinary tract function (Lin et al., 2015; Lim et al., 2025).

Recent studies indicate that adherence to healthy dietary patterns is associated with a lower prevalence of LUTS and improved urinary outcomes, particularly in individuals with metabolic comorbidities. These effects are likely mediated through improvements in insulin sensitivity, reductions in oxidative stress, and modulation of inflammatory pathways, which are increasingly recognized as key contributors to LUTS pathophysiology (Lin et al., 2015; Lim et al., 2025).

In contrast, Western dietary patterns—characterized by high consumption of processed foods, red and processed meats, saturated fats, refined carbohydrates, and sugar-sweetened beverages—are associated with increased systemic inflammation and metabolic dysfunction. These dietary patterns have been strongly linked to obesity and metabolic syndrome, both of which are established risk factors for LUTS. Consequently, diet may influence urinary symptoms not only through direct bladder irritation but also via broader cardiometabolic mechanisms (Lin et al., 2015; Lim et al., 2025).

Importantly, emerging evidence supports the concept that dietary patterns exert cumulative and synergistic effects on health outcomes, suggesting that holistic dietary modification may be more effective than targeting individual dietary components in isolation. This approach is particularly relevant in patients with coexisting metabolic abnormalities, obesity, or sedentary lifestyles.

From a clinical perspective, counseling that promotes overall healthy dietary patterns—rather than focusing exclusively on symptom-triggering foods—may provide broader health benefits and contribute to sustained improvements in LUTS. Integrating dietary modification into comprehensive lifestyle interventions may therefore enhance both urological and systemic health outcomes.

5.4 Micronutrients

The role of micronutrients in lower urinary tract symptoms (LUTS) has gained increasing attention; however, the available evidence remains less robust compared to other dietary domains. Among micronutrients, vitamin D has been the most extensively investigated, largely due to the presence of vitamin D receptors in smooth muscle and pelvic floor tissues, suggesting biologically plausible mechanisms linking deficiency to urinary dysfunction.

A recent systematic review and meta-analysis reported that vitamin D insufficiency is associated with an increased likelihood of LUTS, although the findings are heterogeneous and do not support definitive causal conclusions (Yuan et al., 2021). Proposed mechanisms include effects on detrusor muscle function, neuromuscular signaling, and inflammatory pathways.

Vitamin D deficiency has also been studied in relation to urinary incontinence and pelvic floor disorders, particularly in women. A recent review found suggestive but inconclusive evidence of an association between vitamin D deficiency and urinary incontinence, with limited data supporting the effectiveness of supplementation as a therapeutic intervention (Baer et al., 2022).

Beyond vitamin D, other micronutrients—such as magnesium and antioxidant-related compounds—have been hypothesized to influence LUTS through their roles in neuromuscular function, oxidative stress regulation, and inflammation. For example, oxidative stress has been implicated in bladder dysfunction, and dietary antioxidants may theoretically mitigate these effects. However, current evidence remains sparse and largely observational, precluding firm clinical recommendations (Zheng et al., 2024).

Emerging research also suggests that micronutrient status may interact with broader metabolic and inflammatory pathways, further supporting the concept that LUTS should be considered within a systemic health framework rather than as an isolated urological condition.

Given the current limitations of evidence, routine micronutrient supplementation cannot be universally recommended for LUTS management. Instead, targeted assessment may be appropriate in selected populations, particularly those at risk of nutritional deficiencies or with persistent, unexplained symptoms.

5.5 Clinical Implications of Dietary Modification

Taken together, the available evidence supports the inclusion of dietary assessment and counseling as an integral component of routine evaluation in patients with lower urinary tract symptoms (LUTS). Dietary interventions are particularly attractive due to their low cost, minimal risk, and compatibility with broader preventive and cardiometabolic health strategies (EAU, 2023).

Importantly, dietary recommendations should be individualized rather than standardized. Patients differ in symptom profiles, sensitivity to dietary triggers, comorbid conditions, and readiness to adopt lifestyle changes. Therefore, a personalized approach is essential to maximize adherence and clinical effectiveness.

In clinical practice, several key domains may be prioritized, including total and timed fluid intake, reduction of caffeine consumption, moderation of alcohol intake, identification of bladder-irritating foods or beverages, and promotion of overall healthy dietary patterns. The use of bladder diaries and dietary logs can facilitate identification of patient-specific triggers and support more precise and tailored interventions (Bradley et al., 2017).

Furthermore, emerging evidence supports the integration of dietary modification within broader lifestyle interventions, including weight management and physical activity, to address shared metabolic and inflammatory pathways underlying LUTS (Lim et al., 2025).

Overall, dietary factors appear to play a meaningful role in both the prevention and management of LUTS. Although high-quality interventional studies remain limited in certain areas, current evidence supports a pragmatic, patient-centered approach in which dietary modification is incorporated into comprehensive lifestyle and behavioral strategies aimed at improving both urological and overall health outcomes.

The key lifestyle and dietary determinants of LUTS and their clinical implications are summarized in Table 1.

Table 1. Lifestyle and dietary determinants of LUTS and their clinical implications

Determinant	Mechanisms	Impact on LUTS	Clinical Implications
Obesity	Increased intra-abdominal pressure, inflammation, insulin resistance	Urinary incontinence, urgency, frequency	Weight reduction improves symptoms and quality of life
Physical activity	Improved metabolism, pelvic blood flow, neuromuscular function	Reduced LUTS risk, improved bladder function	Regular moderate exercise and PFMT recommended
Smoking	Oxidative stress, vascular damage, chronic cough	Increased urgency, frequency, incontinence	Smoking cessation as part of LUTS management
Fluid intake	Urine production, bladder irritation	Both excessive and insufficient intake worsen symptoms	Individualized fluid management strategies
Caffeine	Diuretic effect, increased detrusor activity	Urgency, frequency, nocturia	Symptom-guided reduction recommended
Alcohol	Diuresis, sleep disruption	Nocturia, frequency	Limit especially evening consumption
Dietary patterns	Metabolic and inflammatory pathways	Western diet worsens LUTS; healthy diets protective	Promote healthy diet
Micronutrients	Muscle and nerve function	Possible association	Selective supplementation

6. Social and Behavioral Determinants

6.1 Psychosocial Stress

Psychosocial stress is increasingly recognized as a significant and often underappreciated factor influencing lower urinary tract symptoms (LUTS). Chronic stress activates the hypothalamic–pituitary–adrenal (HPA) axis and the autonomic nervous system, leading to dysregulation of cortisol secretion, increased sympathetic activity, and alterations in bladder sensitivity and contractility (Lai et al., 2015; Chess-Williams et al., 2021).

Emerging evidence suggests that central nervous system mechanisms, including dysregulation of the brain–bladder axis, may play a key role in mediating the relationship between psychological stress and LUTS. Functional alterations in neural pathways involved in bladder control may increase urgency perception and reduce bladder capacity, particularly in individuals with overactive bladder (OAB) (Griffiths et al., 2007).

In addition to physiological mechanisms, psychosocial stress significantly influences symptom perception and coping behaviors. Individuals experiencing chronic psychological distress often exhibit heightened interoceptive awareness, which may lead to increased symptom reporting and reduced tolerance of urinary urgency (Chess-Williams et al., 2021). Furthermore, stress-related behavioral changes—such as sleep disturbances, increased caffeine consumption, and reduced physical activity—may further exacerbate LUTS.

Clinical and epidemiological studies consistently demonstrate that patients with LUTS frequently report coexisting anxiety, depression, and impaired quality of life. The relationship between psychological distress and LUTS appears to be bidirectional, with urinary symptoms contributing to emotional burden and psychological factors amplifying symptom severity (Coyne et al., 2008).

These findings underscore the importance of adopting a holistic and multidisciplinary approach to LUTS management, incorporating psychological assessment, stress reduction strategies, and behavioral interventions alongside conventional urological treatment.

6.2 Socioeconomic Status

Socioeconomic status (SES) is a significant determinant of both the prevalence and outcomes of lower urinary tract symptoms (LUTS). Individuals with lower SES are more likely to experience a higher burden of urinary symptoms, as well as reduced access to healthcare services and preventive interventions (Irwin et al., 2006; Coyne et al., 2013). Contributing factors include lower health literacy, financial barriers, and limited availability of specialized urological care.

Lower SES is also associated with increased exposure to lifestyle-related risk factors, including poor diet, obesity, smoking, and physical inactivity, all of which have been linked to LUTS. In addition, occupational factors—such as physically demanding work, shift work, and restricted access to restroom facilities—may contribute to the development or exacerbation of urinary symptoms.

Emerging evidence highlights that social determinants of health, including income, education, and access to care, play a critical role in shaping both disease burden and treatment outcomes in chronic conditions, including LUTS (Shaw et al., 2001; Sexton et al., 2011). Patients from socioeconomically disadvantaged backgrounds are less likely to seek care, receive timely diagnosis, or access specialist services, leading to delayed treatment and worse clinical outcomes.

Health inequalities related to SES may also influence treatment adherence and long-term management. Individuals facing economic or social constraints may have difficulty adhering to lifestyle modifications, attending follow-up visits, or engaging in behavioral interventions due to competing priorities and limited resources.

Furthermore, disparities in access to digital health tools and telemedicine—an increasingly important component of LUTS management—may further widen existing inequalities, particularly among older adults and underserved populations (Nouri et al., 2020).

Addressing SES-related disparities requires a multifaceted approach, including improved access to primary and specialist care, integration of social determinants into clinical assessment, and development of culturally sensitive and accessible patient education programs.

6.3 Health-Seeking Behavior

Despite the high prevalence and significant impact of lower urinary tract symptoms (LUTS), a substantial proportion of affected individuals do not seek medical attention. Contemporary population-based studies indicate that many individuals perceive urinary symptoms as a normal consequence of aging or feel reluctant to discuss them due to embarrassment or stigma, contributing to underreporting and delayed diagnosis (Shaw et al., 2001; Sexton et al., 2011).

Barriers to healthcare-seeking behavior are multifactorial and include limited awareness of available treatments, misconceptions regarding symptom severity, and restricted access to medical services. In addition, social and cultural factors may strongly influence attitudes toward urinary symptoms and willingness to seek care, particularly in older adults and underserved populations (Rubach et al., 2019; Nouri et al., 2020).

Recent evidence suggests that health literacy plays a critical role in shaping help-seeking behavior in chronic conditions, including LUTS. Individuals with lower health literacy are less likely to recognize symptoms as clinically relevant, engage with healthcare providers, or adhere to recommended treatments (Berkman et al., 2011). Furthermore, disparities in access to digital health resources and telemedicine may contribute to inequalities in care utilization and long-term treatment engagement (Nouri et al., 2020).

Improving health-seeking behavior requires a multifaceted approach that integrates patient education, reduction of stigma, and enhanced accessibility of healthcare services. Educational initiatives aimed at increasing awareness of LUTS as treatable conditions, combined with efforts to promote open communication between patients and healthcare providers, are essential.

Primary care providers play a crucial role in early identification and management of LUTS. Proactive screening strategies, routine inquiry about urinary symptoms, and patient-centered communication may help overcome barriers to care and facilitate earlier intervention.

6.4 Behavioral Interventions

Behavioral therapies are widely recognized as first-line treatments for many lower urinary tract symptoms (LUTS) and constitute a cornerstone of non-pharmacological management. These interventions include bladder training, timed voiding, fluid management, pelvic floor muscle training (PFMT), and lifestyle modifications aimed at reducing symptom triggers (Dumoulin et al., 2018; EAU, 2023).

Bladder training involves progressively increasing the interval between voiding to improve bladder capacity and reduce urgency, while timed voiding schedules help patients regain control over bladder function and minimize episodes of incontinence. Pelvic floor muscle training strengthens the muscles supporting the bladder and urethra, thereby enhancing continence mechanisms and reducing symptom severity (Dumoulin et al., 2018).

Behavioral interventions are particularly advantageous due to their non-invasive nature, low cost, and minimal risk of adverse effects. They can be implemented across various healthcare settings, including primary care, and are suitable for long-term management. Importantly, these strategies promote active patient engagement, which has been associated with improved adherence and better clinical outcomes (World Health Organization, 2003).

Recent evidence suggests that integrating behavioral interventions with digital health technologies—such as mobile applications, wearable devices, and telemonitoring systems—may further enhance treatment effectiveness by improving adherence, enabling real-time symptom tracking, and facilitating personalized feedback, as demonstrated in other chronic disease populations (Kitsiou et al., 2015; Nouri et al., 2020; Rosa et al., 2021). These innovations represent a promising direction for the future of LUTS management, particularly in the context of increasing demand for remote and patient-centered care.

Overall, social and behavioral determinants play a critical role in the development, perception, and management of LUTS. Addressing these factors through multidisciplinary and patient-centered approaches may significantly improve both clinical outcomes and quality of life.

7. Digital Health and Artificial Intelligence in LUTS

The rapid development of digital health technologies has introduced innovative tools that are transforming the assessment and management of lower urinary tract symptoms (LUTS). In recent years, mobile health (mHealth), wearable technologies, and artificial intelligence (AI) have gained increasing attention as complementary tools that can enhance traditional clinical approaches (Topol, 2019; Rajkomar et al., 2019).

Mobile health (mHealth) applications represent one of the most widely adopted digital solutions in LUTS management. These applications enable patients to record urinary symptoms, track fluid intake, and maintain real-time voiding diaries. Compared to traditional paper-based diaries, digital tools offer improved accuracy, higher patient adherence, and more detailed longitudinal data, allowing clinicians to better understand symptom patterns and tailor treatment strategies accordingly (Rosa et al., 2021; Wang et al., 2021; Naik et al., 2024).

In addition to self-reported data, wearable devices equipped with biosensors provide objective and continuous monitoring of physiological parameters. These technologies can capture data related to hydration status, physical activity, and sleep patterns, and are increasingly being explored for monitoring urinary behavior. Integration of such data with clinical platforms may enhance diagnostic accuracy, enable early detection of symptom deterioration, and support proactive management strategies (Piwek et al., 2016; Huhn et al., 2022).

Artificial intelligence (AI) has emerged as a particularly promising tool in LUTS diagnostics and management. Machine learning algorithms can analyze large and complex datasets, including electronic health records, imaging data, and patient-reported outcomes, to identify patterns not detectable through conventional analysis. These models have the potential to improve diagnostic precision, predict disease progression, and support clinical decision-making (Rajkomar et al., 2019; Topol, 2019; Esteva et al., 2019).

For example, AI-based models have shown potential in supporting the classification and phenotyping of lower urinary tract conditions by integrating clinical, behavioral, and physiological data, which may improve diagnostic accuracy and enable more personalized treatment strategies (Esteva et al., 2019; Naik et al., 2024)

Natural language processing (NLP), a subfield of AI, is increasingly applied in healthcare settings. NLP techniques enable extraction of clinically relevant information from unstructured data sources, such as physician notes and electronic health records, facilitating large-scale data analysis, improved patient stratification, and identification of population-level trends in LUTS (Rajkomar et al., 2019; Esteva et al., 2019).

Despite these promising developments, several challenges remain. Data privacy and cybersecurity concerns are particularly important given the sensitive nature of urological data. Additionally, integration of digital tools with existing healthcare systems remains technically and logistically complex. Many AI-based models also require external validation and rigorous clinical testing before widespread implementation.

Another important consideration is digital literacy and accessibility. Not all patient populations benefit equally from digital health technologies, particularly older adults or individuals with limited access to digital infrastructure. Addressing these disparities is essential to ensure equitable implementation of these innovations (Nouri et al., 2020).

Nevertheless, digital health and artificial intelligence represent a rapidly evolving field with substantial potential to transform LUTS management. By enabling more precise, personalized, and data-driven approaches, these technologies may significantly enhance both clinical outcomes and patient engagement in the future.

The main social, behavioral, and technological factors influencing LUTS management are summarized in Table 2.

Table 2. Social, behavioral, and technological determinants influencing LUTS management

Determinant	Mechanisms	Impact on LUTS	Clinical Implications
Psychosocial stress	HPA axis, autonomic changes	Increased urgency and symptom perception	Stress management and psychological support
Socioeconomic status	Access to care, lifestyle exposure	Worse outcomes, delayed treatment	Address health inequalities
Health-seeking behavior	Awareness, stigma, literacy	Delayed diagnosis and treatment	Education and proactive screening
Behavioral interventions	Bladder training, PFMT	Improved symptom control	First-line non-pharmacological therapy
Digital health tools	Monitoring, engagement	Better adherence	Use apps, telemedicine, wearables,
Artificial intelligence	Data analysis, prediction	Personalized care	Decision support tools

8. Integration of Lifestyle Interventions in Clinical Practice

Effective management of lower urinary tract symptoms (LUTS) requires a comprehensive, patient-centered, and multidisciplinary approach that extends beyond pharmacological and surgical interventions. Increasing evidence supports the integration of lifestyle and behavioral modifications into standard clinical care as essential components of both prevention and long-term management strategies (EAU, 2023).

Lifestyle interventions—including weight management, physical activity, dietary modification, smoking cessation, and behavioral therapies—should be considered first-line or adjunctive treatments depending on symptom severity and underlying etiology. These approaches are particularly valuable due to their low cost, minimal adverse effects, and potential to target underlying pathophysiological mechanisms such as inflammation, metabolic dysfunction, and pelvic floor impairment (Skokan & Newman, 2016).

In routine clinical practice, clinicians should systematically assess patients' lifestyle habits, dietary patterns, fluid intake behaviors, and psychosocial context. Structured tools such as bladder diaries, fluid logs, and validated symptom questionnaires may support this assessment and provide objective data to guide individualized management (Abrams et al., 2003; Bradley et al., 2017). Identification of modifiable risk factors enables clinicians to tailor interventions that are both clinically relevant and acceptable to patients.

Individualized care plans should be developed in collaboration with patients, taking into account their preferences, expectations, and readiness for behavioral change. Shared decision-making is particularly important in LUTS management, as adherence to lifestyle interventions is strongly influenced by patient motivation and understanding of symptom triggers. Patient education regarding modifiable factors—such as caffeine intake, physical inactivity, and fluid timing—can enhance engagement and improve long-term outcomes (Nouri et al., 2020).

Interdisciplinary collaboration plays a crucial role in optimizing treatment outcomes. Urologists, primary care physicians, physiotherapists, dietitians, and mental health professionals each contribute complementary expertise addressing different aspects of LUTS. For example, physiotherapists may guide

pelvic floor muscle training, dietitians may support dietary modification, and mental health professionals may assist in managing stress-related symptom exacerbation.

In addition, integration of digital health tools into clinical practice offers new opportunities to enhance the implementation of lifestyle interventions. Mobile applications, remote monitoring systems, and telemedicine platforms may improve adherence, enable continuous symptom tracking, and facilitate communication between patients and healthcare providers (Huhn et al., 2022; Naik et al., 2024). These tools support sustained behavioral change and may increase the effectiveness of non-pharmacological interventions.

Despite the recognized benefits of lifestyle interventions, their implementation in clinical practice remains inconsistent. Barriers include limited consultation time, lack of structured protocols, and insufficient training of healthcare providers in behavioral counseling. Addressing these challenges will require the development of standardized clinical pathways, professional education programs, and system-level support to ensure that lifestyle modification becomes an integral component of LUTS management (EAU, 2023).

Overall, integrating lifestyle interventions into routine clinical care represents a critical step toward more holistic, effective, and sustainable management of LUTS. Such an approach not only improves symptom control but also contributes to broader health benefits, including improved metabolic health and quality of life.

9. Discussion

This narrative review highlights the complex and multifactorial nature of lower urinary tract symptoms (LUTS), emphasizing the interplay between lifestyle, dietary, social, behavioral, and technological determinants. The available evidence supports a paradigm shift in which LUTS are not viewed as isolated urological conditions but rather as multifactorial syndromes influenced by systemic, behavioral, and environmental factors. This perspective aligns with contemporary models of chronic disease management that emphasize holistic and patient-centered care (EAU, 2023).

A key finding of this review is the substantial role of modifiable lifestyle factors in both the development and management of LUTS. Obesity, physical inactivity, smoking, and dietary patterns contribute to symptom burden through interconnected mechanisms involving metabolic dysfunction, systemic inflammation, vascular impairment, and pelvic floor alterations. Importantly, these factors represent not only risk modifiers but also therapeutic targets, as lifestyle interventions have been associated with clinically meaningful improvements in symptom severity and quality of life (Subak et al., 2009).

Dietary factors, including fluid intake patterns, caffeine and alcohol consumption, and overall dietary composition, further underscore the complexity of LUTS management. These factors rarely act in isolation but interact with individual susceptibility, comorbidities, and behavioral habits. This highlights the importance of individualized and context-specific dietary counseling rather than uniform recommendations, consistent with emerging evidence supporting personalized approaches to chronic disease management (Lin et al., 2015; Lim et al., 2025).

Another important dimension is the role of social and behavioral determinants. Psychosocial stress, socioeconomic status, and health-seeking behavior significantly influence symptom perception, reporting, and treatment adherence. The bidirectional relationship between psychological distress and LUTS further supports the integration of mental health assessment into routine clinical care (Coyne et al., 2008; Lai et al., 2015).

The integration of digital health technologies and artificial intelligence represents a rapidly evolving frontier in LUTS management. Mobile health applications, wearable devices, and AI-driven analytics offer opportunities for continuous monitoring, personalized treatment strategies, and improved patient engagement. These innovations have the potential to shift care from reactive to proactive models, enabling earlier intervention and more precise disease management (Topol, 2019; Esteva et al., 2019; Dunn et al., 2018; Huhn et al., 2022).

Despite these advances, several limitations should be acknowledged. First, much of the available evidence linking lifestyle and dietary factors to LUTS is derived from observational studies, limiting causal inference. Second, heterogeneity in study design, populations, and outcome measures complicates direct comparison and generalization of findings. Third, implementation of lifestyle interventions in routine clinical practice remains inconsistent, often due to time constraints, lack of standardized protocols, and insufficient training in behavioral counseling (Skokan & Newman, 2016).

Similarly, although digital health and AI technologies show considerable promise, their clinical integration is still evolving. Key challenges include data privacy, interoperability, algorithm transparency, and the need for external validation. In addition, disparities in digital access and health literacy may limit the benefits of these technologies and risk exacerbating existing health inequalities (Nouri et al., 2020).

Future research should prioritize high-quality randomized controlled trials evaluating the effectiveness of lifestyle and dietary interventions in LUTS. Longitudinal studies are needed to clarify causal relationships and long-term outcomes. Furthermore, rigorous evaluation of digital health solutions—including their clinical effectiveness, cost-effectiveness, and impact on patient engagement—is essential.

From a clinical perspective, the findings of this review support a shift toward integrative and multidisciplinary care models. Combining lifestyle modification, behavioral therapy, pharmacological treatment, and digital health tools is likely to offer the most effective approach to LUTS management. Importantly, interventions should be tailored to individual patient characteristics, preferences, and social context.

In conclusion, LUTS represent a complex clinical entity influenced by a wide range of modifiable and non-modifiable factors. Addressing these symptoms requires not only medical treatment but also a comprehensive understanding of lifestyle, behavioral, and technological determinants. Such an approach has the potential to improve patient outcomes, enhance quality of life, and reduce the overall burden of LUTS on healthcare systems.

Conclusions

Lower urinary tract symptoms (LUTS) represent a complex and multifactorial group of conditions influenced by a wide range of modifiable factors, including lifestyle, dietary habits, and behavioral determinants. The evidence summarized in this review highlights the critical role of these factors not only in the development of LUTS but also in their progression and response to treatment.

Addressing modifiable risk factors such as obesity, physical inactivity, smoking, and suboptimal dietary patterns is essential for effective prevention and management. Lifestyle and behavioral interventions offer practical, low-cost, and non-invasive strategies that can complement—or in some cases reduce the need for—pharmacological and surgical treatments. Importantly, these interventions may also contribute to broader improvements in metabolic health, quality of life, and overall well-being.

The integration of digital health technologies and artificial intelligence into LUTS care represents a promising advancement in modern urology. These tools have the potential to enhance symptom monitoring, improve diagnostic precision, support personalized treatment planning, and increase patient engagement. However, their successful implementation will require careful consideration of data security, accessibility, and clinical validation.

A multidisciplinary and patient-centered framework should form the foundation of future LUTS management strategies. Collaboration across healthcare disciplines, combined with individualized care plans and active patient involvement, is essential to achieve optimal outcomes.

In conclusion, effective management of LUTS requires a shift from a purely symptom-focused model toward a more comprehensive and integrative paradigm that incorporates medical, behavioral, and technological perspectives. Such a model has the potential not only to improve clinical outcomes but also to redefine long-term care strategies for patients with LUTS.

Conflicts of Interest: The authors declare no conflicts of interest.

REFERENCES

1. Abrams, P., Cardozo, L., Fall, M., Griffiths, D., Rosier, P., Ulmsten, U., van Kerrebroeck, P., Victor, A., & Wein, A. (2002). The standardisation of terminology of lower urinary tract function: Report from the Standardisation Sub-committee of the International Continence Society. *Neurourology and Urodynamics, 21*(2), 167–178. https://doi.org/10.1002/nau.10052
2. Baer, R., Tene, L., Weintraub, A. Y., & Kalichman, L. (2022). The effect of vitamin D deficiency and supplementation on urinary incontinence: A scoping review. *International Urogynecology Journal, 33*(5), 1083–1090. https://doi.org/10.1007/s00192-021-04963-z
3. Berkman, N. D., Sheridan, S. L., Donahue, K. E., Halpern, D. J., & Crotty, K. (2011). Low health literacy and health outcomes: An updated systematic review. *Annals of Internal Medicine, 155*(2), 97–107. https://doi.org/10.7326/0003-4819-155-2-201107190-00005
4. Bø, K., & Nygaard, I. E. (2020). Is physical activity good or bad for the female pelvic floor? A narrative review. *Sports Medicine, 50*(3), 471–484. https://doi.org/10.1007/s40279-019-01243-1
5. Bradley, C. S., Erickson, B. A., Messersmith, E. E., Pelletier-Cameron, A., Lai, H. H., Kreder, K. J., Yang, C. C., Merion, R. M., Bavendam, T. G., & Kirkali, Z. (2017). Evidence of the impact of diet, fluid intake, caffeine, alcohol and tobacco on lower urinary tract symptoms: A systematic review. *The Journal of Urology, 198*(5), 1010–1020. https://doi.org/10.1016/j.juro.2017.04.097
6. Chess-Williams, R., McDermott, C., Sellers, D. J., West, E. G., & Mills, K. A. (2021). Chronic psychological stress and lower urinary tract symptoms. *Lower Urinary Tract Symptoms, 13*(4), 414–424. https://doi.org/10.1111/luts.12395
7. Coyne, K. S., Sexton, C. C., Bell, J. A., Thompson, C. L., Dmochowski, R., Bavendam, T., Chen, C. I., & Clemens, J. Q. (2013). The prevalence of lower urinary tract symptoms (LUTS) and overactive bladder (OAB) by racial/ethnic group and age: Results from OAB-POLL. *Neurourology and Urodynamics, 32*(3), 230–237. https://doi.org/10.1002/nau.22295
8. Coyne, K. S., Sexton, C. C., Irwin, D. E., Kopp, Z. S., Kelleher, C. J., & Milsom, I. (2008). The impact of overactive bladder, incontinence and other lower urinary tract symptoms on quality of life, work productivity, sexuality and emotional well-being in men and women: Results from the EPIC study. *BJU International, 101*(11), 1388–1395. https://doi.org/10.1111/j.1464-410X.2008.07601.x
9. Coyne, K. S., Sexton, C. C., Thompson, C. L., Milsom, I., Irwin, D., Kopp, Z. S., Chapple, C. R., Kaplan, S., Tubaro, A., Aiyer, L. P., & Wein, A. J. (2009). The prevalence of lower urinary tract symptoms (LUTS) in the USA, the UK and Sweden: Results from the Epidemiology of LUTS (EpiLUTS) study. *BJU International, 104*(3), 352–360. https://doi.org/10.1111/j.1464-410X.2009.08427.x
10. Dumoulin, C., Cacciari, L. P., & Hay-Smith, E. J. C. (2018). Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. *Cochrane Database of Systematic Reviews, 2018*(10), Article CD005654. https://doi.org/10.1002/14651858.CD005654.pub4
11. Dunn, J., Runge, R., & Snyder, M. (2018). Wearables and the medical revolution. *Personalized Medicine, 15*(5), 429–448. https://doi.org/10.2217/pme-2018-0044
12. European Association of Urology. (2023). *EAU guidelines on management of non-neurogenic male lower urinary tract symptoms (LUTS), including benign prostatic obstruction*. https://uroweb.org/guidelines
13. Esteva, A., Robicquet, A., Ramsundar, B., Kuleshov, V., DePristo, M., Chou, K., Cui, C., Corrado, G., Thrun, S., & Dean, J. (2019). A guide to deep learning in healthcare. *Nature Medicine, 25*(1), 24–29. https://doi.org/10.1038/s41591-018-0316-z
14. Gleason, J. L., Richter, H. E., Redden, D. T., Goode, P. S., Burgio, K. L., & Markland, A. D. (2013). Caffeine and urinary incontinence in US women. *International Urogynecology Journal, 24*(2), 295–302. https://doi.org/10.1007/s00192-012-1829-5
15. Griffiths, D., Tadic, S. D., Schaefer, W., & Resnick, N. M. (2007). Cerebral control of the bladder in normal and urge-incontinent women. *NeuroImage, 37*(1), 1–7. https://doi.org/10.1016/j.neuroimage.2007.04.061
16. Hashim, H., & Abrams, P. (2007). Overactive bladder: An update. *Current Opinion in Urology, 17*(4), 231–236. https://doi.org/10.1097/MOU.0b013e32819ed7f9
17. Huhn, S., Axt, M., Gunga, H. C., Maggioni, M. A., Munga, S., Obor, D., Sié, A., Boudo, V., Bunker, A., Sauerborn, R., Bärnighausen, T., & Barteit, S. (2022). The impact of wearable technologies in health research: Scoping review. *JMIR mHealth and uHealth, 10*(1), e34384. https://doi.org/10.2196/34384
18. Irwin, D. E., Kopp, Z. S., Agatep, B., Milsom, I., & Abrams, P. (2011). Worldwide prevalence estimates of lower urinary tract symptoms, overactive bladder, urinary incontinence and bladder outlet obstruction. *BJU International, 108*(7), 1132–1138. https://doi.org/10.1111/j.1464-410X.2010.09993.x
19. Irwin, D. E., Milsom, I., Hunskaar, S., Reilly, K., Kopp, Z., Herschorn, S., Coyne, K., Kelleher, C., Hampel, C., Artibani, W., & Abrams, P. (2006). Population-based survey of urinary incontinence, overactive bladder, and other lower urinary tract symptoms in five countries: Results of the EPIC study. *European Urology, 50*(6), 1306–1314. https://doi.org/10.1016/j.eururo.2006.09.019

20. Kitsiou, S., Paré, G., & Jaana, M. (2015). Effects of home telemonitoring interventions on patients with chronic heart failure: An overview of systematic reviews. *Journal of Medical Internet Research, 17*(3), e63. https://doi.org/10.2196/jmir.4174
21. Kupelian, V., Rosen, R. C., Link, C. L., McVary, K. T., Aiyer, L. P., Mollon, P., Kaplan, S. A., & McKinlay, J. B. (2009). Association of urological symptoms and chronic illness in men and women: Contributions of symptom severity and duration—Results from the BACH Survey. *The Journal of Urology, 181*(2), 694–700. https://doi.org/10.1016/j.juro.2008.10.039
22. Kupelian, V., Wei, J. T., O'Leary, M. P., Norgaard, J. P., Rosen, R. C., & McKinlay, J. B. (2012). Nocturia and quality of life: Results from the Boston Area Community Health Survey. *European Urology, 61*(1), 78–84. https://doi.org/10.1016/j.eururo.2011.05.065
23. Le Berre, M., Presse, N., Morin, M., Larouche, M., Campeau, L., Hu, Y. X., Reid, I., & Dumoulin, C. (2020). What do we really know about the role of caffeine on urinary tract symptoms? A scoping review on caffeine consumption and lower urinary tract symptoms in adults. *Neurourology and Urodynamics, 39*(5), 1217–1233. https://doi.org/10.1002/nau.24344
24. Lai, H., Gardner, V., Vetter, J., & Andriole, G. L. (2015). Correlation between psychological stress levels and the severity of overactive bladder symptoms. *BMC Urology, 15*, Article 14. https://doi.org/10.1186/s12894-015-0009-6
25. Lim, J. S., Hwang, W., Kim, J. K., Kim, M., Kwon, O., Han, S., Oh, B., & Kim, J. S. (2025). Associations of dietary patterns and lower urinary tract symptoms (LUTS) in Korean adults. *Nutrition Research and Practice, 19*(2), 318–327. https://doi.org/10.4162/nrp.2025.19.2.318
26. Lin, P. H., & Freedland, S. J. (2015). Lifestyle and lower urinary tract symptoms: What is the correlation in men? *Current Opinion in Urology, 25*(1), 1–5. https://doi.org/10.1097/MOU.0000000000000121
27. Matsukawa, Y., Kameya, Y., Takahashi, T., Shimazu, A., Ishida, S., Yamada, M., Sassa, N., & Yamamoto, T. (2021). Development of an artificial intelligence diagnostic system for lower urinary tract dysfunction in men. *International Journal of Urology, 28*, 1143–1148. https://doi.org/10.1111/iju.14661
28. Milsom, I., Coyne, K. S., Nicholson, S., Kvasz, M., Chen, C. I., & Wein, A. J. (2014). Global prevalence and economic burden of urgency urinary incontinence: A systematic review. *European Urology, 65*(1), 79–95. https://doi.org/10.1016/j.eururo.2013.08.031
29. Naik, N., Talyshinskii, A., Rassweiler, J., Hameed, B. M. Z., & Somani, B. K. (2024). Digital health innovations in urology: Telemedicine, wearables, and mobile applications—A systematic review of literature. *Current Opinion in Urology, 34*(2), 116–127. https://doi.org/10.1097/MOU.0000000000001153
30. Noh, J. W., Yoo, K. B., Kim, K. B., Kim, J. H., & Kwon, Y. D. (2020). Association between lower urinary tract symptoms and cigarette smoking or alcohol drinking. *Translational Andrology and Urology, 9*(2), 312–321. https://doi.org/10.21037/tau.2020.03.07
31. Nouri, S., Khoong, E. C., Lyles, C. R., & Karliner, L. (2020). Addressing equity in telemedicine for chronic disease management during the COVID-19 pandemic. *NEJM Catalyst Innovations in Care Delivery, 1*(3). https://doi.org/10.1056/CAT.20.0123
32. Osman, N., Mangera, A., Hillary, C., Inman, R., & Chapple, C. (2016). The underactive bladder: Detection and diagnosis. *F1000Research, 5*, Article 102. https://doi.org/10.12688/f1000research.7344.1
33. Parsons, J. K., & Kashefi, C. (2008). Physical activity, benign prostatic hyperplasia, and lower urinary tract symptoms. *European Urology, 53*(6), 1228–1235. https://doi.org/10.1016/j.eururo.2008.02.019
34. Parsons, J. K., Messer, K., White, M., Barrett-Connor, E., Bauer, D. C., Marshall, L. M., & Osteoporotic Fractures in Men Study Group. (2011). Obesity increases and physical activity decreases lower urinary tract symptom risk in older men: The Osteoporotic Fractures in Men study. *European Urology, 60*(6), 1173–1180. https://doi.org/10.1016/j.eururo.2011.07.040
35. Piwek, L., Ellis, D. A., Andrews, S., & Joinson, A. (2016). The rise of consumer health wearables: Promises and barriers. *PLOS Medicine, 13*(2), e1001953. https://doi.org/10.1371/journal.pmed.1001953
36. Rajkomar, A., Dean, J., & Kohane, I. (2019). Machine learning in medicine. *New England Journal of Medicine, 380*(14), 1347–1358. https://doi.org/10.1056/NEJMra1814259
37. Rohrmann, S., Smit, E., Giovannucci, E., & Platz, E. A. (2004). Associations of obesity with lower urinary tract symptoms and noncancer prostate surgery in the Third National Health and Nutrition Examination Survey. *American Journal of Epidemiology, 159*(4), 390–397. https://doi.org/10.1093/aje/kwh060
38. Rosa, D., Villa, G., Bonetti, L., Togni, S., Montanari, E., Destrebecq, A., & Terzoni, S. (2021). The use of mobile applications in urology: A systematic review. *International Journal of Urological Nursing, 15*(3), 105–116. https://doi.org/10.1111/ijun.12282
39. Rubach, A., Balasubramaniam, K., Elnegaard, S., Larsen, S. E., & Jarbøl, D. E. (2019). Barriers to health care seeking with bothersome lower urinary tract symptoms among men—A nationwide study. *Family Practice, 36*(6), 743–750. https://doi.org/10.1093/fampra/cmz019

40. Scarneciu, I., Lupu, S., Bratu, O. G., Teodorescu, A., Maxim, L. S., Brinza, A., Laculiceanu, A. G., Rotaru, R. M., Lupu, A.-M., & Scarneciu, C. C. (2021). Overactive bladder: A review and update. *Experimental and Therapeutic Medicine, 22*(6), Article 1444. https://doi.org/10.3892/etm.2021.10879
41. Sexton, C. C., Coyne, K. S., Thompson, C., Bavendam, T., Chen, C. I., & Markland, A. (2011). Prevalence and effect on health-related quality of life of overactive bladder in older Americans: Results from the Epidemiology of Lower Urinary Tract Symptoms Study. *Journal of the American Geriatrics Society, 59*(8), 1465–1470. https://doi.org/10.1111/j.1532-5415.2011.03492.x
42. Shaw, C., Tansey, R., Jackson, C., Hyde, C., & Allan, R. (2001). Barriers to help seeking in people with urinary symptoms. *Family Practice, 18*(1), 48–52. https://doi.org/10.1093/fampra/18.1.48
43. Skokan, A., & Newman, D. K. (2016). Behavioral intervention for lower urinary tract symptoms in older adults. In T. J. Guzzo, G. W. Drach, & A. J. Wein (Eds.), *Primer of geriatric urology* (2nd ed., pp. 149–162). Springer. https://doi.org/10.1007/978-1-4939-4928-1_11
44. Subak, L. L., Wing, R., West, D. S., Franklin, F., Vittinghoff, E., Creasman, J. M., Richter, H. E., Myers, D., Burgio, K. L., Gorin, A. A., Macer, J., Kusek, J. W., Grady, D., & PRIDE Investigators. (2009). Weight loss to treat urinary incontinence in overweight and obese women. *New England Journal of Medicine, 360*(5), 481–490. https://doi.org/10.1056/NEJMoa0806375
45. Topol, E. J. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine, 25*(1), 44–56. https://doi.org/10.1038/s41591-018-0300-7
46. Wang, E. Y., Breyer, B. N., Lee, A. W., Rios, N., Oni-Orisan, A., Steinman, M. A., Sim, I., Kenfield, S. A., & Bauer, S. R. (2021). Perceptions of older men using a mobile health app to monitor lower urinary tract symptoms and tamsulosin side effects: Mixed methods study. *JMIR Human Factors, 8*(4), e30767. https://doi.org/10.2196/30767
47. World Health Organization. (2003). *Adherence to long-term therapies: Evidence for action*. https://www.who.int/chp/knowledge/publications/adherence_full_report.pdf
48. Yuan, P., Wang, T., Li, H., Lan, R., Li, M., & Liu, J. (2021). Vitamin D and LUTS. *The Journal of Urology, 205*(6), 1584–1594. https://doi.org/10.1097/JU.0000000000001441
49. Zheng, T., Sun, H., Tang, Y., Zeng, Y., & Yan, L. (2024). Association of lower urinary tract symptoms and geriatric nutritional risk index in men: A cross-sectional study based on NHANES. *Frontiers in Medicine, 11*, Article 1356921. https://doi.org/10.3389/fmed.2024.1356921