Review

Global research trends and clinical pathway integration in behavioral therapy for urinary incontinence: A scientometric and visualization analysis

Huijuan Du[1,2], Xiangjun Lyu[1], Baojun Wang[1], and Juan Li[1]*

[1]Senior Department of Urology, Chinese PLA General Hospital, Beijing 100039, China
[2]Graduate School, Medical School of Chinese PLA, Haidian District, Beijing 100853, China

Abstract

Background: Urinary incontinence (UI) results from weakened pelvic tissues or a functionally impaired sphincter. While surgery is effective, its invasiveness limits its extensive use. Behavioral therapy, particularly pelvic floor muscle training (PFMT), offers a non-invasive, non-pharmacological alternative for improving urinary control. **Objective:** This study investigated global research hotspots and emerging frontiers in behavioral therapy for UI, aiming to clarify its core components, evidence base, and collaborative frameworks to inform the optimization of clinical pathways. Data were retrieved from the Web of Science Core Collection (2005–2024) using the terms "urinary incontinence" AND "behavioral therapy." CiteSpace was employed for co-citation, burst detection, and cluster analyses, whereas Bibliometrix (R package) was used to evaluate publication trends, author collaboration, thematic evolution, and scientific mapping. Extracted behavioral intervention parameters (type, frequency, and duration) were compared with current clinical pathway guidelines to identify gaps and alignments. The United States of America, the United Kingdom, and China were leading contributors to UI behavioral therapy research. The thematic evolution shifted from early "lifestyle interventions" to "smart sensor-based training" and, more recently, to "artificial intelligence-assisted rehabilitation." Keyword clustering revealed nine major research themes, emphasizing PFMT, bladder training, biofeedback, and digital self-management. Thematic analysis revealed a growing focus on digitalization, personalization, and adherence management. Integration with clinical pathways highlighted gaps in adherence monitoring, personalized intensity adjustment, and digital follow-up mechanisms. **Conclusion:** The scientometric visualization analysis elucidates the knowledge structure and developmental trends, providing a foundation for the development of standardized, technology-enabled, and ethically governed clinical pathways.

Keywords: Urinary incontinence, Behavioral therapy, Visualization analysis, Bibliometrics, Clinical pathway, Digital health ethics

1. Introduction

Urinary incontinence (UI) primarily results from the degeneration and weakening of pelvic connective and vaginal supportive tissues, which compromise support for the bladder neck and urethra. This dysfunction may stem from neurological disorders, defects in supportive structures, or insufficiency in urethral sphincter function.[1] Both conservative and surgical interventions aim to enhance urethral support and continence mechanisms. Although surgery is clinically effective, its invasive nature and potential complications restrict its use. In contrast, behavioral therapy offers a safe, non-pharmacological, non-invasive first-line option with significant clinical and social benefits.[2] Its core principle involves pelvic floor muscle training (PFMT) to improve long-term urinary control and restore physiological function.

Key components of behavioral therapy include PFMT to strengthen urethral sphincter muscles, bladder training to enhance central inhibition, and behavioral control strategies that modulate voiding habits. This approach enhances patient self-efficacy and has demonstrated effectiveness in improving treatment adherence and modifying behavior.[3] Numerous

***Corresponding author:**
Juan Li (lijuan@301hospital.com.cn)

Submitted: 13 October 2025; Revision received: 14 November 2025; Accepted: 18 November 2025; Published: 06 January 2026

How to cite this article: Du H, Lyu X, Wang B, Li J. Global research trends and clinical pathway integration in behavioral therapy for urinary incontinence: A scientometric and visualization analysis. *Bladder.* 2026:e21200078. doi: 10.14440/bladder.0331

studies and international guidelines consistently recommend behavioral therapy as the initial treatment for all types of UI.[4] However, current clinical pathways remain fragmented and lack systematic integration into routine care.

To bridge these gaps, the present study employed CiteSpace and Bibliometrix to systematically map the domain's intellectual structure, research hotspots, and collaboration patterns in this field.[5,6] The core elements and evidence derived from this bibliometric analysis are then compared with existing clinical pathways to identify optimization opportunities, thereby supporting the standardization, scientific rigor, and accessibility of UI behavioral therapy in clinical practice.

2. Data and methods

2.1. Data sources and retrieval strategy

The literature search covered the period from January 1, 2005, to December 31, 2024, and was limited to articles and reviews, excluding conference abstracts, editorials, and letters. Data were retrieved from the Web of Science Core Collection (WOSCC), including the Science Citation Index Expanded and Social Sciences Citation Index. The search strategy and screening criteria are summarized in Table 1. The initial filtering of search results was conducted using the WOSCC subject categories to confine records to relevant research domains. Subsequently, titles and abstracts were screened manually to exclude studies explicitly focused on pediatric populations, animal experiments, or non-behavioral interventions (such as purely pharmacological or surgical research).

Table 1. Search and filter conditions

Category	Search strategy
Search terms	TS = ("urinary incontinence" AND ("bladder training" OR "bladder drill" OR "timed voiding" OR "scheduled voiding" OR "habit training" OR "pelvic floor muscle train*" OR "PFMT" OR "kegel exercis*" OR "behavior* therapy" OR "behavior* intervention" OR "lifestyle intervention" OR "fluid management" OR "weight reduction" OR "biofeedback"))
Publication year	FPY = (2005–2024)
Language	LA = (English)
Article type	DT = (Article OR Review)
Research field	Urology Nephrology OR Obstetrics Gynecology OR Nursing OR Rehabilitation OR Health Care Sciences Services OR Geriatrics Gerontology OR Public Environmental Occupational Health OR Surgery OR Oncology OR Multidisciplinary Sciences

2.2. Data processing and analysis

Bibliometrix was used to analyze publication volume, country, and institutional output, national collaboration networks, thematic evolution, and strategic diagrams. Duplicate entries were detected and eliminated using the integrated data-cleaning utilities of the Bibliometrix R package. To enhance analytical consistency, author-supplied keywords were systematically merged and standardized. For instance, "pelvic floor muscle training" and its abbreviation "PFMT" were consolidated under the unified descriptor "pelvic floor muscle training." CiteSpace (v6.3.R1) was applied for keyword clustering, co-citation analysis, and burst detection. The parameters were configured as follows: The analysis was divided into consecutive time slices spanning from 2005 to 2024, with each slice covering a 1-year duration. The selection criterion was set to include the top 50 most frequently cited or occurring items within each individual time slice. For network simplification, the Pathfinder algorithm and the Pruning Sliced Networks method were applied. Author-supplied keywords were systematically merged and standardized. Of the 1126 articles included, 14 (1.24%) lacked author keywords, and 2 (0.18%) had no Keywords Plus. Given the minimal missing data, no imputation was performed. Comparative analysis was conducted between thematic clusters and clinical guidelines (European Association of Urology 2022, National Institute for Health and Care Excellence NG123, and American Urological Association 2019) to identify research–practice alignment and implementation gaps.

3. Results

3.1. Publication output

From 2005 to 2018, annual publication volume remained low and fluctuating. A rapid growth phase began in 2019 and has continued steadily, reaching 103 publications by 2024 (Figure 1). This trajectory indicates sustained global interest and expansion in behavioral therapy research for UI.

3.2. Literature citation frequency and core literature

The top 10 most-cited publications (Table S1) consisted mainly of systematic reviews and clinical guidelines addressing risk factors, intervention efficacy, and post-operative management. These high-impact studies reflect the field's strong orientation toward evidence-based practice and clinical translational applicability.

3.3. Country/region collaboration network analysis

The number of publications varies among countries (Table S2). The United States of America (USA; 235 papers) and China (114 papers) dominate output, with the USA acting as a central node due to its high productivity and broad range of international collaborations in the network (Figure 2).

Although international collaboration intensity is low (6.4%), the United Kingdom (UK; 29.6%), Canada (33.9%), Australia (38.0%), and Norway (27.9%) exhibit higher international collaboration rates. European countries are

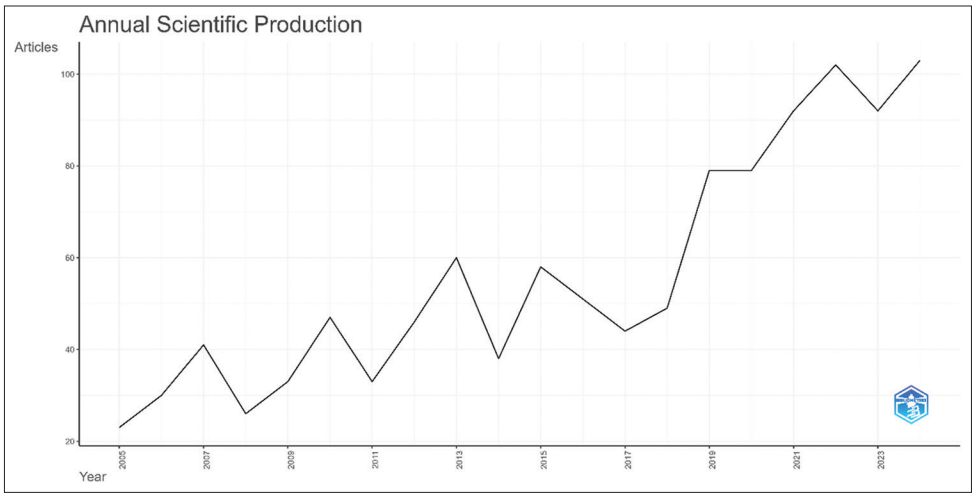

Figure 1. Annual publication production (2005–2024)

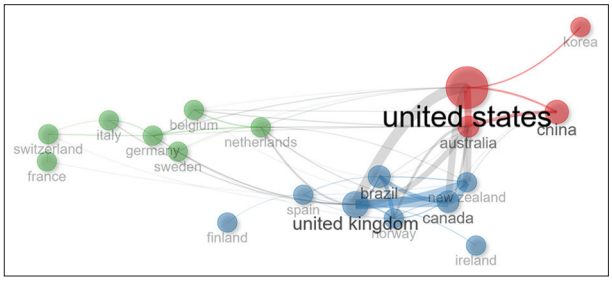

Figure 2. National collaboration network map

closely interconnected, linked to the UK and the USA via the Netherlands and Belgium.

Publications are concentrated in 215 journals, most of which are specialty journals in the field of urology. The top 10 journals accounted for nearly half of all publications, indicating high concentration and a stable core group of journals.

3.4. Research hotspot analysis

3.4.1. High-frequency keywords

Author keywords primarily emphasize specific interventions and clinical pathway nodes (Table S3), such as PFMT, biofeedback, and bladder training, highlighting the focus on rehabilitation training, nursing intervention, and treatment methods.

In contrast, Keywords Plus (Table S3) relate to disease characteristics and epidemiological background (e.g., women, prevalence, management, quality of life [QoL], and risk factors), emphasizing the importance of disease burden, treatment outcomes, and public health research, and revealing the importance of this field in public health and long-term disease management.

3.4.2. Keyword clustering analysis

CiteSpace initially generated 29 keyword clusters. Following previous CiteSpace-based studies, we conducted a sensitivity analysis by excluding micro-clusters with fewer than five author keywords (size <5). After this filtering, nine major clusters (size = 8–36) were retained for visualization and substantive interpretation, whereas the remaining 20 micro-clusters were not displayed in the cluster and timeline views because of their very small size and limited representativeness.

Employing a g-index ($k = 10$) with 1-year time slices, the clustering analysis was performed using cosine similarity, resulting in the formation of nine clusters (Figure 3, Table S4). The cluster silhouette coefficients (S) range from 0.711 to 0.954, with an overall Q value of 0.528 and an S value of 0.794, indicating good consistency. These clusters illustrate a transition from traditional conservative treatments to digitally supported and individualized rehabilitation strategies.

The nine major keyword clusters and their thematic focuses are summarized as follows: Cluster (#0): Pelvic organ prolapse (size 36, S = 0.721) focuses on pelvic organ prolapse, PFMT, pelvic floor dysfunction, and fecal incontinence; Cluster (#1): PFMT (size 35, S = 0.834) centers on PFMT and pelvic floor muscle strength, and also mentions mobile health (mHealth) applications (apps) and feasibility trials; Cluster (#2): Stress UI (size 32, S = 0.819) focuses on UI, self-management, and mobile apps, emphasizing the combination of behavioral/lifestyle management with self-management; Cluster (#3): Prostate cancer (size 32, S = 0.812) concerns male UI and PFMT after prostate cancer surgery, supported by a growing body of evidence from systematic reviews; Cluster (#4): Overactive bladder (OAB) (size 31, S = 0.830) focuses on OAB, lower urinary tract symptoms, detrusor overactivity, electrical stimulation, and urge incontinence;

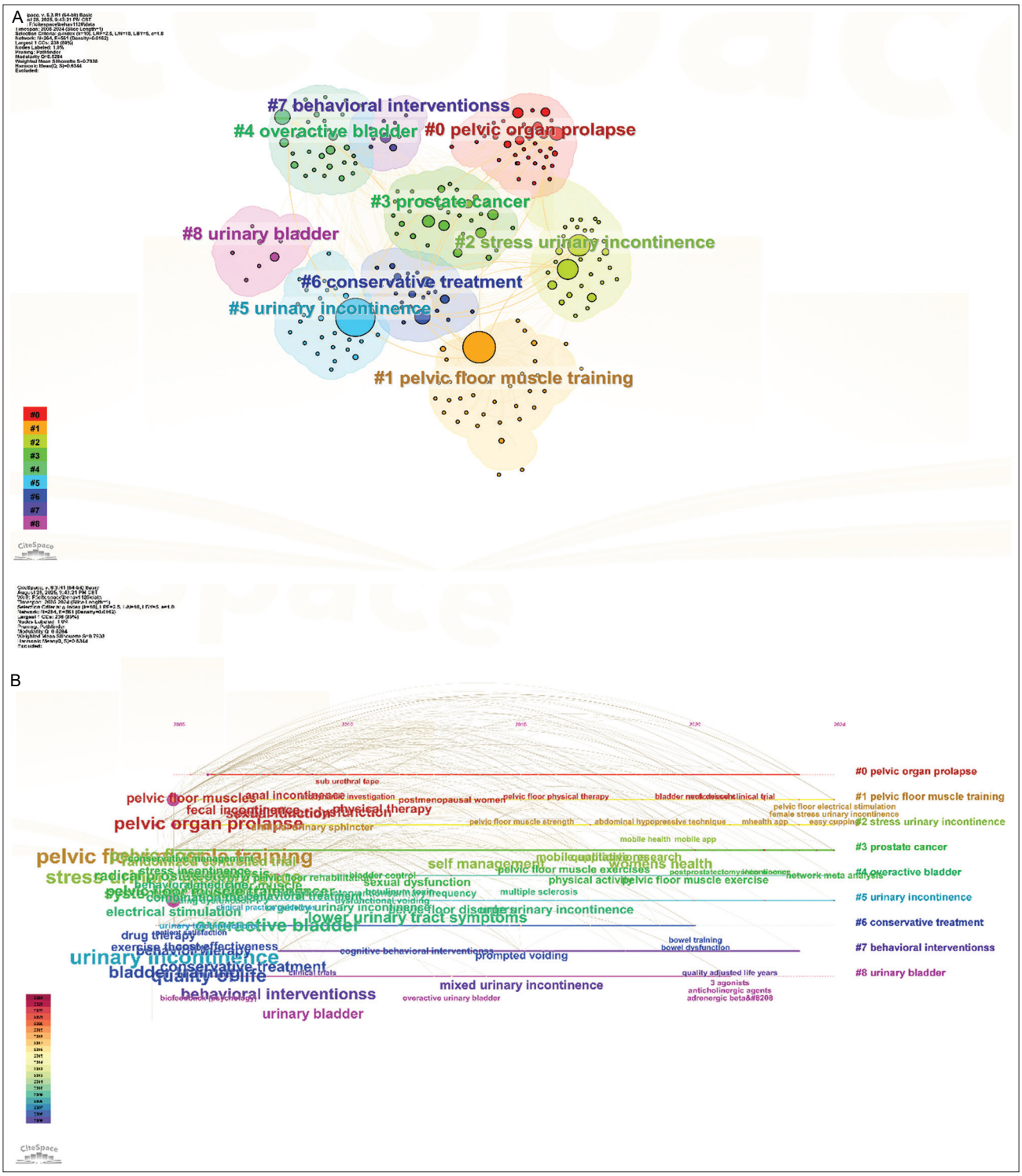

Figure 3. Nine major clusters. (A) Keyword co-occurrence cluster map. Each color represents a separate cluster (e.g., #0 "pelvic organ prolapse," #1 "pelvic floor muscle training"). (B) A keyword temporal evolution diagram displaying the timeline view, illustrating how these clusters evolved over time. A cluster is not merely an aggregation of keywords but a knowledge unit constituted by co-cited documents.
Note: A cluster is not merely an aggregation of keywords but a knowledge unit constituted by co-cited documents.

Cluster (#5): UI (size 27, S = 0.734) focuses on UI, extending to weight management, benign prostatic disease, and nocturia; Cluster (#6): Conservative treatment (size 25, S = 0.711) includes conservative treatment, bladder training, behavioral therapy, nursing, and QoL, representing first-line non-surgical intervention; Cluster (#7): Behavioral interventions (size 10, S = 0.908) includes behavioral interventions, mixed UI, and clinical trials, and reflects the strengthening of standardized intervention schemes and evidence-based verification; Cluster (#8): Urinary bladder (size 8, S = 0.954) is related to neurogenic bladder and biofeedback, representing the specialization of neurostimulation and rehabilitation assessment.

The timeline shows an evolution from "basic—expanded—individualized/digitalized" to "urinary incontinence, bladder training, and PFMT" as the mainstay, forming the framework of primary conservative treatment for female pelvic floor dysfunction. As medicine and technology have developed, the number of self-management and mobile apps for UI has increased rapidly, with behavioral intervention schemes and mHealth apps becoming major points of growth. Meanwhile, the field of prostate cancer rehabilitation for men has entered a period of high productivity, with conservative treatment evidence (systematic reviews) continuously accumulating. Neurogenic bladder and biofeedback signal a renaissance of assessment and neurostimulation techniques.

The core of this field remains conservative intervention—represented by PFMT, bladder training, and behavioral intervention—and is expanding toward digitalization (mHealth, self-management) and population-specific rehabilitation (post-surgical male patients, OAB).

3.5. Thematic evolution and mutation trends analysis

3.5.1. Thematic evolution trends

We compiled the first appearance years, duration, and frequency of author keywords in the field of UI behavioral therapy over the past 20 years (2005–2024) and created a graph showing the evolution of research themes (Figure 4).

Thematic evolution analysis demonstrates a progressive transition in research focus over time. During the early stage (2005–2011), studies mainly addressed pharmacological management and complication-related topics. From 2012 to 2016, research gradually shifted toward conservative and behavioral interventions, accompanied by a notable rise in rehabilitation-oriented publications. Between 2017 and 2019, the integration of multidisciplinary evidence accelerated, leading to the formulation of evidence-based guidelines and the emergence of prostate cancer rehabilitation as a new area of interest. In the most recent phase (2020–2024), research hotspots have increasingly centered on digitalization and remote rehabilitation, reflecting a move toward remote follow-up, adherence monitoring, and home-based training. Meanwhile, the appearance of radiofrequency-related studies in the last 3 years suggests growing attention to electrotherapy, magnetic stimulation, and radiofrequency-assisted techniques.

3.5.2. Hotspot emergence analysis

Using the Kleinberg emergence detection model in CiteSpace, 20 strong emergent keywords were identified (Figure 5).

During the early stage (2006–2012), topics such as urinary tract infections, bladder training, PFMT, and radical prostatectomy emerged successively. This period was characterized by the dominance of conservative interventions, particularly bladder training and PFMT, which established the foundational pathways for two distinct care models—female pelvic rehabilitation and male post-prostatectomy recovery.

Between 2013 and 2019, new themes such as OAB, prostate cancer, self-management, mobile health apps, and randomized controlled trials (RCTs) became prominent. Research attention continued to zero in on urological syndromes and male-specific conditions, whereas the

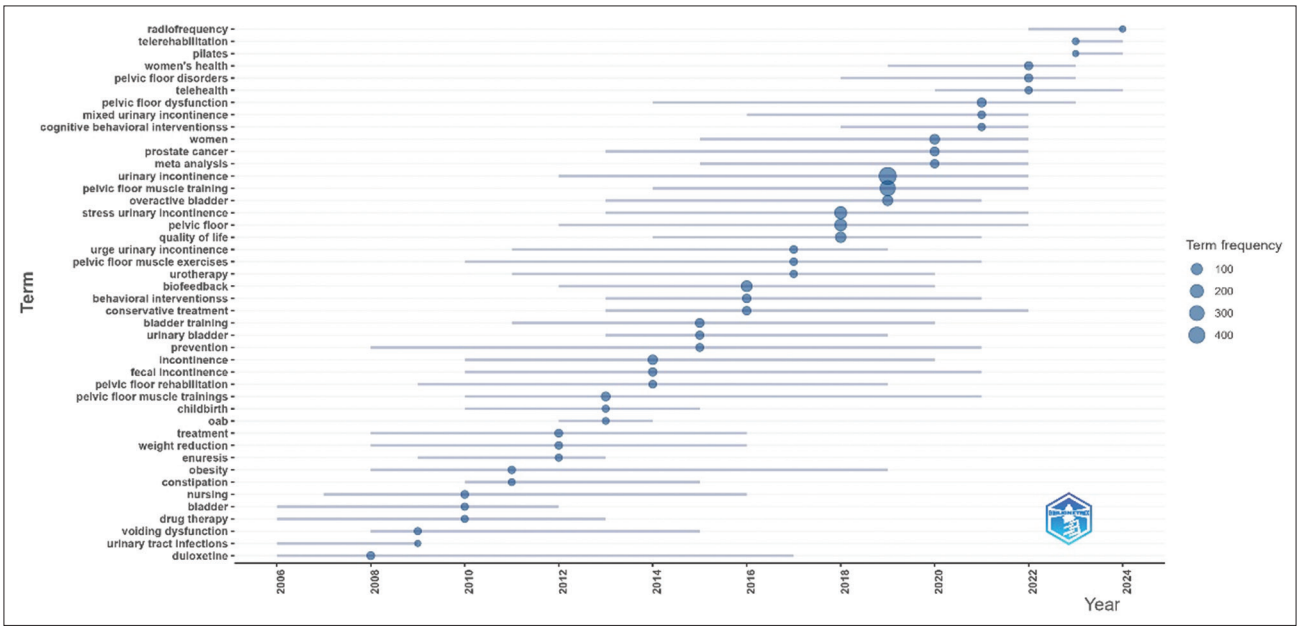

Figure 4. Thematic shift in behavioral therapy research on urinary incontinence, 2005–2024
Notes: Keywords with ≥5 occurrences per year and the top three per year were used to map thematic evolution. The circles mark years of peak activity, their sizes indicate frequency, and blue lines show the duration of keyword persistence.

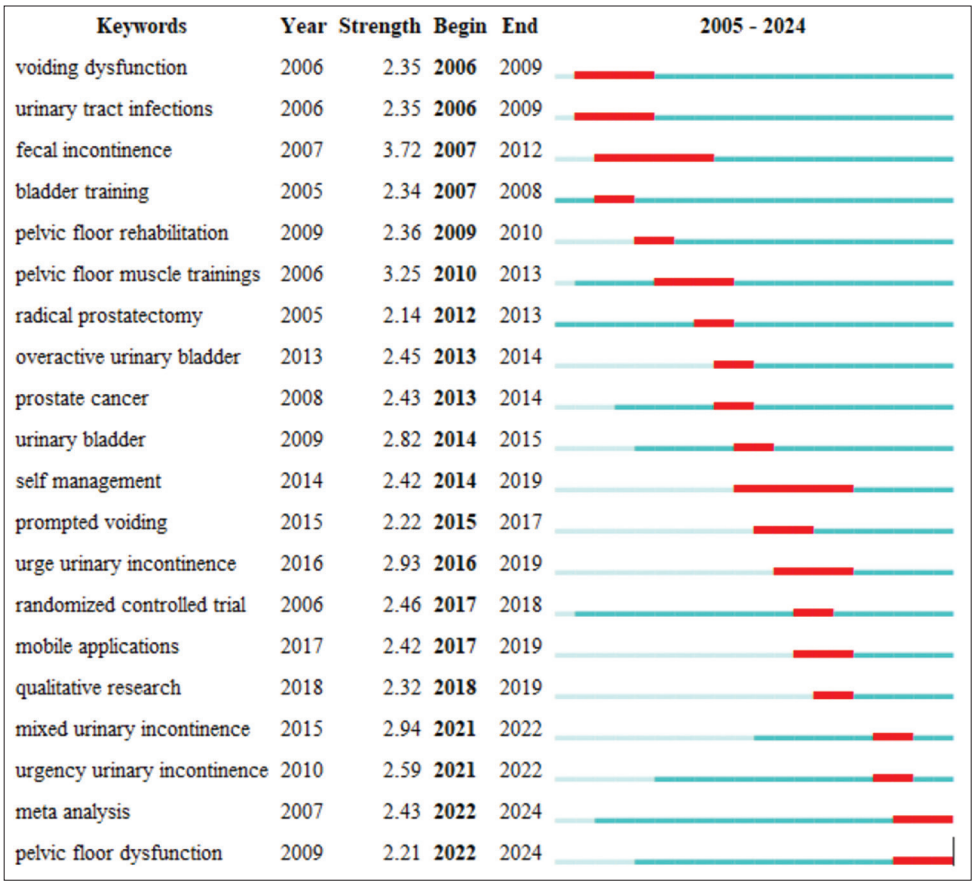

Figure 5. Top 20 keywords with the strongest citation bursts in behavioral therapy for urinary incontinence research
Note: The red line represents the duration of keyword emergence, reflecting the evolution of research hotspots.

scientific emphasis shifted from verifying treatment efficacy to exploring implementation processes. This transition marked the mounting importance of self-management frameworks and mHealth tools, alongside the parallel rise of randomized and qualitative research designs.

In the fine-grained development stage (2021–2024), the emergence of mixed UI and urgency UI indicates increasing depth in subtype-specific investigations. Continued exploration of meta-analyses and pelvic floor dysfunction suggests that the field has entered a phase of evidence integration and comprehensive model construction.

Overall, there is a three-stage evolution from "basic conservative treatment" through "implementation and management" to "evidence consolidation and integrative frameworks." For clinical and nursing practice, future high-value directions include digital adherence monitoring, remote follow-up systems, subtype-specific intervention pathways (particularly for urgency UI and mixed UI), and the synthesis of high-quality evidence focusing on QoL and long-term outcomes.

3.6. Theme structure changes and clinical care pathways

This study used 5-year time slices (2005–2009, 2010–2014, 2015–2019, 2020–2024) and author keywords as the analytical field. A thematic evolution map (Figure 6) and thematic map (Figure 7) were constructed.

3.6.1. Full-period framework and foundation

In the thematic evolution diagram, UI, bladder, OAB, and pelvic floor have remained consistent since the earliest slice and maintain continuous connections with multiple themes. In the thematic map, their high level of association with all themes indicates that they form the foundation of all pathways.

3.6.2. Transition from "symptom–complication" to "assessment + self-management/training"

The 2005–2009 cluster (UI, bladder, OAB, pelvic floor, fecal incontinence, constipation) links to the 2010–2014 cluster (assessment, self-management, training, urotherapy, nursing), signaling that clinical priorities shifted toward an integrated pathway of standardized assessment, patient-led self-management, and structured nursing programs.

3.6.3. Formation and establishment of first-line intervention

Self-management, training, and urotherapy entered the first quadrant in the 2015–2019 time slice, while UI, pelvic floor, and QoL remained in the fourth quadrant. This indicates that

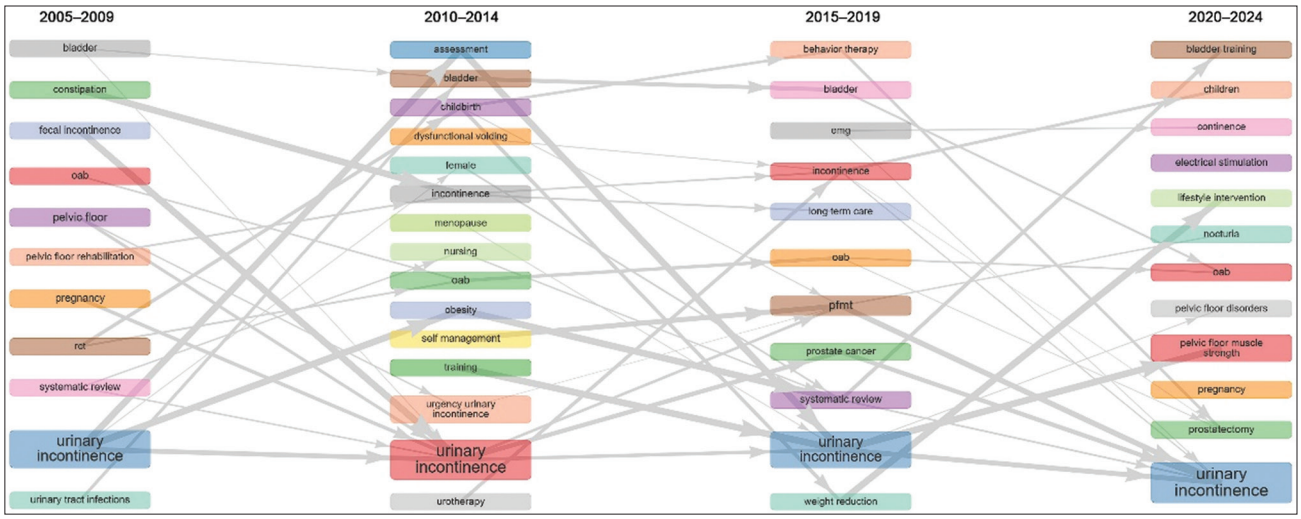

Figure 6. 2005–2024 thematic evolution. The figure illustrates the inheritance and developmental relationships among research themes. For example, early foundational topics such as "urinary incontinence" and "bladder" (2005–2009) are connected with subsequent themes such as "assessment" and "self-management" (2010–2014), indicating a clinical transition toward standardized evaluation and patient-led management.

"PFMT + bladder-related training + behavioral therapy" has become the first-line intervention method.

3.6.4. Multimodal development and expansion of the population

Pelvic floor muscle and bladder training extend and converge with electrical stimulation and lifestyle interventions, and are linked to OAB, mixed incontinence, and nocturia. At the same time, they branch out into pregnancy, children, and post-prostatectomy populations, as well as pelvic floor muscle strength and pelvic floor disorders. Electrical stimulation and digitalized follow-up have become well-established and influential research directions.

3.6.5. Emerging and selective directions

A few device-related, imaging-related, and lifestyle intervention subcategories (e.g., magnetic stimulation, radiofrequency, and medical devices) appear as branches or short connections in the thematic evolution diagram. They mostly fall into the third quadrant, indicating that these topics are still in the exploratory phase and require selective implementation or pilot evaluation.

Based on the scientometric findings and a comparative analysis with international clinical guidelines—the European Association of Urology,[7] the National Institute for Health and Care Excellence,[8] and the American Urological Association[9]—an optimized clinical pathway framework for behavioral therapy in UI is proposed.

This framework integrates emerging research hotspots—such as digitalization, self-management, and adherence monitoring—with core guideline recommendations (e.g., PFMT as first-line therapy), while extending to underrepresented areas, including digital adherence strategies and subtype-specific precision interventions.

(a) Pathway 1: Initial assessment, education, and individualized planning
A comprehensive assessment should include symptom subtype identification, QoL evaluation, and pelvic floor muscle strength testing. Structured education and lifestyle modification (e.g., weight management and fluid intake adjustment) remain foundational.
To enhance precision, AI-driven decision-support tools can assist clinicians in generating individualized behavioral therapy plans based on age, comorbidities, and pelvic floor function.[7,9]

(b) Pathway 2: Structured training and adherence support
Evidence-based first-line interventions such as PFMT, bladder training, and behavioral modification should be implemented using standardized parameters (frequency, duration, and intensity).
Integration of mHealth apps facilitates remote supervision, reminders, and electromyography-based biofeedback, improving patient engagement and adherence.[8]
Motivational interviewing and peer-support systems are further recommended to sustain long-term behavioral change.

(c) Pathway 3: Reinforcement, follow-up, and adjustment
For patients with low adherence or poor self-management capacity, remote telehealth platforms can provide structured follow-up and progress monitoring.
Adjunctive interventions (e.g., electrical stimulation) may be introduced for refractory cases.
Dynamic checkpoints (e.g., week 4 and week 8) enable adaptive adjustments in exercise intensity and treatment frequency based on digital adherence data and clinical assessment.[9]

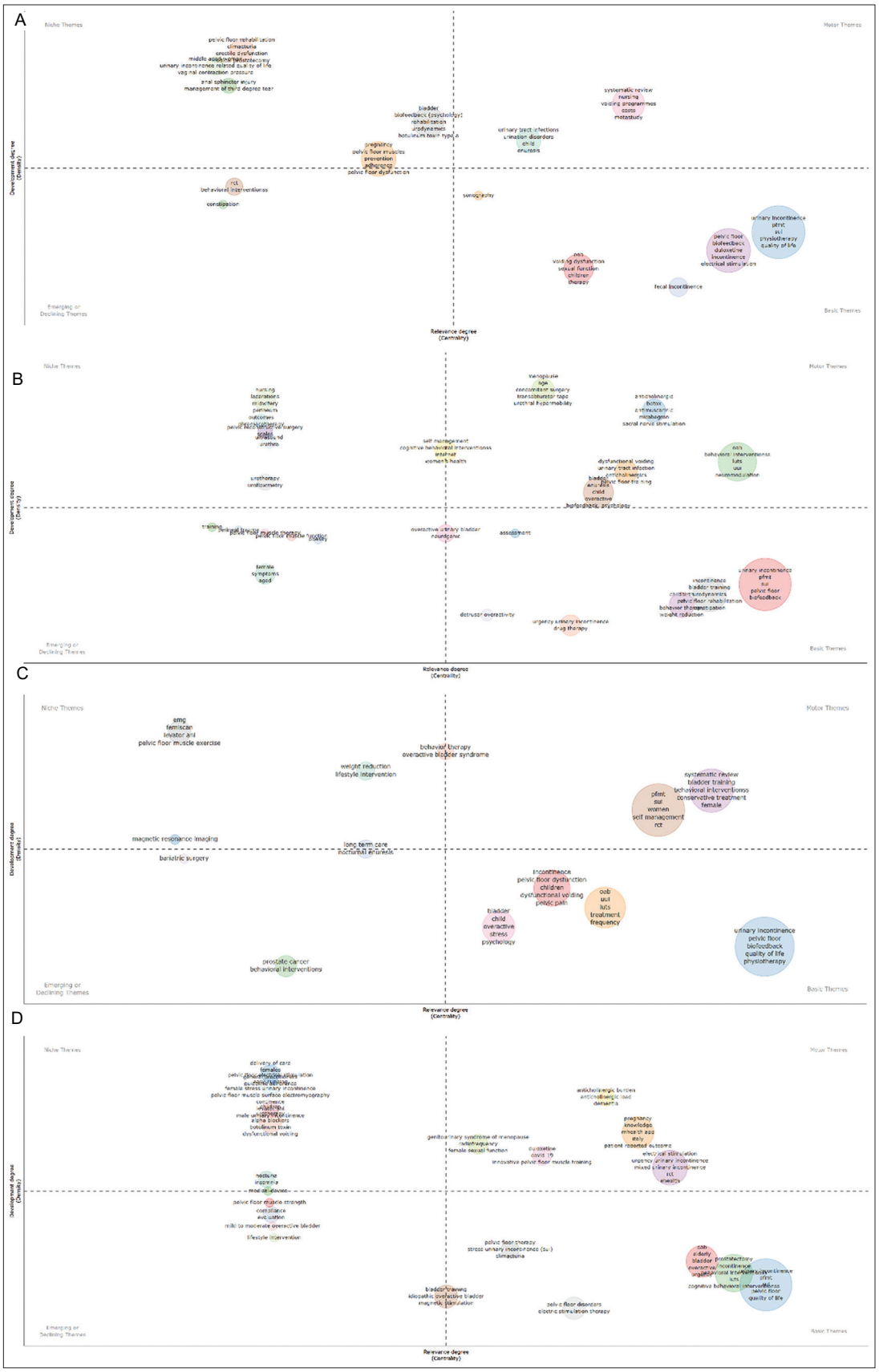

Figure 7. 2005–2024 thematic map (strategic diagram). (A) 2005–2009 thematic map. (B) 2010–2014 thematic map. (C) 2015–2019 thematic map. (D) 2020–2024 thematic map. The figure is divided into four quadrants: the first quadrant (motor themes – well-developed and central), the second quadrant (niche themes – well-developed but peripheral), the third quadrant (emerging or declining themes – underdeveloped and peripheral), and the fourth quadrant (basic themes – central but underdeveloped).

(d) Pathway 4: Special population pathways
Tailored approaches should be developed for special groups such as pregnant or postpartum women, elderly patients, pediatric populations, and men after prostatectomy.
Training frequency and intensity must be adapted to physiological conditions to ensure safety (e.g., avoiding abrupt increases in intra-abdominal pressure in frail elderly patients).[7,8]

(e) Pathway 5: Emerging and research-oriented pathways
Innovative interventions such as magnetic stimulation and radiofrequency therapy may be selectively applied in high-resource centers or incorporated into research protocols to evaluate their feasibility and long-term efficacy.[9] For example, a standardized care pathway for pelvic floor disorders developed at a tertiary center implemented patient—decision aids, telehealth follow-up, and clearly defined transition criteria to primary care.[10] In addition, a mobile health trial for UI behavioral treatment (women veterans) found that app-based PFMT combined with remote sessions yielded earlier symptom improvement, supporting the incorporation of mHealth platforms into pathway design.[11] Collectively, these optimized pathways bridge scientometric insights with guideline-based clinical practice, forming a multidimensional, evidence-driven, and patient-centered model for UI behavioral therapy that emphasizes personalization, digital integration, and multidisciplinary collaboration.

4. Discussion

4.1. Current research landscape and collaboration

Global research demonstrates sustained scholarly engagement, with the USA, UK, China, Australia, and the Netherlands emerging as the predominant contributors. The collaborative network exhibits a multipolar structure, characterized by strong intra-regional cooperation in Europe and Australia, complemented by expanding transnational partnerships with Chinese institutions.

Topic evolution analysis reveals the multidisciplinary team approach as the predominant paradigm in clinical management. Tsai *et al*.[12] established that an integrated multidisciplinary team model spanning urogynecology, colorectal surgery, rehabilitation, and psychological services significantly reduces recurrence rates and complications while enhancing patient-reported outcomes and treatment adherence. In resource-limited settings, alternative implementation models have emerged. A nationwide Jordanian survey demonstrated that tiered referral systems ensure efficient use of available expertise.[13] This tiered-collaboration model effectively leverages available resources while maintaining specialized care access.

The integration of engineering and computer science disciplines through artificial intelligence (AI) and wearable technology represents a promising frontier. However, current authorship shows limited representation from these fields, indicating opportunities for deeper interdisciplinary engagement. The combination of RCT evidence, observational data, and validation studies of digital tools reflects growing methodological diversity and real-world applicability.

4.2. Research hotspots and frontier evolution

PFMT, bladder training, and QoL assessment remain fundamental to UI management. However, treatment adherence has emerged as the critical determinant of therapeutic success. The US insurance data[14] show that behavioral interventions are underutilized, underscoring the need for structured adherence monitoring.

Self-efficacy represents the primary predictor of rehabilitation outcomes, surpassing conventional factors such as age or muscle strength.[15] Contemporary research explores dual-support models that combine technological innovation with human supervision. Recent innovations—such as AI-driven telerehabilitation, gamified biofeedback,[16] and nurse-led digital follow-ups[17]—demonstrate substantial improvements in compliance and outcomes. In special populations, such as older adults or post-prostatectomy incontinence patients, digital and intelligent technologies are rapidly transforming traditional care pathways. Pre-operative initiation of app-based integrated care featuring AI-adjusted training intensity improves 6-month adherence to 78% and increases 1-month continence rates from 30% to 54%.[18] Intraoperative 3D sling-positioning systems reduce failure rates from 28% to 12% in patients aged ≥75 years,[19] whereas post-operative remote-monitoring platforms decrease 30-day readmission rates for artificial urinary sphincter implantation from 9.4% to 3.2%,[14] confirming the cost-effectiveness and sustainability of these digital interventions, particularly in elderly and post-operative populations.

The convergence of e-Health/m-Health technologies establishes continuous care pathways between clinical and home environments. Zhu *et al*.[20] documented significant reductions in pregnancy-related UI progression through app-based risk assessment and personalized training. Wearable sensors enable real-time biofeedback, with continuous electromyographic monitoring achieving clinical improvement within 4 weeks, compared to 24 weeks for conventional approaches.[11] Hybrid models combining remote supervision with digital content demonstrate medium-to-large effect sizes across multiple outcomes.[21]

Machine learning algorithms facilitate the transition from standardized to personalized interventions, enabling

individualized treatment intensity and adaptive feedback mechanisms.[22] Economic evaluations confirm the cost-effectiveness of algorithm-customized PFMT,[23] while long-term (15-month) data demonstrate sustained engagement in 58% of users through AI-driven reinforcement.[24] Even without significant adherence improvement, digital platforms enhance PFMT knowledge and self-efficacy.[25] Collectively, these findings highlight a paradigm shift toward precision continence care supported by data-driven feedback loops, establishing foundations for future research.

4.3. Implications for clinical pathway optimization and integration strategies

Evidence consistently demonstrates that training efficacy depends on frequency–intensity combinations rather than total volume. Rocha *et al*.[26] established the superiority of combined bladder training and intravaginal electrical stimulation over isolated interventions, while Tosun *et al*.[27] confirmed the safety and efficacy of high-intensity, multicomponent training regimens.

Synthesis of population studies[28-30] supports the implementation of standardized protocols: ≥3 sessions weekly, comprising 2–3 daily sets of 10–15 contractions (6–10 s at 50–70% maximum voluntary contraction), maintaining 1:1–1:2 contraction–relaxation ratios. For rapid intensification, limited-duration multicomponent intensive PFMT modules with automatic de-escalation triggers (≥10% maximum voluntary contraction reduction) are recommended. These evidence-based parameters should replace vague recommendations in clinical guidelines.

Adherence optimization requires systematic integration of structured education, motivational interviewing, digital reminders, and peer support. Standardized workflows should incorporate initial education materials, automated adherence monitoring, and regular progress evaluation to establish continuous feedback mechanisms.

Digital integration necessitates validated assessment tools, certified biofeedback devices, and automated alert systems for adherence lapses (e.g., >2 missed days or 3 consecutive days at <40% maximum voluntary contraction intensity). All digital solutions must meet regulatory standards for efficacy, safety, and data protection, and should incorporate clinical decision support for adverse-event management.

Establishing dynamic evaluation and adjustment nodes is vital for personalized management. Initially, AI can generate individualized plans based on patient profiles, automatically matching older or post-operative patients with low-intensity, safe-posture training.[31] Mandatory evaluation points at weeks 4 and 8 should guide automatic exercise progression if subjective scores and objective data improve, or automatic de-escalation with educational "rehabilitation tips" if fatigue or symptom exacerbation occurs. Differentiated requirements for special populations—such as avoiding sudden intra-abdominal pressure, increasing maneuvers for older adults, and prohibiting concurrent abdominal contraction for post-prostatectomy incontinence patients—enable a "single-pathway, multiple-branch" precision management approach.

Advancing UI management requires establishing cross-disciplinary collaborations, unified data standards, and iterative pathway updates through continuous evidence synthesis. This systematic approach will enable the transition toward precision continence care characterized by scalability and adaptability.

4.4. Trust and boundaries in the digital era

4.4.1. Liability attribution and algorithmic explainability

Digital transformation introduces challenges in data security, liability attribution, and human–AI collaboration. AI-assisted diagnosis creates accountability challenges when algorithmic errors occur, with current legal frameworks providing insufficient guidance for distributing liability among developers, healthcare institutions, and clinicians. We propose establishing dual safeguards that comprise algorithm traceability requirements and human–AI collaborative responsibility frameworks: First, enforcing algorithmic traceability to ensure auditability and interpretability of AI decision-making processes (explainable AI); and second, establishing a human–AI collaborative accountability framework that clearly defines clinicians' supervisory and decision-making roles, thereby preventing overreliance on algorithmic outputs.

4.4.2. Data security and privacy protection

Given the sensitive nature of pelvic floor physiological data, stringent data protection measures are required. Compliance with personal information protection laws—such as the General Data Protection Regulation, Health Insurance Portability and Accountability Act, and China's Personal Information Protection Law—necessitates the adoption of granular consent mechanisms that clearly communicate the scope and purpose of data collection, use, and sharing, while guaranteeing the right to withdraw consent. Encrypted transmission and secure data storage represent fundamental technical safeguards.

4.4.3. Regulatory boundaries and efficacy validation

A clear distinction must be made between remote monitoring and real-time treatment. Products that solely record or

monitor physiological data should be regulated differently from those that provide real-time biofeedback or automated therapeutic adjustments. Devices performing therapeutic functions must obtain medical device registration certification and be integrated into hospital quality management systems to prevent "monitoring-only" products from bypassing regulatory scrutiny. Furthermore, rigorous RCTs should be required to establish efficacy and safety before market promotion, avoiding premature claims based on preliminary feasibility studies.

4.4.4. Ethical governance frameworks

While AI systems exhibit remarkable pattern-recognition capabilities, their capacity for contextual reasoning and value-based judgment remains limited. Therefore, the establishment of comprehensive governance frameworks encompassing technical, ethical, and legal dimensions is essential. This includes forming ethics review boards to oversee digital therapeutic research and applications, setting industry standards to ensure algorithmic fairness and impartiality, and advancing legislative improvements that delineate clear ethical and legal boundaries for digital healthcare innovation.

4.5. Limitations and future prospects

Several limitations warrant consideration. The exclusive focus on English-language literature may overlook significant contributions in other languages, particularly those related to regional implementation practices. Bibliometric methodology, while revealing structural patterns, cannot substitute for rigorous quality assessment of individual studies. The translation of current research hotspots into clinical practice is nevertheless impeded by considerable obstacles. Furthermore, our analysis of clinical pathways relies on published guidelines rather than real-world implementation data, and qualitative validation through expert Delphi methods or consensus meetings is lacking. Moreover, despite the rapid adoption of digital products, the corresponding ethical norms and legal regulations remain underdeveloped, with mechanisms for data security, liability attribution, and protection of the rights of both patients and healthcare providers yet to be systematically established.

Future research should incorporate multilingual, multi-database strategies to enhance comprehensiveness and support the development of detailed, actionable treatment protocols. Implementation science methodologies—such as integrating AI-driven adherence monitoring within multicentre trials—should be employed to identify barriers and enablers in clinical practice, while health economic evaluations would further strengthen the case for digital interventions. The development of adapted regulatory frameworks remains crucial for ensuring ethical technology integration.

5. Conclusion

This comprehensive analysis of UI behavioral therapy research delineates the field's global knowledge structure and evolving clinical integration. While PFMT and bladder training remain fundamental, digital technologies are driving transformation toward personalized, remote delivery. The successful integration of these advances requires standardized pathway incorporation of digital tools, adherence strategies, and specialized protocols, supported by appropriate ethical and regulatory frameworks. Future efforts should focus on real-world implementation and continuous refinement of these optimized approaches.

Acknowledgments

The authors would like to thank colleagues and affiliated institutions for their support during the preparation of this manuscript.

Funding

None.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Author contributions

Conceptualization: Juan Li
Formal analysis: All authors
Supervision: Juan Li
Writing–original draft: Huijuan Du
Writing–review & editing: Juan Li

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Data availability statement

Not applicable.

References

1. Shen JH, Li L. Anatomical pathogenesis of stress urinary incontinence in women. *J Mod Urol.* 2025;30(2):99-105. doi: 10.3969/j.issn.1009-8291.2025.02.003
2. Shiyan W, Xiuli S. Evidence-based non-surgical treatment

strategies for female urinary incontinence. *J Pract Obstetr Gynecol*. 2022;38(6):407-410.
3. Hua J, Li T, Liu S, *et al*. Self-efficacy with Pelvic floor muscle training mediates the effect of an App-based intervention on improving postpartum urinary incontinence severity among pregnant women: A causal mediation analysis from a randomised controlled trial. *Midwifery*. 2024;135:104052. doi: 10.1016/j.midw.2024.104052
4. Moris L, Heesakkers J, Nitti V, *et al*. Prevalence, diagnosis, and management of stress urinary incontinence in women: A collaborative review. *Eur Urol*. 2025;87(3):292-301. doi: 10.1016/j.eururo.2024.12.017
5. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. *J Informetr*. 2017;11(4):959-975. doi: 10.1016/j.joi.2017.08.007
6. Chen C. Science mapping: A systematic review of the literature. *J Data Inf Sci.* 2017;2(2):1-40. doi: 10.1515/jdis-2017-0006
7. Nambiar AK, Arlandis S, Bø K, *et al.* European association of urology guidelines on the diagnosis and management of female non-neurogenic lower urinary tract symptoms. Part 1: Diagnostics, overactive bladder, stress urinary incontinence, and mixed urinary incontinence. *Eur Urol*. 2022;82(1):49-59. doi: 10.1016/j.eururo.2022.01.045
8. National Institute for Health and Care Excellence (NICE). *Urinary Incontinence and Pelvic Organ Prolapse in Women: Management*. London: NICE; 2019.
9. Lightner DJ, Gomelsky A, Souter L, Vasavada SP. Diagnosis and treatment of overactive bladder (Non-neurogenic) in adults: AUA/SUFU guideline amendment 2019. *J Urol*. 2019;202(3):558-563. doi: 10.1097/JU.0000000000000309
10. Caldwell L, Papermaster AE, Halder GE, White AB, Young A, Rogers RG. Evidence-based pelvic floor disorder care pathways optimize shared decision making between patients and surgeons. *Int Urogynecol J*. 2022;33(10):2841-2847. doi: 10.1007/s00192-021-05021-4
11. Markland AD, Goldstein KM, Beasley TM, *et al*. Remote access to urinary incontinence treatments for women veterans: The practical randomized clinical trial. *JAMA Netw Open*. 2025;8(9):e2532111.
doi: 10.1001/jamanetworkopen.2025.32111
12. Tsai TY, Huang SH, Liao CK, *et al*. Multidisciplinary team approach to pelvic floor disorders: A systematic review. *Biomed J*. 2025:100912. doi: 10.1016/j.bj.2025.100912
13. Qatawneh A, Lari FN, Sawas WA, *et al*. Management of stress urinary incontinence by obstetricians and gynecologists in Jordan: A nationwide survey study. *Healthcare* (*Basel*). 2024;12(15):1489. doi: 10.3390/healthcare12151489
14. Pan LC, Datar M, McKinney JL, Keyser LE, Goss TF, Pulliam SJ. Adherence to professional society guidelines among women with stress or mixed urinary incontinence. *Neurourol Urodyn*. 2022;41(6):1489-1497. doi: 10.1002/nau.24986
15. Er-Rabiai Y, Torres-Lacomba M, Casaña J, Núñez-Cortés R, Calatayud J. Correlation of self-efficacy for pelvic floor muscle exercise with symptoms of stress urinary incontinence in women. *Int Urogynecol J*. 2024;35(7):1487-1493. doi: 10.1007/s00192-024-05818-z
16. Janela D, Areias AC, Molinos M, *et al*. Digital care program for urinary incontinence in females: A large-scale, prospective, cohort study. *Healthcare* (*Basel*). 2024;12(2):141. doi: 10.3390/healthcare12020141
17. Yan F, Xiao L, Huang C, Tang S, Li L. Effectiveness of a nurse led hybrid self-management program for community-dwelling older people with urinary incontinence: A randomized controlled trial. *Int J Nurs Stud*. 2025;170:105157. doi: 10.1016/j.ijnurstu.2025.105157
18. Castellan P, Ferretti S, Litterio G, Marchioni M, Schips L. Management of urinary incontinence following radical prostatectomy: Challenges and solutions. *Ther Clin Risk Manag*. 2023;19:43-56. doi: 10.2147/Tcrm.S283305
19. Kim JC, Cho KJ. Current trends in the management of post prostatectomy incontinence. *Korean J Urol*. 2012;53(8):511-518. doi: 10.4111/kju.2012.53.8.511
20. Zhu Y, Cai W, Liu S, *et al*. Mobile app-based self-management of urinary incontinence in pregnant women: Multicenter pragmatic randomized controlled trial. *J Med Internet Res.* 2025;27:e72883. doi: 10.2196/72883
21. Hao J, Yao Z, Remis A, Huang B, Li Y, Yu X. Pelvic floor muscle training in telerehabilitation: A systematic review and meta-analysis. *Arch Gynecol Obstet*. 2024;309(5):1753-1764. doi: 10.1007/s00404-024-07380-x
22. Chen KY, Jones MK, Zillioux JM, Rapp DE. Pilot study of a novel online comprehensive pelvic floor program for urinary incontinence in women. *Int Urogynecol J*. 2024;35(2):415-421. doi: 10.1007/s00192-023-05695-y
23. Ekersund J, Samuelsson E, Lindholm L, Sjöström M. A mobile app for the treatment of female mixed and urgency incontinence: A cost-effectiveness analysis in Sweden. *Int Urogynecol J*. 2022;33(5):1273-1282. doi: 10.1007/s00192-022-05137-1
24. Wadensten T, Nyström E, Nord A, Lindam A, Sjöström M, Samuelsson E. App-based self-management of urgency and mixed urinary incontinence in women: One-year follow-up. *Neurourol Urodyn*. 2022;41(4):945-954. doi: 10.1002/nau.24898
25. Jaffar A, Mohd Sidik S, Foo CN, Muhammad NA, Abdul Manaf R, Suhaili N. Preliminary effectiveness of mHealth app based pelvic floor muscle training among pregnant women to improve their exercise adherence: A pilot randomised control trial. *Int J Environ Res Public Health*. 2022;19(4):2332. doi: 10.3390/ijerph19042332
26. Rocha AK, Monteiro S, Campos I, *et al*. Isolated bladder training or in combination with other therapies to improve overactive bladder symptoms: A systematic review and meta analysis of randomized controlled trials. *Braz J Phys Ther.* 2024;28(4):101102. doi: 10.1016/j.bjpt.2024.101102
27. Tosun OC, Keser I, Dayican DK, Yavuz O, Tosun G, Kurt S.

Does multiple-component intensive pelvic floor muscle training decrease muscle fatigue and symptoms in women with urinary incontinence? *Int Urogynecol J*. 2023;34(9):2067-2080.
doi: 10.1007/s00192-023-05499-0

28. Petter Rodrigues M, Bérubé MÈ, Charette M, McLean L. Conservative interventions for female exercise-induced urinary incontinence: A systematic review. *BJU Int*. 2024;134(6): 906-917.
doi: 10.1111/bju.16474
29. Frawley HC, Bennell K, Nelligan RK, *et al.* Telehealth exercise for continence after gynaecological cancer treatment (TELE-CONNECT): A protocol for a co-designed pragmatic randomised controlled trial. *BMC Womens Health*. 2024;24(1):529.
doi: 10.1186/s12905-024-03365-9
30. Santos JE, Brasil VV, Azevedo C, *et al*. Pelvic floor muscle training in men with post-prostatectomy urinary incontinence: A scoping review. *Rev Lat Am Enfermagem*. 2024;32:e4386.
doi: 10.1590/1518-8345.7335.4386
31. Singla N, Singla AK. Post-prostatectomy incontinence: Etiology, evaluation, and management. *Turk J Urol.* 2014;40(1):1-8.
doi: 10.5152/tud.2014.222014