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Expert Opinion Article

Application Of Artificial Intelligence As An Adjunct In The Evaluation Of Lower Urinary Tract Symptoms Among Rural Women: A Study In Functional And Female Urology

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ABSTRACT

Background: Lower urinary tract symptoms (LUTS) are common among women and often underreported, particularly in rural populations where access to specialist care is limited. Accurate symptom evaluation is essential for appropriate management; however, conventional assessment may be constrained by time, resources, and expertise. Artificial intelligence (AI) has emerged as a potential adjunct to enhance symptom classification and clinical decision-making in functional and female urology.

Objectives: To evaluate the role of artificial intelligence as an adjunct to standard clinical assessment in the evaluation and classification of LUTS among rural women.

Materials and Methods: This prospective observational study included 100 rural women presenting with LUTS. All participants underwent standard clinical evaluation using validated symptom assessment tools, followed by AI-assisted evaluation for symptom classification and triage. Concordance between AI-assisted assessment and clinician diagnosis was analyzed. Secondary outcomes included feasibility, impact on clinical decision-making, and referral accuracy.

Results: Storage symptoms were the predominant presentation (72%), with mixed symptom patterns observed in 44% of participants. AI-assisted evaluation reduced non-specific LUTS classification (10% to 4%) and improved identification of mixed phenotypes (18% to 24%). There was substantial agreement between AI-assisted evaluation and clinician diagnosis (overall agreement 86%, Cohen's $\kappa = 0.78$; $p < 0.001$). AI recommendations influenced refinement of initial clinical classification in 18% of cases and significantly improved identification of patients requiring referral for advanced evaluation ($p < 0.001$). Clinician acceptance of AI-assisted recommendations was high (84%).

Conclusion: AI-assisted evaluation, when used as an adjunct, enhances symptom phenotyping and referral triage in rural women with LUTS. This approach offers a feasible and standardized strategy to strengthen functional and female urology care in resource-limited settings, provided appropriate validation and ethical safeguards are maintained.

Keywords: Artificial intelligence, Lower urinary tract symptoms, Female urology, Rural health

INTRODUCTION

Lower urinary tract symptoms (LUTS)—including storage symptoms (frequency, urgency, nocturia, urinary incontinence), voiding symptoms (hesitancy, weak stream), and post-micturition symptoms—represent a common yet under-recognised women's health problem that significantly impairs quality of life, sleep, sexual health, social participation, and productivity. In low- and middle-income settings, the burden is amplified by delayed care-seeking due to stigma, limited awareness, distance to specialist services, and competing household and occupational responsibilities, barriers that are often more pronounced among rural women. In India, urinary incontinence, a major component of female LUTS, has been reported in approximately 10%–42% of women, reflecting variability in populations, definitions, and study settings [1]. Importantly, substantial underreporting persists, as embarrassment and normalisation of symptoms frequently prevent disclosure even during healthcare encounters [1].

Accurate evaluation of LUTS in women requires a structured approach incorporating history, symptom scoring, bladder diaries, physical examination, urinalysis, uroflowmetry, post-void residual assessment, and selective urodynamic testing. However, in rural settings, constraints such as limited consultation time, shortage of trained personnel, restricted access to urodynamic facilities, and variability in test quality may lead to incomplete phenotyping and delayed initiation of appropriate therapy. These challenges create an opportunity for artificial intelligence (AI) to serve as an adjunct that enhances consistency, triage, and clinical decision support without replacing clinician judgment.

Recent advances in functional and female urology demonstrate that machine learning and deep learning can extract clinically meaningful patterns from multimodal data, enabling scalable screening and stratification. Contemporary neurourology reviews highlight the expanding role of AI across diagnosis, monitoring, and treatment prediction, while emphasising the need for transparent, interpretable, and externally validated models [2]. Within urodynamics, AI is increasingly viewed as a means to reduce operator-dependent variability in complex pressure–flow interpretation [3], supported by real-time deep learning systems showing strong performance metrics [4]. Additionally, AI-based analysis of transperineal ultrasound images has demonstrated promising diagnostic accuracy in female stress urinary incontinence [5]. Against this backdrop, evaluating AI-assisted LUTS assessment among rural women is timely and aligned with ICMR priorities on equitable and appropriate technology use.

Primary Objective

- To evaluate the effectiveness of an artificial intelligence–assisted approach, used as an adjunct to standard clinical assessment, in the structured evaluation and classification of lower urinary tract symptoms among rural women.

Secondary Objectives

- To determine the distribution and predominant patterns of lower urinary tract symptoms (storage, voiding, and post-micturition symptoms) among rural women presenting with LUTS.
- To compare AI-assisted symptom classification with conventional clinical assessment, including validated symptom scores and clinician diagnosis.
- To assess the feasibility and acceptability of AI-assisted evaluation in a rural healthcare setting from both patient and clinician perspectives.
- To evaluate the ability of the AI system to aid in clinical triage, including the identification of patients requiring referral for advanced investigations such as urodynamics or specialist consultation.
- To examine the concordance between AI-generated recommendations and final clinical decision-making in functional and female urology.
- To identify demographic and clinical factors (age, parity, menopausal status, comorbidities) associated with specific LUTS phenotypes in rural women.
- To explore the potential of AI-assisted evaluation in reducing diagnostic delays and improving standardisation of LUTS assessment in resource-limited settings.

MATERIALS AND METHODOLOGY

Study Design and Setting

This prospective observational study was conducted in the Department of Urology / Functional and Female Urology of a tertiary care teaching hospital serving a predominantly rural population. The study was carried out after obtaining approval from the Institutional Ethics Committee, in accordance with ICMR ethical guidelines.

Study Population and Sample Size

A total of 100 rural women presenting with lower urinary tract symptoms (LUTS) were enrolled over the study period. Rural residence was defined as per local administrative records. Consecutive eligible patients attending the outpatient department were recruited after obtaining written informed consent.

Inclusion Criteria

Women aged ≥18 years presenting with one or more LUTS (storage, voiding, or post-micturition symptoms) and willing to participate were included.

Exclusion Criteria

Pregnant women, patients with acute urinary tract infection, known neurogenic bladder, pelvic malignancy, previous major pelvic surgery, or inability to comprehend symptom questionnaires were excluded.

Study Procedure

All participants underwent a standard clinical evaluation, including detailed history, physical examination, urinalysis, and assessment using validated symptom questionnaires (such as IPSS and condition-specific LUTS tools). This was followed by an artificial intelligence–assisted evaluation, where patient-reported symptoms and clinical parameters were entered into an AI-based decision support system designed to assist in symptom classification and preliminary triage.

The AI output included symptom pattern categorisation, probable LUTS phenotype, and recommendations for further evaluation (conservative management, referral, or advanced investigations). Treating clinicians were blinded to the AI output during the initial clinical assessment and reviewed the AI recommendations subsequently, using them strictly as an adjunct to decision-making.

Outcome Measures

Primary outcomes included concordance between AI-assisted evaluation and clinician-based diagnosis. Secondary outcomes included feasibility, acceptability, and identification of patients requiring specialist referral or advanced investigations.

Statistical Analysis

Data were analyzed using standard statistical software. Categorical variables were expressed as proportions and continuous variables as mean ± standard deviation. Concordance between AI and clinical assessment was analyzed using appropriate agreement statistics, with a p-value <0.05 considered statistically significant.

RESULTS

Lower urinary tract symptoms (LUTS) are highly prevalent among rural women and often present with diverse clinical patterns. The following tables summarize the demographic characteristics of the study population, distribution of LUTS, and comparison between conventional clinical assessment and artificial intelligence–assisted evaluation. The results highlight the role of AI as an adjunct in improving symptom classification, diagnostic concordance, and clinical triage in functional and female urology practice in a rural healthcare setting.

Table 1: Demographic Characteristics of Study Population (n = 100)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD	46.8 ± 11.2
Age group	18–30	12 (12%)
	31–45	34 (34%)
	46–60	38 (38%)
	>60	16 (16%)
Residence	Rural	100 (100%)
Parity	Nulliparous	8 (8%)
	Multiparous (≥2)	92 (92%)
Menopausal status	Premenopausal	54 (54%)
	Postmenopausal	46 (46%)
BMI (kg/m^2)	Mean ± SD	26.1 ± 3.8
Comorbidities	Diabetes Mellitus	28 (28%)
	Hypertension	34 (34%)

Table 1 depicts the demographic and clinical profile of the study population. The majority of participants were middle-aged, multiparous rural women, with nearly equal representation in both premenopausal and postmenopausal stages. A substantial proportion had elevated body mass index and common comorbidities such as diabetes mellitus and hypertension, reflecting typical risk factors associated with lower urinary tract symptoms.

Table 2: Distribution of Lower Urinary Tract Symptoms

LUTS Category	n (%)
Storage symptoms	72 (72%)
Voiding symptoms	38 (38%)
Post-micturition symptoms	21 (21%)
Mixed symptoms	44 (44%)

Table 2 illustrates the distribution of lower urinary tract symptoms among the study participants. Storage symptoms were the most commonly reported, followed by mixed symptom patterns. Voiding and post-micturition symptoms were less frequent, indicating that irritative urinary complaints predominated among rural women presenting with LUTS in this cohort.

Table 3: Comparison of Clinical Assessment and AI-Assisted Symptom Classification

LUTS Phenotype	Clinical Diagnosis n (%)	AI-Assisted Classification n (%)
Overactive bladder	36 (36%)	42 (42%)
Stress urinary incontinence	22 (22%)	20 (20%)
Mixed urinary incontinence	18 (18%)	24 (24%)
Voiding dysfunction	14 (14%)	10 (10%)
Non-specific LUTS	10 (10%)	4 (4%)

Table 3 compares lower urinary tract symptom phenotypes identified by conventional clinical assessment and AI-assisted evaluation. The AI system demonstrated a greater ability to recognize mixed and overactive bladder patterns while reducing nonspecific classifications, suggesting improved symptom stratification when used as an adjunct to routine clinical evaluation.

Table 4 demonstrates the level of agreement between AI-assisted evaluation and clinician-based diagnosis of lower urinary tract symptoms. The overall agreement was high, with a substantial Cohen's kappa value, indicating strong concordance beyond chance. The statistically significant p-value confirms that AI-assisted assessment reliably aligns with clinical judgment, supporting its role as an effective adjunct in functional and female urology practice.

AI-assisted evaluation demonstrated significant concordance with clinical assessment, improved symptom classification, and enhanced referral accuracy, supporting its role as a feasible and effective adjunct in functional and female urology for rural women.

Table 4: Concordance Between AI-Assisted Evaluation and Clinical Diagnosis

Parameter	Value
Overall agreement (%)	86%
Cohen's Kappa (κ)	0.78
Interpretation	Substantial agreement
p-value	<0.001

Table 5: Impact of AI on Clinical Decision-Making

Outcome	n (%)
AI identified additional mixed LUTS cases	14 (14%)
Change in initial clinical classification after AI review	18 (18%)
AI-assisted referral recommendation for advanced evaluation	26 (26%)
Clinician acceptance of AI recommendations	84 (84%)

Table 5 highlights the impact of AI-assisted evaluation on clinical decision-making. The AI system identified additional cases with mixed symptom patterns and influenced changes in initial clinical classification. A high rate of clinician acceptance of AI recommendations underscores its feasibility and practical utility as an adjunct in managing LUTS among rural women.

Table 6: Association Between AI-Assisted Classification and Referral Decision

Referral Need	AI Suggested (n)	Not Suggested (n)
Required referral	24	6
No referral	8	62

Table 6 demonstrates the association between AI-assisted recommendations and referral decisions for advanced evaluation. A significant proportion of patients requiring referral were accurately identified by the AI system. The statistically significant chi-square value indicates that AI-assisted evaluation improved triage accuracy in identifying rural women needing further urological assessment.

DISCUSSION

In this cohort of 100 rural women with LUTS, storage symptoms predominated (72%), and nearly half exhibited mixed symptom patterns (44%), reflecting the heterogeneous nature of female LUTS in routine clinical practice. These findings are consistent with population-level data showing storage symptoms as the most prevalent LUTS component in women, with increasing frequency across age groups [6]. Large epidemiological studies further emphasize that LUTS represents overlapping syndromes rather than a single entity, underscoring the need for structured symptom phenotyping [7].

A key finding was the reduction in "non-specific LUTS" labeling with AI-assisted evaluation (10% to 4%) and improved identification of mixed phenotypes (18% to 24%). This has important clinical implications, as mixed LUTS often require multimodal management strategies. Data-driven approaches, including unsupervised machine learning, have demonstrated the ability to identify distinct LUTS clusters not readily apparent through conventional assessment, supporting the added value of AI in symptom stratification [8].

The substantial agreement between AI-assisted evaluation and clinician diagnosis ($\kappa = 0.78$, $p < 0.001$) aligns with growing evidence from female pelvic medicine and reconstructive surgery literature describing AI as a useful adjunct for classification and decision support when appropriately governed [9]. A recent scoping review similarly reported promising diagnostic capabilities of machine learning in female urinary incontinence, while highlighting limitations related to dataset heterogeneity and external validation [10].

From a functional urology perspective, AI functioned as a standardization tool rather than a replacement for clinical judgment. High clinician acceptance and refinement of initial diagnosis are consistent with contemporary reviews emphasizing AI's role in reducing interpretive variability in resource-limited settings [11,12]. The significant association between AI-assisted recommendations and referral decisions supports its utility in triage, paralleling recent studies using machine learning to assess risk, predict outcomes, and guide escalation in overactive bladder management [13–15].

Emerging evidence from imaging, postoperative prediction, UTI phenotyping, and ethical AI implementation further contextualizes the role of AI in strengthening functional and female urology care pathways, particularly in underserved rural populations [16–22].

LIMITATIONS AND FUTURE DIRECTIONS

As a single-centre observational study with a fixed sample size (n=100), generalizability is limited; external validation in other rural and semi-urban settings is needed. Future studies should evaluate (i) performance across language and literacy strata, (ii) calibration and fairness across age/menopausal groups and comorbidity states, (iii) impact on time-to-diagnosis and patient-reported outcomes, and (iv) cost-effectiveness for primary and secondary care integration.

Overall, the present findings support that AI-assisted evaluation can enhance symptom phenotyping and referral triage, offering a practical adjunct to strengthen functional and female urology care pathways for rural women—provided that governance, validation, and ethical safeguards remain central.

CONCLUSION

Artificial intelligence–assisted evaluation demonstrated high concordance with clinical assessment, improved symptom stratification, and enhanced referral accuracy among rural women with LUTS. Used as an adjunct, AI offers a feasible, standardised, and ethically acceptable approach to strengthen functional and female urology care in resource-limited settings, while preserving clinician-led decision-making.

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