

# The Role of Microbiome in Urinary Incontinence

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**Abstract:** Urinary incontinence (UI) is a highly prevalent condition with significant physical, psychological, and social consequences. Traditionally, its pathophysiology has been attributed to neuromuscular dysfunction, hormonal changes, aging, and structural abnormalities of the lower urinary tract. Recent advances in molecular microbiology have challenged the long-standing belief that urine is sterile, revealing a resident urinary microbiome (urobiome). Emerging evidence suggests that alterations in the urobiome are associated with urinary incontinence, particularly urgency urinary incontinence (UUI) and overactive bladder (OAB). This manuscript reviews current knowledge regarding the composition of the normal urobiome, changes associated with urinary incontinence, proposed mechanisms linking microbial dysbiosis to bladder dysfunction, and the potential diagnostic and therapeutic implications.

**Keywords:** Urobiome, urinary microbiome, urinary incontinence, urgency urinary incontinence, overactive bladder, Lactobacillus

## 1. Introduction

Urinary incontinence affects over 400 million individuals worldwide and represents a major public health concern. It is broadly classified into stress urinary incontinence (SUI), urgency urinary incontinence (UUI), and mixed urinary incontinence. While SUI is predominantly caused by urethral hypermobility and pelvic floor weakness, UUI is characterized by involuntary detrusor contractions and heightened bladder sensory signaling.

For decades, the urinary bladder was believed to be sterile in healthy individuals, with bacteria detected only during infection. The advent of culture-independent techniques, including 16S rRNA gene sequencing and expanded quantitative urine culture (EQUC), has demonstrated that healthy urine contains a diverse but low-biomass microbial community. This discovery has led to increasing interest in the role of the urobiome in lower urinary tract symptoms, including urinary incontinence.

### The Normal Urobiome

#### Composition and Characteristics

The urobiome consists of a relatively small number of bacterial species compared with the gut microbiome. Commonly identified genera include *Lactobacillus*, *Corynebacterium*, *Streptococcus*, *Gardnerella*, and *Actinomyces*. In women, *Lactobacillus* species frequently dominate, particularly in premenopausal individuals.

#### Factors Influencing the Urobiome

Several host factors influence urobiome composition:

- **Sex:** Women generally have a more *Lactobacillus*-rich urobiome than men.
- **Age and menopause:** Postmenopausal women exhibit reduced *Lactobacillus* dominance and increased microbial diversity.
- **Hormonal status:** Estrogen levels influence both vaginal and urinary microbiota.
- **Antibiotic exposure:** Antibiotics can significantly disrupt urinary microbial communities.

#### Alterations of the Urobiome in Urinary Incontinence

##### Urgency Urinary Incontinence and Overactive Bladder

Multiple studies have demonstrated that women with UUI or

OAB harbor urinary microbial communities that differ from those of continent controls. These differences include altered bacterial diversity, shifts in dominant taxa, and changes in overall community structure.

Reduced *Lactobacillus* abundance and increased representation of genera such as *Gardnerella*, *Prevotella*, *Aerococcus*, and *Escherichia* have been reported in several cohorts.

##### Stress Urinary Incontinence

The relationship between SUI and the urobiome is less clear. Most evidence suggests that SUI is primarily mechanical in origin, though secondary microbial alterations may occur due to urine leakage, local inflammation, or recurrent antibiotic use.

##### Postmenopausal Urinary Incontinence

Postmenopausal women frequently exhibit urobiome dysbiosis characterized by decreased *Lactobacillus* and increased microbial diversity. These changes may contribute to bladder irritation, recurrent urinary symptoms, and increased susceptibility to UUI.

**Table 1:** Differences Between Normal Urobiome and Urobiome in Urinary Incontinence

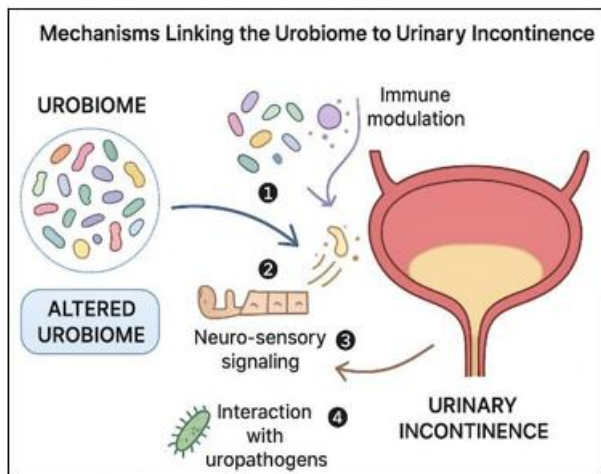
Feature	Healthy Individuals	Urinary Incontinence
Dominant bacteria	<i>Lactobacillus</i> spp.	Reduced <i>Lactobacillus</i> , increased diversity
Microbial diversity	Low to moderate	Increased or altered
Inflammatory markers	Minimal	Often elevated
Association with symptoms	None	Urgency, frequency, incontinence

##### Proposed Mechanisms Linking the Urobiome to Urinary Incontinence

- 1) **Immune and inflammatory modulation:** Commensal bacteria regulate innate immune responses within the bladder. Dysbiosis may promote chronic low-grade inflammation, increasing bladder hypersensitivity and urgency.
- 2) **Urothelial barrier integrity:** Beneficial microbes enhance epithelial tight junctions. Loss of these organisms may increase urothelial permeability and sensory nerve activation.
- 3) **Neuro-sensory signaling:** Microbial metabolites and

inflammatory mediators can influence afferent nerve pathways, contributing to detrusor overactivity.

- 4) **Colonization resistance:** A healthy urobiome inhibits colonization by uropathogens. Dysbiosis may permit subclinical infections that exacerbate urgency and frequency.



## 2. Clinical Implications

### Diagnostic Potential

Urobiome profiling may serve as a biomarker for differentiating types of urinary incontinence and identifying patients at risk for severe symptoms or poor treatment response.

### Therapeutic Implications

- **Probiotics:** Lactobacillus-based probiotics have been explored, with mixed results.
- **Hormonal therapy:** Estrogen replacement may indirectly modulate the urobiome.
- **Personalized medicine:** Microbiome-guided treatment selection for OAB medications is an emerging concept.

## 3. Conclusion

The urobiome represents a critical and previously underappreciated factor in urinary tract health. Growing evidence supports an association between urobiome dysbiosis and urinary incontinence, particularly urgency urinary incontinence. While causality has not yet been definitively established, understanding the urobiome offers promising avenues for improved diagnosis, prevention, and treatment of urinary incontinence.

**Table 2:** Summary of Key Studies on the Urobiome and Urinary Incontinence

Author (Year)	Study Type	Population	Key Findings
Pearce et al. (2014)	Cohort	Women with UUI	Distinct urobiome vs controls
Wu et al. (2017)	Observational	OAB patients	Altered microbial diversity
Bae et al. (2022)	Review	LUTS patients	Urobiome linked to OAB
Carnes et al. (2024)	Cohort	Women with UI	Microbiome types correlate with severity

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