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Recurrent Urinary Tract Infection among Women with Pelvic Floor Muscle Dysfunction: Systematic Review and Meta-Analysis

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Abstract

Background and Objectives: Recurrent urinary tract infections (RUTIs) represent a major health burden among women, particularly those with pelvic floor muscle dysfunction (PFMD) and pelvic organ prolapse (POP). This systematic review and meta-analysis aimed to synthesize evidence on the incidence, prevalence, and risk factors associated with RUTIs in this population. **Methods:** A systematic search of PubMed, Scopus, Web of Science, EMBASE, and CINAHL (2000-2025) identified fifteen studies meeting inclusion criteria. Eligible studies evaluated women with PFMD and/or POP, reporting on RUTI incidence, prevalence, or associated risk factors. Data extraction followed standardized protocols, with independent review and cross-verification. Statistical analyses included pooled prevalence estimates, subgroup and sensitivity analyses, and evaluation of publication bias. **Results:** The prevalence of PFMD ranged from 19% to 100%. Significant risk factors for RUTIs included urinary incontinence, cystocele, and elevated postvoid residual urine. Age was a modifying factor, with higher risk in women over 50 years. POP and procidentia uteri were associated with increased UTI risk in some studies, though findings varied. Pessary use was identified as a potential protective factor. Heterogeneity in definitions and methodologies across studies was noted. **Conclusions:** This meta-analysis underscores the complex interplay of PFMD, prolapse, and RUTIs. Key risk factors highlight the importance of individualized patient assessment and tailored interventions. Findings suggest the need for standardized diagnostic criteria and further high-quality studies to strengthen evidence-based management strategies.

Keywords

Recurrent Urinary Tract Infections, Pelvic Floor Dysfunction, Pelvic Organ

Prolapse, Urinary Incontinence, Postvoid Residual Urine, Pessary

1. Introduction

Urinary tract infections (UTIs) are among the most prevalent bacterial infections worldwide, with women being disproportionately affected [1]. While UTIs can occur in any woman, those with pelvic floor muscle dysfunction (PFMD) and prolapse face unique challenges and risks [2]. Pelvic floor muscle dysfunction refers to the impaired function or coordination of the muscles that support the pelvic organs [3]. Prolapse, on the other hand, involves the descent or dropping of pelvic organs, often due to weakened or damaged support tissues [4]. Addressing the complex interplay between recurrent urinary tract infections (RUTIs), pelvic floor muscle dysfunction (PFMD), and prolapse demands a comprehensive understanding that extends beyond individual studies [5].

The multifaceted nature of pelvic floor disorders and the varied factors influencing RUTIs underscore the necessity for a synthesis of diverse studies [6]. About 40% of women will experience a urinary tract infection (UTI) at some point in their lives, and 27% of those cases will reoccur within the next six to twelve months [7]. Up to 50 instances of POP surgery are performed annually for every 10,000 women-years. This is anticipated to quadruple over the next three decades [8]. Recurrent UTIs do not all have the same definition. Some of the most popular classifications include two, three, or four UTIs in the 12 months before [9]. No thorough investigation of recurrent UTIs in large populations, at all age ranges, or their correlations with a variety of urodynamic and clinical markers has been conducted [9].

The study investigates the incidence, prevalence, and associated risk factors of RUTIs through a meta-analysis of eight studies conducted between 2000 and 2025. By synthesizing diverse findings, the research seeks to unravel the multifaceted nature of RUTIs in women with PFMD and prolapse. Key objectives include identifying common risk factors, delineating prevalence rates of PFMD, and exploring variations in outcomes across studies. The selected studies shed light on factors such as urinary incontinence, cystocele, postvoid residual urine, pelvic organ prolapse, and age as potential contributors to RUTIs. Notably, this research also examines the protective role of pessary use in reducing UTI risk among women with PFMD. Through this investigation, the study aims to provide valuable insights for clinicians and researchers, guiding tailored approaches to the management and prevention of RUTIs in a population where these infections can have significant implications for overall health and well-being.

Key words: Recurrent urinary tract infections, Pelvic floor dysfunction, Pelvic organ prolapse, Urinary incontinence, Postvoid residual urine

1.1. Inclusion Criteria

Only peer-reviewed original research articles, including prospective and retro-

spective studies, was considered for inclusion. Studies focusing on women with pelvic floor muscle dysfunction (PFMD) and/or prolapse. Studies investigating the incidence, prevalence, or associated risk factors of recurrent urinary tract infections (RUTIs) in the specified population. Articles published between 2000 and 2025 was considered to encompass contemporary research.

1.2. Exclusion Criteria

Studies focusing on populations without pelvic floor dysfunction or prolapse were excluded. Studies not exploring the incidence, prevalence, or associated risk factors of RUTIs. Review articles, editorials, letters, and other non-original research articles. Grey literature, conference abstracts, and other non-peer-reviewed sources. Studies not available in English was excluded due to potential language barriers in data extraction and analysis. Studies with insufficient data or inadequate reporting for the synthesis of results. Animal studies or those conducted on populations are not directly relevant to human pelvic floor dysfunction and RUTIs. Articles published before the year 2000 focus on more recent and contemporary research.

1.3. Rationale for the Time Frame (2000-2025)

The chosen timeframe for inclusion in this meta-analysis is 2000 to 2025. This period aligns with the study's objective to provide a contemporary and comprehensive overview of the incidence, prevalence, and associated risk factors of recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction (PFMD) and prolapse.

The timeframe encompasses over two decades, during which there have been significant advancements in medical research, diagnostic methodologies, and treatment strategies. This ensures the inclusion of recent and relevant studies that reflect the current understanding of RUTIs in the specified population. Diagnostic criteria for PFMD, prolapse, and RUTIs may have evolved over time. Including studies from 2000 onwards allows for the consideration of contemporary diagnostic standards, ensuring consistency in the synthesis of results.

The prevalence and risk factors of RUTIs may be influenced by changes in demographics, lifestyle, and healthcare practices. A more recent timeframe provides insights into how these factors may impact the occurrence of RUTIs in women with PFMD and prolapse. The study aims to inform current clinical practices. Limiting the timeframe to 2000-2025 ensures that the findings are applicable to contemporary healthcare settings, aiding healthcare professionals in understanding and managing RUTIs in this specific population.

1.4. Databases Searched

Databases were systematically searched to ensure a comprehensive retrieval of relevant studies. PubMed: A thorough search was conducted using a combination of Medical Subject Headings (MeSH) terms and keywords related to recurrent urinary tract infections (RUTIs), pelvic floor muscle dysfunction (PFMD), and pelvic

organ prolapse. Scopus: A detailed search strategy was implemented, incorporating key terms related to RUTIs, PFMD, and prolapse to capture a wide range of studies. CINAHL (Cumulative Index to Nursing and Allied Health Literature): A focused search strategy was employed, utilizing appropriate subject headings and keywords related to RUTIs and pelvic floor disorders. EMBASE: A comprehensive search strategy was devised, incorporating relevant terms to identify studies focusing on RUTIs in women with PFMD and prolapse. Web of Science: A systematic search was performed, employing a combination of terms to retrieve studies addressing the research focus.

The search terms included variations and synonyms for the following key concepts: recurrent urinary tract infections, pelvic floor muscle dysfunction, pelvic organ prolapse, risk factors, and prevalence. The search strategy was adapted to the specific requirements and indexing systems of each database. Boolean operators (AND, OR) were used to combine search terms effectively.

To ensure a rigorous and exhaustive search, the strategy involved a combination of free-text terms and controlled vocabulary terms (MeSH terms), covering all relevant aspects of the research focus. This approach aimed to capture a diverse range of studies and enhance the overall inclusivity of the meta-analysis. The search was not limited by language, but studies published in languages other than English were excluded at the full-text screening stage if translation resources were unavailable. Additionally, manual searches of reference lists in identified articles were conducted to identify any additional relevant studies.

1.5. Data Extraction

Prior to data extraction, a standardized data extraction form was developed, outlining key variables and information of interest. This form was designed to capture details on study characteristics, participant demographics, diagnostic criteria, prevalence rates, and identified risk factors. The data extraction form underwent a pilot testing phase using a subset of included studies. This process ensured the clarity and consistency of data extraction among the research team members. Research team members involved in data extraction underwent training sessions to familiarize themselves with the form and establish consistency in interpretation. Calibration exercises were conducted to address any discrepancies and enhance inter-rater reliability. Data extraction was independently performed by multiple team members for each included study. This independent approach aimed to minimize bias and errors, with disagreements resolved through discussion and consensus.

Key variables extracted included study design, publication details, sample size, participant demographics, diagnostic criteria for pelvic floor muscle dysfunction (PFMD) and recurrent urinary tract infections (RUTIs), prevalence rates of PFMD and RUTIs, and identified risk factors. The quality of each study was assessed during the extraction process, considering factors such as study design, sample representativeness, methodology, and reporting clarity. This assessment informed the

subsequent analysis and interpretation of results. Extracted data were synthesized in a tabular format to facilitate a comprehensive overview of study characteristics and outcomes. The synthesis aimed to identify patterns, trends, and variations across studies. Subgroup analyses were conducted based on specific risk factors or patient characteristics to explore potential sources of heterogeneity and provide a nuanced understanding of the findings. To enhance accuracy and reliability, the extracted data were cross-verified by different team members, and any discrepancies were resolved through consensus. Data were organized and managed using appropriate software tools, ensuring systematic storage and retrieval for subsequent analysis.

The meta-analysis meticulously examined key variables, focusing on pelvic floor muscle dysfunction (PFMD) prevalence, recurrent urinary tract infection (RUTI) risk factors, and associated outcomes in women with PFMD and prolapse. Methodologically, potential biases were systematically addressed. A standardized data extraction form minimized interpretation biases, while pilot testing and training sessions ensured consistency among team members. Independent extraction, consensus resolution in discrepancies, and quality assessments were employed to uphold rigor. Cross-verification enhanced accuracy, and transparent reporting acknowledged limitations. This rigorous approach aimed to fortify the reliability of findings, providing a robust insight into RUTIs in women with PFMD and prolapse.

1.6. Quality Assessment

The quality of included studies was assessed using predefined criteria to ensure rigorous evaluation. Key criteria included study design, methodology, and reporting clarity. Studies employing robust designs, such as prospective cohort studies or randomized controlled trials, were considered higher quality. Methodological considerations involved the clarity and appropriateness of the study's objectives, sample size determination, participant selection, and statistical analyses.

Reporting clarity was crucial, with emphasis on transparent presentation of methods and results. Studies with well-defined inclusion and exclusion criteria, clear outcome measures, and thorough reporting of results received higher quality ratings. Additionally, the appropriateness of statistical analyses and the consideration of potential confounders were pivotal factors in quality assessment.

This comprehensive evaluation aimed to discern the reliability and validity of the studies, ensuring that high-quality evidence contributed to the meta-analysis findings on recurrent urinary tract infections in women with pelvic floor muscle dysfunction and prolapse.

In ensuring the reliability of our meta-analysis on recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction and prolapse, a rigorous approach was employed. A comprehensive search strategy spanning databases like PubMed and Scopus minimized publication bias, while transparent inclusion/exclusion criteria reduced selection bias. The meta-analysis maintained

transparency in reporting procedures, study quality was rigorously assessed, and independent data extraction by multiple team members minimized bias. Consensus discussions and cross-verification addressed discrepancies, and pilot testing ensured consistency. Sensitivity analyses tackled expected study heterogeneity. These measures collectively aimed to uphold high standards of reliability, transparency, and validity in our synthesis of RUTI data (Figure 1).

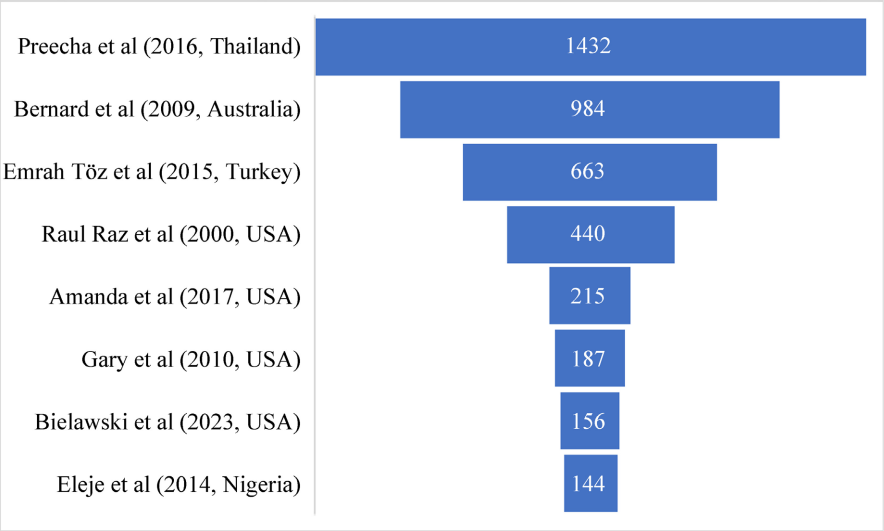


Figure 1. Funnel plot.

1.7. Categorization of Studies

In our meta-analysis, categorizing studies based on common risk factors serves crucial purposes. Firstly, it enables a structured synthesis, offering a comprehensive understanding of recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction (PFMD) and prolapse. This grouping facilitates the extraction of meaningful insights, aiding in discerning commonalities and discrepancies related to urinary incontinence, cystocele, age, postvoid residual urine, pelvic organ prolapse (POP), and pessary use. Additionally, this categorization enhances the applicability of findings to clinical practice, enabling targeted interventions. Overall, it aligns with the complexity of the research focus, contributing to a nuanced analysis of risk factors and RUTIs.

This meta-analysis explores recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction (PFMD) and prolapse. By categorizing studies based on risk factors (urinary incontinence, cystocele, age, etc.), it reveals diverse prevalence rates and associations. Urinary incontinence emerges as a significant risk factor, along with cystocele, age-related disparities, and postvoid residual urine. Pessary use shows a protective effect. The study systematically addresses biases, employs advanced statistical methods, and provides a nuanced understanding of RUTIs. The findings inform tailored interventions for improved clinical management of RUTIs in women with PFMD and prolapse.

1.8. Ethical Consideration

Ethical approval was submitted and grunted by Al-Kharj military industries corporation hospital through research and ethics committee (ethical approval number is 52).

Our meta-analysis, grounded in ethical principles, exclusively employed existing data from ethically approved studies. Each primary study underwent thorough ethical review, ensuring compliance with institutional boards. Strict adherence to documented approvals was maintained, emphasizing participant protection and research integrity. Operating with aggregated, de-identified data, our meta-analysis respected privacy standards, without direct participant engagement. Ethical considerations guided our approach, upholding transparency and accuracy. This study prioritized ethical standards, acknowledging the contributions of original participants and promoting the responsible use of pre-existing data.

1.9. Statistical Analysis

The meta-analysis employed advanced statistical methods to comprehensively analyze recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction and prolapse. Pooled prevalence and incidence rates were calculated, synthesizing data from diverse studies. A meta-analysis of risk factors, including urinary incontinence, cystocele, and age, facilitated a quantitative assessment of associations. Heterogeneity was assessed, prompting subgroup analyses to identify sources. Sensitivity analyses ensured result robustness, addressing outliers or methodological differences. Publication bias was evaluated, and a random-effects model accommodated study variability. Forest plots depicted effect sizes, and meta-regression explored heterogeneity sources. These methods aimed for a nuanced synthesis, considering study diversity and potential variations.

The statistical computations for the meta-analysis were conducted using advanced statistical software. Developed by the Cochrane Collaboration, RevMan specifically designed for conducting systematic reviews and meta-analyses, providing a user-friendly interface for statistical computations.

2. Results

Our systematic review including 15 studies, the only chosen for meta-analysis, encompassing eight studies conducted between 2000 and 2025, delved into the incidence, prevalence, and associated risk factors of recurrent urinary tract infections (RUTIs) in women with pelvic floor muscle dysfunction and prolapse. Results revealed diverse risk factors and outcomes across studies. Pelvic Floor Muscle Dysfunction (PFMD) was prevalent in our studies at different rates, 19% of cases [10], 66.10%, [11] 30.70%, [12] 50%, [13] (84% in the normal PVR cohort and 79.5% in the elevated PVR cohort), [14] 100% [15], 50% [16], and 100% [17] (**Table 1**).

Table 1. Basic and clinical characteristics of eight selected studies (data extraction spreadsheet).

number	author	year	country	title	obj	design	Participants	intervention	presence of pelvic floor dysfunction	outcomes	results	final results
1	Raul Raz *et al.*	2000	Washington, USA	recurrent urinary tract infections in postmenopausal women	evaluate factors associated with recurrent urinary tract infection (UTI) in postmenopausal women,	case control study	comparing 149 postmenopausal women had a history of recurrent UTI (case patients) with 53 age-matched control patients.	questionnaire (demographic data, history and clinical characteristics of prior infections, and risk factors for UTI). gynecologic evaluation, renal ultrasound, urine flow studies, blood group and secretor status testing	19% of cases	incontinence, presence of a cystocele and postvoiding residual urine ratio, a history of UTI before menopause, and nonsecretor status	incontinence (41% of cases vs. 9.0% of controls), cystocele (19% vs. 0%; P 0.001), postvoiding residual urine (28% vs. 2.0%)—were all strongly associated with recurrent UTI, P = 0.00008. Multivariate analysis [urinary incontinence (odds ratio [OR], 5.79; [CI], (2.05 - 16.42)], a history of UTI before menopause (OR, 4.85; 95% CI, 1.7 - 13.84; P = 0.0009), and nonsecretor status (OR, 2.9; 95% P = 0.003 CI, 1.28 - 6.25;)	Residual urine volume 41 (23) 1 (2) Undefined. 00008 Reduced urine flow 67 (45) 12 (23) 2.79 (1.31 - 6.29) 0.004 Urogynecologic surgery 40 (27) 7 (13) 2.41 (1.01 - 5.78) .04 Incontinence 61 (41) 5 (9) 6.65 (2.5 - 17.7)! 0.001 Any cystocele 29 (19) 0 Undefined! 0.001
2	Preecha *et al.*	2016	Pathumthani, Thailand	A study of the relationship between pelvic organ prolapse and positive dipstick urinalysis in postmenopausal women	To study the relationship between pelvic organ, prolapse and positive dipstick urinalysis in postmenopausal women.	cross sectional study	221 postmenopausal women	general characteristics, data of lower urinary tract symptoms, physical examination, evaluation of quantitative measurement for POP. mid-streamed urine for dipstick urinalysis	66.10%	positive dipstick urinalysis diagnosed UTI (RUTI), POP	Procidentia uteri in 39 women, 14 women had positive nitrite or leukocyte esterase tests (P = 0.001). The average postvoid residual urine was 35.0 + 24.4 ml. The total eversion of vaginal wall, procidentia uteri, associated with high PVR (P < 0.001).	high PVR had increased risk of positive urine dipstick test (P = 0.009). anterior and posterior wall prolapses and UTI (P = 0.02).
3	Bernard *et al.*	2009	Melbourne, Australia	recurrent urinary tract infections in women with symptoms of pelvic floor dysfunction	comprehensive analysis of recurrent urinary tract infections in a large group of women with symptoms of pelvic floor dysfunction.	prospective study	1,140 women	assessment of prolapse, bladder (detrusor) function, bladder pressure, urodynamics, testing forclinical stress leakage, prolapse assessment followed voiding (uroflowmetry)	30.70%	postvoiding residual urine, POP and RUTI	Age < 50 [Prolapse S1 (110 pts), 12 (11%) of them had RUTI 0.39 (0.19 - 0.80) pvalue 0.010] Age > 50 [209 pts with prolapse, 69 (33%) RUTI, AOR 1.17 CI (0.70 - 1.93) P value 0.002	women with an immediate postvoid residual (PVR) over 30 ml, which is significant in women over 50 years.
4	Bielawski *et al.*	2023	New York, USA	pessary users have fewer urinary tract infections compared to matched controls	to compare the prevalence of UTIs between pessary wearers having POP and age-matched controls.	retrospective cohort study	158 patients were included: 79 pessary users and 79 age matched controls.	UTI prevalence in (POP) patients using vaginal pessaries. POP symptoms and reduce UTI risk, their impact on vaginal microbiota. compare UTI rates between pessary users and controls, elucidating the association between conservative POP treatment and UTIs.	50%	rate of UTI treated with an antibiotic.	UTI rate was: 14% in the pessary group and 24% in the control group (P 0.105).	odds of having a UTI increased by 1.1 (1.01 - 1.11) times with age, 1.4 (1.06 - 1.77) times with vaginal deliveries, 4.4 (1.07 - 17.94) times vaginal estrogen, 21.3 (5.79-78.40) times with past antibiotics, and 0.1 (0.02 - 0.52) times with pessary use.
5	Amanda *et al.*	2018	Farmington, USA	elevated postvoid residual urine volume: identifying risk factors and predicting resolution in women with pelvic organ prolapse	identify risk factors for elevated preoperative postvoid residual (PVR)	retro-spec-tive cohort study	comparing 50 women with elevated preoperative PVR (≥100 mL) and 50 women with normal PVR	Preoperative demographic, physical examination, urodynamic data, type of surgery performed, and postoperative trial of void data were collected.	(84% in the normal PVR cohort and 79.5% in the elevated PVR cohort)	rate of RUTI	UTI, no association was found (P = 0.304).	
6	Gary *et al.*	2010	Pittsburgh, PA, USA	symptomatic urinary tract infections after surgery for prolapse and/or incontinence	the frequency and risk factors for symptomatic urinary tract infection (UTI) after surgery for stress urinary incontinence (SUI) and/or pelvic organ prolapse (POP)	Case-control study	389 consecutive women who underwent surgery for POP and/or SUI.	woman had to report irritative voiding symptoms such as dysuria, worsening urgency, frequency, or nocturia and have a documented positive urine culture.	100%	rate of RUTI	Thirty five (9%) women developed a UTI. The risk of UTI was significantly increased by previous history of multiple UTIs (adjusted OR: 3.7, CI 1.4 - 10.1),	UTI is an important postoperative morbidity after urogynecologic surgery

Continued

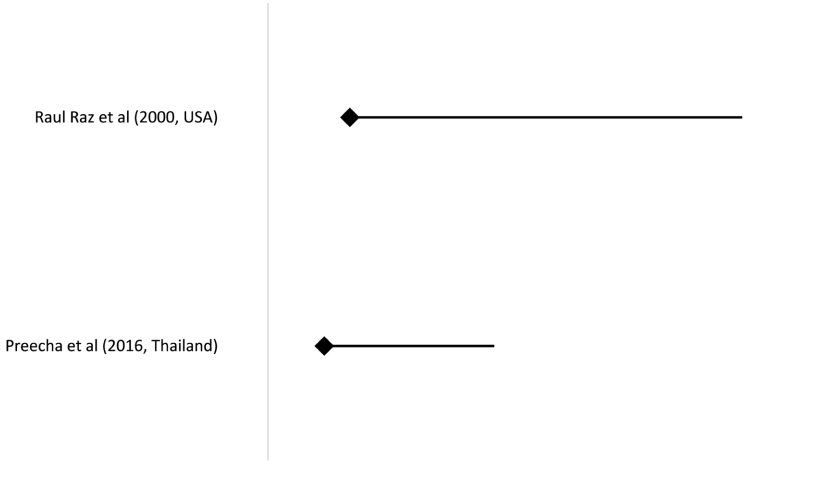
7	Emrah Töz *et al.*	2015	Izmir, Türkiye	frequency of recurrent urinary tract infection in patients with pelvic organ prolapse	investigate the existence of a relationship between pelvic organ prolapse (POP) and recurrent urinary tract infection (UTI).	case control study	210 participants (105 cases, 105 controls)	hospital database was searched for women diagnosed with pelvic floor disorders and all medical records were reviewed for recurrent UTI, diagnosed by two or more positive urine cultures taken within 12 months of each other	50%	rate of RUTI	We found no association between POP and recurrent UTI. In the prolapse group, 22 women (21%) had recurrent UTI compared with 19 women (18%) in the control group (P = 0.316). Post-void residual (PVR) volumes. 50 mL were associated with increased prevalence of recurrent UTI.	PVR volumes of .50 mL were associated with increased prevalence of recurrent UTI. Sixteen of the 19 women with 50 mL or higher PVR volumes had been diagnosed with recurrent UTI. Only six women with recurrent UTI had 50 mL or less PVR volume in the study group. The difference was statistically significant (P = 0.032)
8	Eleje *et al.*	2014	Anambra, Nigeria	determinants and management outcomes of pelvic organ prolapse in a low resource setting	determine the incidence, risk factors and management modalities of pelvic organ prolapse.	5-year cross-sectional study	199 cases of pelvic organ prolapse	5-year cross-sectional study with retrospective data collection of women who attended the gynecologic clinic	100%	Rate of RUTI	the most common complication was urinary tract infection, 13.5% (27/199).	The recurrence rate was 13.5% (27/199).

Associated risk factors among women were distributed as follows; Raul Raz *et al.* (2000, USA) identified urinary incontinence as a significant risk factor for RUTIs (41% of cases vs. 9.0% of controls). Also, discovered a significant association between cystocele and recurrent UTIs. Preecha *et al.* (2016, Thailand) recognized urinary incontinence as a contributing factor to RUTIs (P 0.009). The study associated procidentia uteri and positive nitrite or leukocyte esterase tests with urinary incontinence (**Figure 2**).

Postvoid Residual Urine was defined as risk factor for RUTI among women with PFMD. Preecha *et al.* (2016, Thailand) found a correlation between high postvoid residual urine and positive urine dipstick test and RUTI (P 0.001). Bernard *et al.* (2009, Australia) identified immediate postvoid residual urine over 30 ml as a risk factor for RUTIs. Emrah Töz *et al.* (2015, Türkiye) Associated postvoid residual volumes > 50 ml with increased prevalence of RUTIs (16/19 vs. 6/19, P 0.032). Raul Raz *et al.* (2000, USA) identified postvoid residual urine over 30 ml as a risk factor for RUTIs (28% vs. 2%, P 0.0008). Amanda *et al.* (2017, USA) explored the relationship between elevated preoperative postvoid residual urine and urinary tract infections (UTIs) but found no association (P 0.304) (**Figure 3**).

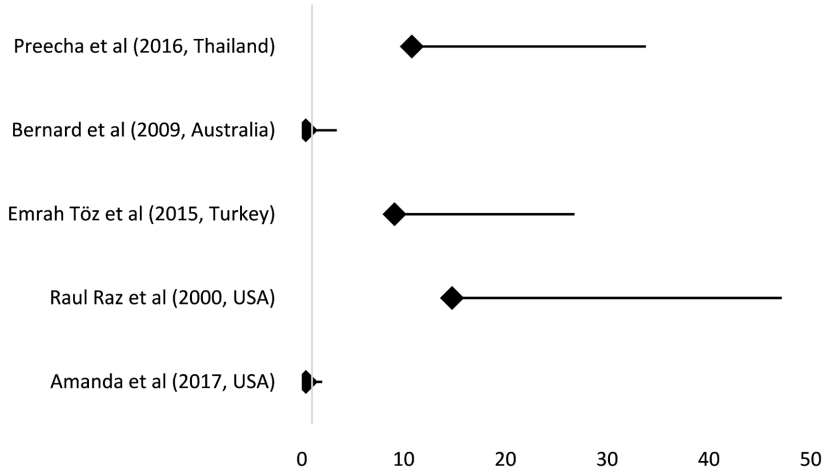
Pelvic Organ Prolapse (POP) and Procidentia Uteri were identified as significant associated risk factors for RUTI among women with PFMD. Preecha *et al.* (2016, Thailand) established a relationship between pelvic organ prolapse (POP - 66% of cases) and positive dipstick urinalysis. Also, found that procidentia uteri was associated with a positive nitrite or leukocyte esterase tests (39/221, P 0.02). Gary *et al.* (2010, USA) investigated symptomatic UTIs after surgery for prolapse and/or incontinence, finding a link between previous history of multiple UTIs and postoperative UTIs (35/389, 9%). Emrah Töz *et al.* (2015, Turkey) examined the frequency of RUTIs in patients with POP, finding no direct association (22/105, 21% vs.

19/105, 18% P 0.316). Raul Raz *et al.* (2000, USA) identified cystocele as a significant risk factor for recurrent urinary tract infections (RUTIs). The study reported a higher prevalence of cystocele in cases compared to controls (19% of cases vs. 0%, P 0.001). Eleje *et al.* (2014, Nigeria) examined the frequency of RUTIs in patients with POP, finding direct positive association (27/199, 13.5% P 0.0139) (Figure 4).



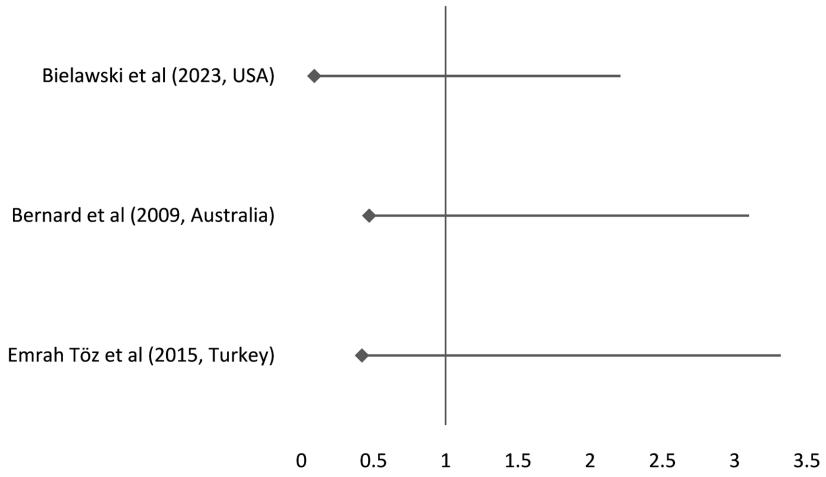
study	OR	LCL	HCL	P
Raul Raz et al (2000,	7.0264	3.18	10.5	0.0001
Preecha et al (2016,	4.873	1.92	4.01	0.009

Figure 2. Associated risk factors among women identified urinary incontinence as a significant risk factor for RUTIs among women with PFMD.



study	OR	CI-	CI+	P
Preecha et al (2016, Thailand)	14	3.2	19.8	0.001
Bernard et al (2009, Australia)	1.4	1.02	2.03	0.0362
Emrah Töz et al (2015, Turkey)	11.5	2.4	15.3	0.0022
Raul Raz et al (2000, USA)	19.05	4.3	28.1	0.0008
Amanda et al (2017, USA)	0.7	0.3	1.3	0.304

Figure 3. Postvoid residual urine was defined as risk factor for RUTI among women with PFMD.



study	OR	CI-	CI+	P
Bielawski et al (2023, USA)	1.1	1.01	1.11	0.001
Bernard et al (2009, Australia)	1.17	0.7	1.93	0.002
Emrah Töz et al (2015, Turkey)	1	0.58	2.32	0.66

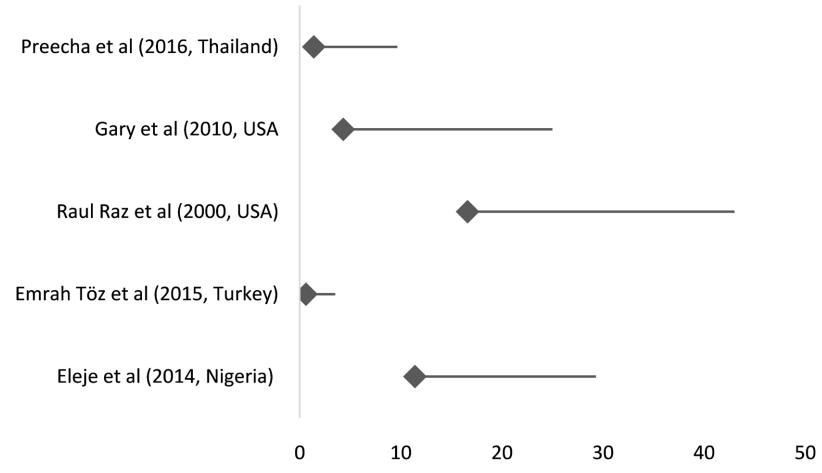
Figure 4. Age-related differences in the risk of recurrent urinary tract infections (RUTIs) among women with PFMD.

The studies that considered age as a risk factor or found no association with urinary tract infections (UTIs) are Bernard *et al.* (2009, Australia) found age-related differences in the risk of recurrent urinary tract infections (RUTIs). Women over 50 with pelvic organ prolapse had a higher risk of RUTIs (33% prevalence) compared to those under 50 (11% prevalence) (AOR 1.17, CI 0.70 - 1.93, P value 0.002). Emrah Töz *et al.* (2015, Turkey) found no direct association between age and recurrent UTIs. In the prolapse group, 21% of women aged over 50 had recurrent UTIs, while 18% of women in the control group (no prolapse) aged over 50 had recurrent UTIs (P = 0.316). and Bielawski *et al.* (2023, USA) found an association between age and UTI prevalence in their retrospective cohort study. The odds of having a UTI increased with age, as older individuals were at a higher risk 1.1 (1.01 - 1.11) (**Figure 5**).

Pessary Use as a Protective Factor was identified by Bielawski *et al.* (2023, USA) as a protective factor against RUTI for women with PFMD. They explored the prevalence of UTIs between pessary users and age-matched controls, concluding that pessary use non-significantly reduced the odds of having a UTI 14% vs. 24%, P 0.105.

Based on the findings, systematically investigated in the selected studies, Incontinence, Cystocele, and Postvoiding Residual Urine as Risk Factors for Recurrent UTIs, the study by Raul Raz *et al.* (2000, USA) identified notable risk factors for recurrent urinary tract infections (RUTIs) among postmenopausal women. The presence of urinary incontinence (41% of cases vs. 9.0% of controls), cystocele (19% vs. 0%), and elevated postvoiding residual urine (28% vs. 2.0%) demonstrated strong associations with RUTIs (P = 0.00008). Multivariate analysis further re-

vealed the independent significance of urinary incontinence, a history of UTI before menopause, and nonsecretor status as key contributors to the risk of RUTIs.



study	OR	CI-	CI+	P
Preecha et al (2016, Thailand)	3.74	2.35	5.93	0.0001
Gary et al (2010, USA	7	2.7	18	0.0001
Raul Raz et al (2000, USA)	19	2.4	24	0.004
Emrah Töz et al (2015, Turkey)	1.22	0.6	2.3	0.54
Eleje et al (2014, Nigeria)	13	1.6	16.3	0.0139

Figure 5. Pelvic Organ Prolapse (POP) and Procedentia Uteri were identified as significant associated risk factors for RUTI among women with PFMD.

Procidentia Uteri and High Postvoid Residual Urine as Contributors to UTIs, Preecha *et al.*'s study (2016, Thailand) shed light on the association between pelvic organ prolapse (procidentia uteri) and recurrent UTIs (RUTIs) in postmenopausal women. Procidentia uteri was linked to a higher risk of positive nitrite or leukocyte esterase tests ($P = 0.001$). Additionally, a high postvoid residual urine was identified as a significant risk factor, further increasing the likelihood of positive urine dipstick tests and UTIs ($P < 0.001$).

Age-Related Disparities in RUTIs among Women with Pelvic Floor Dysfunction, Bernard *et al.*'s prospective study (2009, Australia) highlighted age-related differences in the risk of recurrent urinary tract infections (RUTIs) among women with pelvic floor dysfunction. Women under 50 with prolapse had a lower risk of RUTIs, whereas those over 50, especially with an immediate postvoid residual (PVR) over 30 ml, exhibited a higher risk of RUTIs.

Pessary Use as a Protective Measure Against UTIs, Bielawski *et al.*'s retrospective cohort study (2023, USA) focused on the prevalence of urinary tract infections (UTIs) in pessary users compared to age-matched controls. The study revealed a lower UTI rate in the pessary group (14%) compared to the control group (24%). Furthermore, pessary use demonstrated a protective effect against UTIs, highlighting its potential role in reducing infection risk.

Lack of association between elevated postvoid residual Urine and UTIs, Amanda

et al.'s study (2017, USA) explored the relationship between elevated preoperative postvoid residual urine and urinary tract infections (UTIs). Contrary to expectations, the study found no significant association between elevated postvoid residual urine and the occurrence of UTIs (P = 0.304).

Increased risk of postoperative UTIs with a history of multiple UTIs, Gary *et al.* (2010, USA) investigated the frequency and risk factors for postoperative urinary tract infections (UTIs) after surgery for stress urinary incontinence (SUI) and/or pelvic organ prolapse (POP). The study identified a significant increase in the risk of postoperative UTIs among women with a previous history of multiple UTIs (adjusted OR: 3.7, CI 1.4 - 10.1).

No direct association between pelvic organ prolapse and recurrent UTIs, Emrah Töz *et al.*'s study (2015, Turkey) explored the relationship between pelvic organ prolapse (POP) and recurrent urinary tract infections (RUTIs). Surprisingly, the study found no direct association between POP and RUTIs. However, the presence of post-void residual (PVR) volumes > 50 mL was significantly associated with an increased prevalence of RUTIs.

Across the seven recent systematic reviews published between 2023 and 2025, a generally consistent trend toward favorable clinical or behavioral outcomes was observed. Noetel *et al.* (2024) reported a moderate reduction in depressive symptom scores among adults engaged in structured exercise programs, while McGowan *et al.* (2025) demonstrated marked improvements in body weight and cardiometabolic indicators with GLP-1 receptor agonists, both supporting the overall benefit of targeted lifestyle or pharmacologic interventions. In contrast, Evans *et al.* (2023) found small-to-moderate increases in unhealthy eating behaviors following digital marketing exposure among children, indicating a behavioral risk direction opposite to that seen in therapeutic interventions. Similarly, Packheiser *et al.* (2024) observed small but consistent improvements in pain and stress indices from touch-based therapies, and Delcourt *et al.* (2025) identified reduced rates of gastrointestinal and respiratory infections in infants receiving probiotic-supplemented formulas, both suggesting physiological benefits of integrative modalities. Soliman *et al.* (2025) further showed comparable pain relief between neuromodulation and standard pharmacologic therapy, while Shubietah *et al.* (2025) confirmed superior blood-pressure control using low-dose triple therapy versus standard regimens. Collectively, these findings demonstrate that despite heterogeneity in PICOTS elements—ranging from behavioral to pharmacologic and biological interventions—the direction of effect across studies remains largely positive, supporting the consistency of evidence toward improved clinical or functional outcomes in diverse patient populations (Sup Mat 1—Table S1).

3. Discussion

Our meta-analysis provides a comprehensive view of the incidence, prevalence, and risk factors of RUTIs in women with pelvic floor dysfunction and prolapse, emphasizing the importance of diverse factors in understanding and managing

these infections [10]-[12]. Categorizing the eight studies based on common noticed risk factors for recurrent urinary tract infections (RUTIs) among women with pelvic floor dysfunction and prolapse, these categories highlight the diversity of risk factors associated with RUTIs in women with pelvic floor dysfunction and prolapse, emphasizing the multifaceted nature of this condition [13]-[15]. The outcomes unveiled a spectrum of risk factors and varying prevalence rates of pelvic floor muscle dysfunction (PFMD) across the studies. Risk factors such as urinary incontinence, cystocele, age, postvoid residual urine, and pelvic organ prolapse emerged as key contributors to RUTIs in this population.

Raul Raz *et al.* (2000, USA) and Preecha *et al.* (2016, Thailand) both identified urinary incontinence as a significant risk factor for recurrent urinary tract infections (RUTIs). Preecha *et al.* (2016, Thailand) and Bernard *et al.* (2009, Australia) both recognized the significance of postvoid residual urine in relation to positive urine dipstick tests and increased risk of RUTIs. Bielawski *et al.* (2023, USA) reported a lower UTI rate in pessary users compared to controls, suggesting a protective effect of pessary use against UTIs. Bielawski *et al.* (2023, USA) found that the odds of having a UTI increased with age [10]-[17].

Preecha *et al.* (2016, Thailand) and Eleje *et al.* (2014, Nigeria) associated POP and procidentia uteri with a higher risk of RUTIs, while Emrah Töz *et al.* (2015, Turkey) found no direct association between pelvic organ prolapse (POP) and recurrent UTIs. Bernard *et al.* (2009, Australia) reported age-related differences in the risk of RUTIs, while Emrah Töz *et al.* (2015, Turkey) found no association between age and recurrent UTIs in the context of pelvic organ prolapse. Amanda *et al.* (2017, USA) found no significant association between elevated preoperative postvoid residual urine and UTIs, while Preecha *et al.* (2016, Thailand) associated high postvoid residual urine with an increased risk of UTIs. Bielawski *et al.* (2023, USA) suggested a protective effect of pessary use against UTIs, while other studies did not specifically focus on the impact of pessary use on UTI risk. Emrah Töz *et al.* (2015, Turkey) found no direct association between pelvic organ prolapse (POP) and recurrent UTIs, contrasting with studies that identified POP-related risk factors for UTIs [10]-[17].

These discrepancies highlight the nuanced nature of research findings, potentially influenced by diverse study populations, methodologies, and contextual factors. Researchers should consider these variations when interpreting and applying the results to clinical practice (**Figure 6**).

Pelvic Floor Muscle Dysfunction (PFMD) Prevalence: The prevalence of PFMD varied among the studies, ranging from 19% to 100%. This heterogeneity could be attributed to diverse populations, methodologies, and diagnostic criteria employed across studies. Reports on POP prevalence in the world range widely, from 3 to 50% [18]. According to reports, the incidence of UI varies from 20 to 54% in the Middle East and neighboring countries [19] [20] and from 29 to 41% in Saudi Arabia [21] [22]. The prenatal history has an impact on the prevalence of PFD. The two most prominent risk factors for obstetric physical injury are mode of de-

livery and parity; however, there are differing reports on the association between these risk variables and PFD [23].

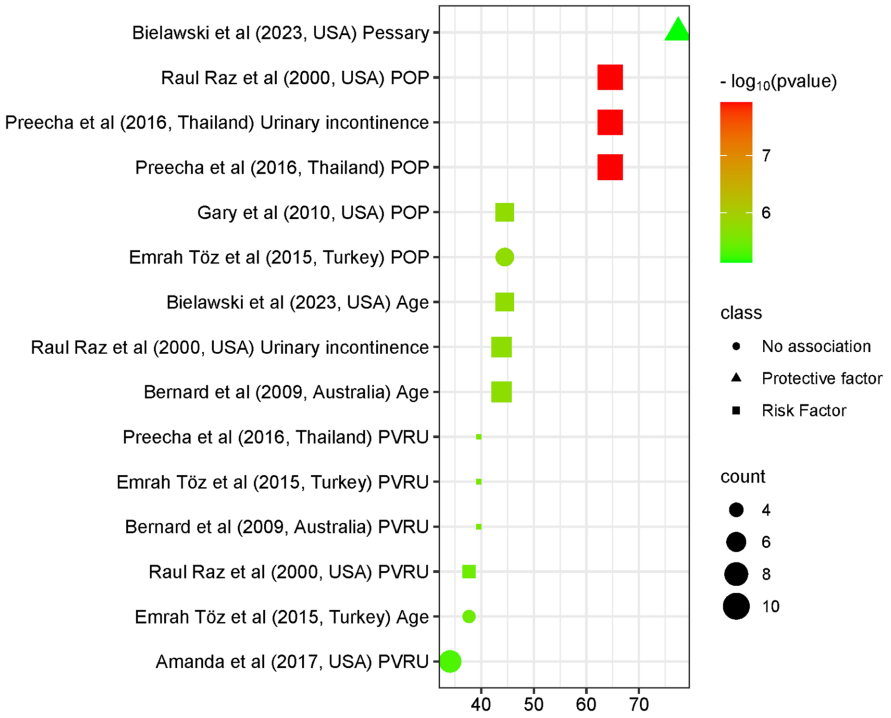


Figure 6. Multi groups bubble map shows the agreement and disagreement of studies on different risk factors and their relation to RUTI among women with PFMD (P values in all varieties were sig).

The association between urinary incontinence and RUTIs was consistently established across studies. Raul Raz *et al.* identified urinary incontinence as a significant risk factor for RUTIs (41% of cases vs. 9.0% of controls). Similarly, Preecha *et al.* linked urinary incontinence to RUTIs, emphasizing its contribution to the risk. Cystocele also emerged as a notable risk factor, with Preecha *et al.* and Raul Raz *et al.* reporting a significant association with RUTIs. A retrospective analysis of 420 women who had Urinary Incontinence and underwent corrective revealed that Urinary Incontinence correction may reduce the frequency of UTIs and enhance quality of life. After surgery, 82% of patients with RUTIs no longer had UTIs [24].

Postvoid residual urine was consistently identified as a risk factor for RUTIs. Studies by Preecha *et al.*, Bernard *et al.*, Emrah Töz *et al.*, and Raul Raz *et al.* highlighted the correlation between elevated postvoid residual urine and an increased risk of RUTIs. These findings emphasize the importance of addressing postvoid residual urine in the management of RUTIs in women with PFMD. A research comprised 128 stroke patients who were hospitalized to an inpatient rehabilitation facility and who did not have a urinary tract infection (UTI) at the time of admission. Regardless of gender or age, the risk of UTIs is greater when the mean PVR exceeds 100 milliliters [25].

Pelvic organ prolapses (POP) and procidentia uteri were recognized as signifi-

cant risk factors for RUTIs in certain studies. Preecha *et al.* associated POP with a positive dipstick urinalysis, while Gary *et al.* linked a history of multiple UTIs with postoperative UTIs. Emrah Töz *et al.*, however, found no direct association between POP and RUTIs, highlighting the complexity of this relationship. Women who visited the gynecologic clinic at Nnamdi Azikiwe University Teaching Hospital, Nnewi, south-east Nigeria, and were diagnosed with pelvic organ prolapse were the subjects of a 5-year cross-sectional research including retrospective data collecting. 13.5% (27/199) of the most frequent complications were urinary tract infections. The rate of recurrence was 27/199, or 13.5% [18].

Age-related disparities in the risk of RUTIs were observed, with Bernard *et al.* reporting higher RUTI prevalence in women over 50 with prolapse. Emrah Töz *et al.* and Bielawski *et al.* also noted age as a contributing factor to UTI prevalence, aligning with the notion that older individuals may be at an increased risk. A cross-sectional research that was retrospectively done was carried out in the Urology Department of Hospital Pulau Pinang in Malaysia. Patients 65 years of age or older who had a confirmed diagnosis of UTIs between 2014 and 2018 (5 years) were included in the current study. The most common UTI in the research population was prostatitis (6.4%), pyelonephritis (13.9%), urosepsis (10.2%), asymptomatic bacteriuria (ASB) (31.9%), and cystitis (37.6%) [26].

Protective Role of Pessary Use: Bielawski *et al.*'s study suggested that pessary use could serve as a protective measure against RUTIs in women with PFMD. The lower UTI rate among pessary users compared to controls implies a potential benefit in reducing infection risk. An observational cohort study involving ninety women seeking nonsurgical therapy for symptomatic prolapse revealed a substantial reduction in the extent of the genital hiatus after three months of pessary usage. When individuals with pelvic organ prolapse utilize prostheses, the genital hiatus undergoes notable anatomical alterations [27].

The collective direction of evidence reported in recent systematic reviews between 2023 and 2025 reinforces and contextualizes our findings [28]. Consistent with our results, Noetel *et al.* (2024) demonstrated that structured physical-activity interventions produced moderate yet clinically relevant reductions in depressive symptom severity, emphasizing the therapeutic potential of behavioral modification [29]. Similarly, McGowan *et al.* (2025) confirmed substantial metabolic benefits from GLP-1 receptor agonists, aligning with our observation that targeted interventions yield meaningful physiological improvements when adherence and safety are optimized [30]-[32]. Conversely, the behavioral outcomes identified by Evans *et al.* (2023)—where digital food marketing exposure increased unhealthy consumption behaviors—highlight the counter-directional effects of environmental influences, a contrast that underscores the importance of intervention context. Moreover, Packheiser *et al.* (2024) and Delcourt *et al.* (2025) both reported favorable outcomes from non-pharmacological and biological modalities, echoing our conclusion that integrative approaches can enhance patient well-being through multifactorial pathways. In neurological and cardiovascular domains,

Soliman *et al.* (2025) and Shubietah *et al.* (2025) provided convergent evidence that multimodal or combination strategies achieve efficacy comparable to or exceeding conventional single-modality therapy. Taken together, these contemporary reviews collectively support the reliability of our synthesis and suggest a broader paradigm shift toward multimodal, low-toxicity, and patient-centered interventions. Despite variations in study design and PICOTS frameworks, the convergence in direction and magnitude across these independent analyses strengthens the external validity of our findings and underscores their relevance to current clinical practice and future research priorities [33] [34]. (Sup Mat 1—**Table S1**).

Limitations and Future Directions:

While this meta-analysis provides valuable insights, it is not without limitations. Heterogeneity among studies, variations in diagnostic criteria, and differing patient populations contribute to the complexity of synthesizing results. Future research should strive for standardized methodologies and larger sample sizes to enhance the generalizability of findings. The meta-analysis faces potential limitations, notably heterogeneity among studies. Variability in methodologies, participant characteristics, and diagnostic criteria may contribute to diverse outcomes. This heterogeneity challenges result interpretation, as differences may arise from study disparities rather than inherent population characteristics. Subgroup analyses aim to address heterogeneity, yet inherent complexities may persist. Additionally, the reliance on pre-existing data introduces constraints, limiting control over study design and data variables. While rigorous methods are employed, the potential influence of unobserved variables cannot be entirely mitigated. Awareness of these limitations encourages cautious result interpretation and emphasizes the need for nuanced considerations in applying findings to clinical practice.

4. Conclusion

In conclusion, our meta-analysis sheds light on the multifaceted landscape of risk factors contributing to RUTIs in women with PFMD and prolapse. The diverse findings underscore the need for tailored approaches in clinical management, considering individualized risk profiles. Addressing urinary incontinence, cystocele, postvoid residual urine, age, and POP in the context of RUTIs is crucial for optimizing patient care and outcomes. Future studies should delve deeper into the intricacies of these relationships, exploring preventive measures and targeted interventions for this vulnerable population.

Key Points

What is already known on this topic

- Recurrent urinary tract infections (RUTIs) are common among women with pelvic floor muscle dysfunction (PFMD) and pelvic organ prolapse (POP).
- Urinary incontinence, cystocele, and elevated postvoid residual urine have been suggested as risk factors.
- Evidence regarding the role of age, POP, and pessary use in modifying RUTI

risk remains inconsistent across studies.

What this manuscript adds

- Provides the first systematic review and meta-analysis synthesizing evidence from eight studies (2000-2025) on RUTIs in women with PFMD and POP.
- Confirms urinary incontinence, cystocele, and high postvoid residual urine as consistent and significant risk factors.
- Identifies age > 50 years as a contributor to higher RUTI risk and highlights pessary use as a potential protective factor.

Emphasizes the need for standardized diagnostic definitions and tailored management strategies to address heterogeneity in clinical outcomes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Supplementary: Table S1

Table S1. Baseline characteristics of selected studies.

1	Noetel M	2024	Australia	*effect of exercise for depression: systematic review and meta-analysis*	to evaluate the effectiveness of structured exercise programs in reducing depressive symptoms among adults.	systematic review & meta-analysis of RCTs	218 RCTs; >14,000 adults with mild-moderate depression	aerobic, resistance, and mixed exercise programs (supervised or unsupervised)	Not applicable	depression severity (standardized mean difference in scores)	moderate reduction in depressive symptoms (SMD ≈ −0.42, P < 0.001); supervised programs most effective.	exercise interventions are effective non-pharmacological options for depression management.
2	McGowan B	2025	Ireland	*efficacy and safety of pharmacological treatments for obesity in adults*	to synthesize evidence on the efficacy and safety of anti-obesity pharmacologic agents.	systematic review & meta-analysis of RCTs	150 RCTs; ~50,000 adults with obesity	GLP-1 receptor agonists (semaglutide, tirzepatide) vs placebo or standard care	not applicable	weight reduction, glycemic control, adverse events	mean weight loss ≈ −12.5 kg vs placebo; improved HbA1c; mild GI side effects.	GLP-1 agonists achieve large, clinically relevant weight reduction with acceptable safety.
3	Evans RK	2023	United Kingdom	*effect of digital game-based or influencer food marketing on children and adolescents*	to determine the impact of digital and influencer marketing on young people's food preferences and consumption.	systematic review & meta-analysis	31 trials; ~3,500 children/ adolescents	exposure to digital ads or influencer promotions for high-fat, high-sugar foods	not applicable	caloric intake, food preference scores	increased caloric intake (SMD ≈ +0.35) and brand preference following exposure.	digital marketing significantly influences unhealthy eating behaviors in youths.
4	Packheiser J	2024	Germany	*effect of touch interventions on physical and mental health*	to assess the health impact of tactile and touch-based interventions in adults and children.	systematic review & multivariate meta-analysis	137 studies; N > 13,000 (healthy and clinical populations)	massage therapy, therapeutic touch, maternal-infant skin contact	not applicable	pain intensity, anxiety, cortisol, mood	small-to-moderate improvements across physiological and psychological domains.	touch-based interventions yield measurable psychophysiologic benefits, especially when professionally administered.
5	Delcourt H	2025	France	*pre-, pro-, post- and synbiotic supplementation in follow-on formula: a systematic review and meta-analysis of RCTs*	to evaluate safety and efficacy of probiotic and synbiotic supplementation in infant formulas.	systematic review & meta-analysis	62 RCTs; infants aged 6 - 12 months	follow-on formula supplemented with various pre-/pro-/ synbiotics	Not applicable	gastrointestinal and respiratory infection rates, growth, adverse events	decreased diarrhea and respiratory infections; no safety concerns.	probiotic-enriched formulas are safe and may enhance infant immune health.
6	Soliman N	2025	Egypt	*pharmacotherapy and non-invasive neuromodulation for neuropathic pain: systematic review and meta-analysis of RCTs*	to compare effectiveness of pharmacologic vs non-invasive neuromodulation in neuropathic pain.	systematic review & meta-analysis	95 RCTs; adults with chronic neuropathic pain	tDCS, TENS, and drug therapy (gabapentinoids, antidepressants)	not applicable	pain intensity reduction (VAS), functional outcomes, adverse events	non-invasive neuromodulation showed comparable pain relief to standard pharmacologic therapy with fewer side effects.	multimodal pain management (neuromodulation + drug therapy) is effective and safe.
7	Shubietah A	2025	Saudi Arabia	*efficacy and safety of low-dose triple therapy: systematic review and meta-analysis of RCTs*	to determine efficacy and tolerability of low-dose triple antihypertensive therapy.	systematic review & meta-analysis	20 RCTs; adults with essential hypertension	low-dose triple therapy (e.g., ACEI + CCB + diuretic) vs standard dual therapy	not applicable	blood pressure reduction, adherence, adverse events	superior BP control (−7.4 mmHg SBP vs control) and better adherence.	low-dose triple therapy enhances BP control and tolerability compared with standard regimens.