Distinct predictors of stress vs. urge urinary incontinence after transurethral prostatectomy: A prospective cohort study

Mostafa M. Mostafa[1], Abdelrahman Abdelshafi[2], Hamza Mohamed[2], Amr E. Darwish[1]
[1]Department of Urology, Faculty of Medicine, Assiut University, Assiut, Egypt; [2]Faculty of Medicine, Assiut University, Assiut, Egypt

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Corresponding author: Dr. Mostafa M. Mostafa, Department of Urology, Faculty of Medicine, Assiut University, Assiut, Egypt; mostafamostafa@aun.edu.eg

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ABSTRACT

Introduction: Urinary incontinence (UI) remains a distressing complication following surgical treatment of benign prostatic hyperplasia (BPH). Although postoperative UI is well described, few prospective studies have distinguished predictors of stress urinary incontinence (SUI) from those of urge urinary incontinence (UUI).

Methods: In this prospective cohort study (July 2022–July 2024), 133 men undergoing bipolar transurethral resection of the prostate (B-TURP) or bipolar enucleation of the prostate (BipolEP) were followed-up for ≥ 1 year. Preoperative and intraoperative variables were evaluated using univariate testing and multivariable logistic regression to identify independent predictors of persistent SUI and UUI.

Results: SUI occurred in 20.3% of patients and was independently associated with older age and use of the enucleation technique with additional univariate associations observed for larger prostate volume, lower baseline Qmax, and greater resected tissue weight. UUI occurred in 15.8% and was independently predicted by higher IPSS scores and preoperative detrusor overactivity with univariate association also noted for older age; no intraoperative factor predicted UUI.

Conclusions: SUI is primarily driven by anatomical and surgical factors, whereas UUI reflects underlying bladder dysfunction. Differentiating these predictive profiles supports individualized patient counseling, procedural planning, and preoperative risk stratification for men undergoing transurethral prostatectomy.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most common conditions affecting aging men, with its prevalence steadily increasing with advancing age and approaching 90% by the eighth decade. As the gland enlarges, many patients develop bladder outlet obstruction (BOO) and the accompanying lower urinary tract symptoms (LUTS) that often require intervention (1). Bipolar transurethral approaches, including bipolar transurethral resection of the prostate (B-TURP) and bipolar enucleation of the prostate (BipolEP), are established treatments that effectively relieve BOO and improve symptoms (2).

Despite their efficacy, postoperative urinary incontinence (UI) remains one of the most distressing complications, causing significant anxiety, dissatisfaction, and reduced quality of life (3–5). Reported rates vary widely, influenced by differing surgical techniques, definitions of UI, and follow-up methodologies across studies (6,7). Most importantly, postoperative UI is commonly reported as a single outcome, even though stress urinary incontinence (SUI) and urge urinary incontinence (UUI) arise from fundamentally different mechanisms. This lack of distinction limits the interpretability and clinical usefulness of prior findings.

Identifying predictors of postoperative SUI versus UUI is essential for tailoring patient counseling, refining surgical planning, and improving continence outcomes (8). However, prospective evidence on this distinction after transurethral prostatectomy remains scarce.

The present study was designed to address this gap. Using a prospective cohort of men undergoing B-TURP or BipolEP, we examined a wide range of preoperative and intraoperative factors to determine which variables independently predict SUI and which predict UUI. Our goal was to offer practical data that clinicians can use during preoperative discussions and to help tailor postoperative expectations and management.

METHODS

This is a prospective cohort study conducted on BPH patients who underwent either BipolEP or B-TURP at University Urology Hospital in the period from July 2022 to July 2024. Inclusion criteria included a diagnosis of BPH complicated by BOO. All patients had transrectal ultrasound (TRUS) evidence of BPH, with prostate volumes of ≥25 ml (9). The BOO was defined as a BOO index >40 using the International Continence Society nomogram (10). We excluded patients with prostate cancer, previous urethral or prostatic surgery, neurogenic bladder, and/or urethral stricture. In cases of suspected prostate cancer by digital rectal examination (DRE), TRUS, or elevated serum prostate-specific antigen (PSA) level, TRUS-guided biopsies were taken, and patients with cancer were also excluded.

All patients had a routine initial evaluation with a complete medical history, DRE, international prostate symptom score (IPSS) questionnaire, routine laboratory investigation (complete blood count, coagulation profile, and renal function tests), assessment of surgical fitness, postvoid residual urine volume (PVR), TRUS, maximum urinary flow rate (Qmax), and determination of serum PSA when needed before proceeding to any surgical intervention in addition to a urodynamics study. Prostate volume was measured using TRUS and calculated using a conventional formula (length*width*height*π/6). Four surgeons performed standardized B-TURP and BipolEP techniques on the study participants.

UI was defined in this study as persistent involuntary leakage of urine lasting more than one year following the procedure. Only patients who met this criterion were considered to have clinically significant UI. To further classify the type of UI, a detailed patient history was obtained, focusing on the nature and circumstances of urine leakage. Based on the reported symptoms, UI was categorized as either SUI, defined as the involuntary leakage of urine during physical exertion, sneezing, or coughing, or UUI, characterized by a sudden, intense urge to urinate followed by involuntary leakage. Then, patients were divided into two groups based on the type of UI they suffered from. The first group included patients who developed SUI, while the second group involved patients who developed UUI. The preoperative and intraoperative parameters of each of these two groups of patients were compared with those of the patients who didn't develop the respective type of UI to figure out if there are preoperative or intraoperative predictors for the development of each type of UI after the procedure. The preoperative parameters included age, diabetes mellitus, hypertension, IPSS, BPH degree, prostate volume, median lobe enlargement, PVR, Qmax, and detrusor overactivity (DO). On the other hand, the intraoperative parameters included the technique (B-TURP or BipolEP), operative time, and weight of resected prostatic tissue.

To minimize potential sources of bias, this study employed a prospective design with predefined inclusion and exclusion criteria, standardized surgical techniques, uniform follow-up duration, and multivariable regression analysis to adjust for confounding variables.

Statistical analysis

All statistical analyses were performed using Jamovi version 2.6.2. The normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed variables were summarized as means with standard deviations and compared using the independent samples t-test. Non-normally distributed quantitative or ordinal variables were expressed as medians with interquartile ranges (IQR) and compared using the Mann–Whitney U test. Categorical variables were reported as frequencies and percentages, and group differences were assessed using the chi-squared test. All hypothesis tests were two-sided, and a p-value <0.05 was considered statistically significant.

To identify independent predictors of postoperative SUI and UUI, binary logistic regression models were constructed separately for each incontinence outcome. Variables demonstrating a statistically significant association in univariate analysis ($p < 0.05$) were subsequently entered into multivariable logistic regression. For the SUI model, these variables included age, BPH degree, prostate volume, baseline Qmax, surgical technique, and weight of resected prostatic tissue. For the UUI model, the variables meeting the inclusion threshold were age, preoperative IPSS, and DO. Each multivariable model generated adjusted odds ratios (OR) with corresponding 95% confidence intervals (CI). Model stability and convergence were confirmed before interpretation. Statistical significance was defined as $p < 0.05$.

RESULTS

A total of 133 patients met inclusion criteria and completed the required follow-up period. Among these, 27 patients (20.3%) developed SUI, and 21 patients (15.8%) developed UUI. The preoperative and intraoperative characteristics of the cohort were evaluated to identify predictors of development of SUI and UUI.

Predictors of stress urinary incontinence (SUI)

Univariate associations

Patients who experienced SUI were significantly older than those who remained continent (72.9 ± 3.09 vs. 64.8 ± 5.35 years, $p < 0.001$). Higher BPH degree was also associated with SUI, with third-degree hypertrophy more common in the SUI group (74.1% vs. 47.2%, $p = 0.012$). Median prostate volume was significantly larger in the SUI group (95 vs. 75 mL, $p = 0.011$). Furthermore, baseline uroflowmetry values differed significantly, with the SUI group demonstrating a lower median Qmax (3.50 vs. 6.55 mL/s, $p = 0.006$).

Regarding intraoperative characteristics, SUI occurred more frequently following enucleation than resection (70.4% vs. 29.6%, $p = 0.006$). Additionally, median resected tissue weight was significantly greater in patients who developed SUI (78 vs. 53.5 g, $p = 0.012$). Other preoperative factors, including comorbidities, IPSS, median lobe enlargement, PVR, and DO, and operative time were not significantly associated with SUI (Table 1).

Multivariable analysis

In the multivariable logistic regression model incorporating all univariate predictors with $p < 0.05$, two factors retained independent significance. Increasing age was strongly associated with a higher risk of SUI (OR 1.85, 95% CI 1.42–2.42, $p < 0.001$). Surgical technique remained a significant predictor, with enucleation conferring markedly higher odds of SUI compared with resection (OR 8.40, 95% CI 1.63–43.38, $p = 0.011$). BPH degree demonstrated a trend toward significance (OR 49.39, 95% CI 0.53–4619.53, $p = 0.092$), though with wide confidence intervals; prostate volume, Qmax, and resected tissue weight did not retain statistical significance in the adjusted model (Table 2).

Overall, these findings indicate that SUI following transurethral prostatectomy is influenced primarily by age-related pelvic floor vulnerability and the anatomical extent of dissection associated with the enucleation technique.

Predictors of urge urinary incontinence (UUI)

Univariate associations

Patients who developed UUI were significantly older than those without UUI (70.8 ± 5.2 vs. 65.6 ± 5.75 years, $p < 0.001$). UUI was also associated with higher preoperative median IPSS scores (29 vs. 25, $p = 0.006$), reflecting more severe baseline symptom burden. The strongest univariate association was observed with DO, present in 85.7% of UUI patients compared with only 8% of non-UUI patients ($p < 0.001$).

No preoperative anatomical parameters (prostate volume, median lobe), uroflowmetry indices, or intraoperative variables, including surgical technique, operative time, or resected tissue weight, showed significant associations with UUI (Table 3).

Multivariable analysis

In the multivariable logistic regression model, preoperative IPSS and DO emerged as independent predictors of UUI. Each one-point increase in IPSS was associated with a 38% increase in the odds of postoperative UUI (OR 1.38, 95% CI 1.09–1.75, $p = 0.008$). DO was the strongest predictor, with affected patients demonstrating dramatically higher odds of UUI (OR 142.77, 95% CI 18.4–1105.10, $p < 0.001$). Age did not remain statistically significant after adjustment (Table 4).

Collectively, these findings underscore that UUI after transurethral prostatectomy is determined largely by intrinsic bladder dysfunction, rather than surgical technique or resection characteristics, and is most strongly linked to preoperative DO.

DISCUSSION

This prospective cohort study demonstrates that SUI and UUI after transurethral prostatectomy arise from distinct pathophysiological and procedural mechanisms and therefore have different predictive profiles. By analyzing both preoperative and intraoperative variables, our findings clarify why certain patients develop SUI, others develop UUI, and some develop neither, an area insufficiently addressed in prior BPH surgical literature.

SUI in our cohort was primarily associated with anatomical and surgical parameters, including older age, greater prostate volume, higher BPH degree, lower baseline Qmax, enucleation technique, and increased resected tissue weight. These associations suggest that SUI is largely mediated by mechanical disruption or functional impairment of the continence mechanism. Larger prostates and more advanced degrees of gland enlargement commonly require deeper dissection near the apex and bladder neck, areas essential for sphincteric function (11). This finding is consistent with reports that enucleation techniques may transiently affect urethral support structures. This justification aligns with the American Urological Association Guidelines, which indicate that surgical intervention for BPH, particularly in patients with large prostates, is significantly associated with postoperative SUI, especially in cases of extensive tissue removal (3). Additionally, according to the Canadian Urological Association Guidelines, procedure-specific risks, particularly those affecting continence, are regulated by prostate volume and the extent of dissection, especially in regions adjacent to the detrusor muscle, the urethral sphincter, the levator ani muscle, and their innervation (12). Age-related declines in pelvic floor muscle mass, pudendal nerve integrity, and urethral sphincter resilience likely amplify this vulnerability, as supported by prior studies documenting age-dependent continence impairment after prostate surgery (13–16).

In contrast, UUI was predicted by preoperative functional variables, specifically worse baseline IPSS and DO, along with older age. These results highlight the role of detrusor physiology rather than surgical mechanics in the development of UUI. Because urgency and UUI are driven by neurogenic or myogenic detrusor instability, it is expected that UUI reflects pre-existing lower urinary tract dysfunction rather than operative trauma. This distinction is consistent with previous literature demonstrating that high baseline symptom burden, urodynamic DO, and impaired bladder compliance predict persistence or worsening of storage symptoms after BOO relief procedures (17,18).

The incidence of postoperative UI observed in this cohort is consistent with previously reported outcomes following transurethral prostate surgery, particularly in studies including enucleation-based techniques and longer follow-up. Systematic reviews and meta-analyses have demonstrated wide variability in reported continence outcomes after resection and enucleation procedures, with postoperative UI rates ranging broadly depending on surgical approach, definition of UI, and duration of follow-up. Notably, studies that distinguish stress from urgency-related incontinence and include enucleation techniques have reported SUI rates approaching 20–25% at intermediate to long-term follow-up, while urgency-related symptoms may occur in up to 30% of patients early after surgery and frequently improve over time. The 1-year incidence rates observed in the present study therefore fall within the expected range, while providing the added value of prospective differentiation between UI subtypes (4,6).

An important clinical observation was the differing temporal behavior of SUI and UUI during follow-up. In our cohort, patients who developed SUI at 6 months continued to experience SUI at 12 months, suggesting limited spontaneous recovery once sphincteric compromise has occurred. In contrast, a proportion of patients with UUI at 6 months demonstrated improvement by 12 months, supporting the concept that urgency-related symptoms may partially resolve over time following relief of obstruction. Although this study was not designed to formally assess predictors of symptom resolution, it is plausible that the severity of preoperative DO and baseline symptom burden influence the persistence of UUI.

The divergence between SUI and UUI predictors underscores the importance of subtype-specific counseling. While SUI risk appears modifiable through optimizing surgical technique, careful dissection, or potentially preoperative pelvic floor conditioning, UUI risk is more closely tied to preoperative bladder behavior and may be mitigated through early postoperative pharmacologic therapy or preoperative management of DO.

These findings also have practical implications for postoperative management. Patients at higher risk of SUI, particularly older men undergoing enucleation-based procedures, may benefit from early initiation of pelvic floor physiotherapy, lifestyle modifications, and structured continence rehabilitation. Conversely, patients with significant preoperative LUTS or documented DO should be counseled regarding the possibility of persistent urgency symptoms and may benefit from early postoperative pharmacologic therapy, including antimuscarinic agents or β3-agonists. Incorporating these strategies into postoperative care pathways may improve symptom control and patient satisfaction despite successful relief of BOO.

Our intraoperative findings further support this dichotomy. Enucleation was an independent predictor of SUI, reflecting its more extensive anatomical dissection, whereas none of the intraoperative parameters predicted UUI. Similarly, resected tissue weight, another indicator of surgical magnitude, was associated with SUI but not UUI. These observations align with prior literature on radical prostatectomy (RP) where deeper apical or bladder-neck dissection correlates with SUI, while urgency outcomes correlate with bladder characteristics rather than surgical parameters (19–22).

As for functional predictors affecting the risk of developing UI, the significant association between Qmax and the risk of developing SUI may be attributed to the fact that low Qmax may reflect increased urethral resistance or detrusor underactivity, which can alter bladder emptying (23). This may contribute to chronic bladder overdistension or impaired emptying, which will gradually affect the integrity of urethral support structures or disrupt the neural pathways essential for maintaining continence. This may also be justified by the fact that detrusor contraction power decreases with age and obstruction, contributing to low Qmax and voiding dysfunction (24,25). Individuals with persistently low flow may recruit compensatory straining behaviors during voiding, which increase intra-abdominal pressure and could weaken pelvic floor support over time, facilitating SUI development (26).

Several components of our findings parallel results from studies in RP populations. Prior systematic reviews have shown consistent associations between age, prostate volume, and postoperative UI; however, the contribution of functional variables such as IPSS and urodynamic DO has been less emphasized in TURP-based literature. Our prospective design and explicit separation of SUI and UUI add important nuance and clinical relevance to existing evidence. In the systematic review conducted by Lardas et al. in 2022, which included 119 studies assessing factors associated with UI after RP, the study found that age and prostate volume were statistically significant predictive factors for UI after three months of follow-up ($p < 0.05$). This aligns with our study findings. However, the study also stated that other factors like the membranous urethral length and the Charlson Comorbidity Index, which assesses the 10-year mortality risk based on existing comorbidities, were also statistically significant predictive factors for post-RP UI (27). However, another study conducted by Liu et al. in 2024 assessed post-laparoscopic RP UI and found that prostate volume did not emerge to be a statistically significant predictor for UI, which opposes our findings regarding SUI (28). However, it aligns with our results of UUI. An online prediction model developed by Collette et al. in 2021 found that the severity of LUTS, surgeon experience, and higher patient age were statistically significant predictors for UI (29).

Strengths and limitations

Key strengths include the prospective design, standardized surgical techniques performed by experienced surgeons, and systematic differentiation between SUI and UUI rather than treating postoperative UI as a single heterogeneous outcome. However, some limitations must be acknowledged. The single-center design may limit external generalizability, and although the sample size was adequate for primary analyses, larger cohorts may allow further stratification by prostate size categories, surgeon experience, and baseline pelvic floor function. Follow-up duration, while sufficient to capture persistent UI, may not fully reflect long-term continence recovery, particularly for SUI, which may improve beyond the one-year threshold. The wide confidence intervals observed for some predictors likely reflect the limited number of outcome events and should be interpreted accordingly. Future multicenter work with longer follow-up and integration of pelvic floor imaging or biomarkers may deepen understanding of mechanisms underlying postoperative continence trajectories.

CONCLUSIONS

This prospective cohort study demonstrates that postoperative UI after transurethral prostate surgery is driven by distinct mechanisms. SUI was independently associated with patient age and enucleation-based techniques, with additional univariate associations observed for prostate volume, BPH degree, resected tissue weight, and baseline urinary flow rate, underscoring the anatomical and surgical contribution to sphincteric vulnerability. In contrast, UUI was linked to functional bladder parameters, particularly elevated IPSS scores and preoperative DO, highlighting a pathophysiology centered on detrusor instability rather than surgical disruption.

Differentiating the predictors of SUI and UUI has direct clinical relevance. These findings support more individualized preoperative counseling, careful surgical selection in patients at higher risk of SUI, and early identification of those predisposed to urgency-related symptoms. Incorporating age, prostate characteristics, and urodynamic findings into preoperative risk stratification may enhance patient expectations and improve postoperative management strategies. Future multicenter studies with longer follow-up are warranted to validate these predictors and refine patient-specific continence preservation strategies.

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FIGURES AND TABLES

Table 1. Preoperative and intraoperative predictors of stress urinary incontinence at 1 year (univariate analysis)

Variables	**SUI (n=27)**	**No SUI (n=106)**	**p**
Preoperative predictors			
Age (years)*	72.9 (3.09)	64.8 (5.35)	**<0.001**[1]
Diabetes mellitus**	3 (11.1%)	17 (16%)	0.523[2]
Hypertension**	7 (25.9%)	23 (21.7%)	0.639[2]
Preoperative IPSS***	27 (11)	26 (8.75)	0.608[3]
BPH degree**			
Second-degree	7 (25.9%)	56 (52.8%)	**0.012**[2]
Third-degree	20 (74.1%)	50 (47.2%)	
Preoperative prostate volume (mL)***	95 (31)	75 (27.8)	**0.011**[3]
Median lobe enlargement**	15 (55.6%)	45 (42.5%)	0.222[2]
Preoperative PVR (mL)***	150 (104)	81 (90)	0.294[3]
Preoperative Qmax (mL/s)***	3.50 (6.05)	6.55 (5.03)	**0.006**[3]
Preoperative DO**	3 (11.1%)	24 (22.6%)	0.184[2]
Intraoperative predictors			
Technique**			
B-TURP	8 (29.6%)	63 (59.4%)	**0.006**[2]
BipolEP	19 (70.4%)	43 (40.6%)	
Operative time (min)***	65 (21)	70 (20)	0.460[3]
Weight of resected prostatic tissue (g)***	78 (21)	53.5 (38.8)	**0.012**[3]

*Mean (standard deviation). **Number (percentage). *** Median (interquartile range)
[1]Independent samples T-test. [2]Chi-squared test. [3] Mann-Whitney U test. BipolEP: bipolar enucleation of the prostate; BPH: benign prostatic hyperplasia; B-TURP: bipolar transurethral resection of the prostate; DO: detrusor overactivity; IPSS: International Prostate Symptom Score; PVR: postvoid residual urine volume. SUI: stress urinary incontinence; Qmax: maximum urinary flow rate.

Table 2. Multivariable logistic regression identifying independent predictors of 1-year stress urinary incontinence			
Predictor	**Odds ratio**	**95% CI**	**p**
Age (years)	1.85	1.42 – 2.42	**<0.001**
BPH degree (third-degree vs. second-degree)	49.39	0.53 – 4619.53	0.092
Preoperative prostate volume (mL)	0.99	0.94 – 1.05	0.768
Preoperative Qmax (mL/s)	1.05	0.86 – 1.29	0.631
Technique (BipolEP vs B-TURP)	8.40	1.63 – 43.38	**0.011**
Weight of resected prostatic tissue (g)	0.99	0.90 – 1.09	0.853

BipolEP: bipolar enucleation of the prostate; BPH: benign prostatic hyperplasia; B-TURP: bipolar transurethral resection of the prostate. CI: confidence interval; Qmax: maximum urinary flow rate. Model performance: McFadden R^2=0.581, AIC=70.2

- Binary logistic regression with logit link function.
- Reference categories: second-degree BPH, B-TURP.
- Odds ratios >1 indicate increased odds of 1-year SUI.
- Continuous variables entered as linear predictors.
- Variables included based on univariate p<0.05.

Table 3. Preoperative and intraoperative predictors of urge urinary incontinence at 1 year (univariate analysis)			
	UUI (n=21)	**No UUI (n=112)**	**p**
Preoperative predictors			
Age (years)*	70.8 (5.20)	65.6 (5.75)	**<0.001**[1]
Diabetes mellitus**	4 (19%)	16 (14.3%)	0.575[2]
Hypertension**	4 (19%)	26 (23.2%)	0.675[2]
Preoperative IPSS***	29 (4)	25 (10.3)	**0.006**[3]
BPH degree**			0.616[2]
Second-degree	11 (52.4%)	52 (46.4%)	
Third-degree	10 (47.6%)	60 (53.6%)	
Prostate volume (mL)***	75 (30)	87 (32)	0.380[3]
Median lobe (yes or no)**	9 (42.9%)	51 (45.5%)	0.821[2]
Preoperative PVR (mL)***	125 (80)	85 (90)	0.259[3]
Preoperative Qmax (mL/s)***	5 (1.50)	6.1 (5.72)	0.928[3]
Preoperative DO**	18 (85.7%)	9 (8%)	**<0.001**[2]
Intraoperative predictors			
Technique**			0.707[2]
B-TURP	12 (57.1%)	59 (52.7%)	
BipolEP	9 (42.9%)	53 (47.3%)	

Operative time (min)*	71.6 (12.6)	69.3 (13.9)	0.479[1]
Weight of resected prostatic tissue (g)***	48 (42)	68 (39.3)	0.961[3]

[1]Independent samples T-test. [2]Chi-squared test. [3] Mann-Whitney U test. BipolEP: bipolar enucleation of the prostate; BPH: benign prostatic hyperplasia; B-TURP: bipolar transurethral resection of the prostate; DO: detrusor overactivity IPSS: International Prostate Symptom Score; PVR: postvoid residual urine volume; Qmax: maximum urinary flow rate; UUI: urge urinary incontinence. *Mean (standard deviation). **Number (percentage). *** Median (interquartile range)

Table 4. Multivariable logistic regression identifying independent predictors of 1-year urge urinary incontinence

Predictor	**Odds ratio**	**95% CI**	**p**
Age (years)	1.12	0.98–1.27	0.103
Preoperative IPSS	1.38	1.09–1.75	**0.008**
Preoperative DO	142.77	18.44–1105.10	**<0.001**

DO: detrusor overactivity; CI: sonfidence interval; IPSS: International Prostate Symptom Score**;** Model performance: McFadden R^2=0.47, AIC=66.5.

- Binary logistic regression with logit link function.
- Reference category: no detrusor overactivity.
- Odds ratios >1 indicate increased odds of 1-year UUI.
- Variables included based on univariate p<0.05.