International Urogynecology Journal (2023) 34:707–716
https://doi.org/10.1007/s00192-022-05228-z

ORIGINAL ARTICLE

Toileting behaviors, urinary cues, overactive bladder, and urinary incontinence in older women

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Received: 14 January 2022 / Accepted: 28 April 2022 / Published online: 19 May 2022

Abstract

Introduction and hypothesis Overactive bladder (OAB) and urinary incontinence (UI) are prevalent in older women. We investigated relations of toileting behaviors and urinary urge cues to OAB and UI in women ≥ 65 years. We tested mediation hypotheses that toileting behaviors lead to higher sensitivity to urinary urge cues (the mediator), which leads to both OAB and UI.

Methods An e-panel was recruited to respond to an electronic survey that included demographic information, Urinary Cues Scale version 2, Toileting Behaviors-Women's Elimination Behaviors (TB-WEB) scale, and the International Consultation on Incontinence Questionnaire Short Forms for Urinary Incontinence (ICIQ-SF-UI) and Overactive Bladder (ICIQ-SF-OAB). Descriptive statistics were conducted; correlation matrices were created to explore relationships among major variables. Regression analyses were conducted to test our mediation hypotheses.

Results There were 338 respondents with average age 70.9 (SD ± 5.55) years. Most were white, overweight or obese, and had UI. Urinary urge cues fully mediated the relationship of TB-WEB with OAB. Urinary urge cues partially mediated the relationship of TB-WEB with UI; the direct effect of toileting behaviors on UI remained significant. Age and body mass index had significant partial correlations with UI but not with OAB.

Discussion Toileting behaviors appear to contribute to sensitivity to urinary cues, which are related to both OAB and UI. Toileting behaviors have indirect effects on OAB and both indirect and direct effects on UI. Interventions to change toileting behaviors and extinguish urinary cues are needed.

Conclusions Behavioral and conditioning factors contribute to UI in older women.

Keywords Aged · Cues · Female · Surveys · Overactive bladder · Urinary incontinence

Introduction

Urination, an essential bodily function, normally occurs for adult women while experiencing a sensation of a full bladder, during a mounting urge to urinate, and after engaging in behaviors to seek, reach, and use a location for bladder emptying. However, overactive bladder (OAB) and urinary incontinence (UI) disrupt this normal process in as many as 80% of women > 60 years of age [1]. A number of factors have been identified as possible causes of OAB and UI, but little attention has been given to behavioral and conditioning factors. Women use certain behaviors prior to and during bladder emptying. These toileting behaviors include actions related to place of preference to urinate, assuming different positions or postures to urinate, delayed urination, premature urination (before having either a sensation of bladder fullness or urge to urinate), and straining to urinate, [2].

Some toileting behaviors appear to be dependent on the environments where women urinate (i.e., home or away from home) and environmental challenges (e.g., privacy and cleanliness) [3]. Employed women report having to wait until predesignated times to use the restroom and that toilets may be located far from their specific work site [4]. Moreover, women's toileting

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behaviors have been shown to be related to lower urinary tract symptoms of OAB and UI [5–7].

Environmental stimuli are also related to the experience of urges to urinate. A series of studies [8–10] has shown that people report that they associate a variety of stimuli, such as arriving at their front door, being near a familiar bathroom, and the sound of running water, with the urge to urinate. These associations are consistent with Pavlovian or classical conditioning. Pavlovian conditioning occurs when a stimulus (e.g., one's front door), formerly unrelated to a particular response, becomes paired with an unconditioned stimulus (e.g., a full bladder) that leads naturally to that response (e.g., bladder contraction and urination). After enough pairings, the once unrelated stimulus becomes a conditioned stimulus resulting in a response even in the absence of the unconditioned stimulus. Urinary urges, then, occur in the presence of the urinary cues like one's front door, even in the absence of bladder fullness. We have estimated that the average adult voids well over 2000 times per year, and many of these voids occur in remarkably similar environments [8]. Thus, there is ample opportunity for Pavlovian conditioning to occur. This research has also shown that some individuals appear to respond more frequently and to a larger number of cues than other individuals, indicating a range of sensitivity to cues in the population.

Moreover, there is evidence that the associations between stimuli and urinary urges are represented in the brain. Exposure to urinary cues or triggers has been shown in functional magnetic resonance imaging (fMRI) studies to result in increased activity in the prefrontal cortex and limbic system [11]. Similarly, Clarkson et al. showed that images of personalized urinary urge cues generated significantly different brain activity (via fMRI) in bladder-related brain circuits than images of cues not related to urinary urges [12]. Thus, urinary cues play a role in brain-bladder connections. In addition, sensitivity to urinary cues has been shown to be related to OAB [8, 9].

Lower urinary tract symptoms are known to increase with age, especially in women. However, little research has been published about toileting behaviors older women use. In addition, the relation between toileting behaviors and sensitivity to urinary cues has not been investigated previously. Unhealthy toileting habits like voiding prematurely, delaying voiding, or waiting to void until reaching a preferred toilet could predispose women, especially older women, to experience conditioned stimuli that will lead to urinary urges, urinary urgency, and possibly UI. Because behavioral interventions are considered the first-line treatment for UI in older women [13], research investigating the relationships of toileting behaviors and urinary urge cues to OAB and UI could assist in the development of targeted interventions to prevent and treat OAB and UI.

The purpose of this study is to investigate whether sensitivity to urinary urge cues mediates (explains) the relationship between toileting behaviors and LUTS in women 65 years and older. Guided by a theory, mediation analysis is a method, based on regression analysis, of demonstrating how a third variable (the mediator) influences the relationship between two other variables [14]. We use Pavlovian conditioning theory to hypothesize that toileting behaviors, such as place preference for voiding, delayed voiding, and premature voiding, lead to urinating in familiar environments that become conditioned cues for bladder emptying. The development of conditioned cues for bladder emptying lead to urinary urges, urinary urgency, and UI in the presence of such stimuli. We hypothesized that higher sensitivity to urinary urge cues is the underlying mechanism for (mediates) the relationships of toileting behaviors to OAB and to UI.

Materials and methods

Study design

A sample of women aged ≥ 65 years old from panels of participants contracted by a market research firm was recruited for a survey study. A 20-min electronic survey was administered during Spring, 2021. Researchers did not have access to subjects' names or identifying information. Subjects were paid approximately $1.35 to $2.00 according to prior contractual arrangements they had made with the companies that maintain the panels. The study was considered exempt by the universities' institutional review boards.

Setting

Qualtrics Research Services, the market research firm used in this study, aggregates many online panel resources, and most use what are called "dynamic surveys" that are distributed in a dashboard style where potential participants see a dashboard of surveys that they are likely qualified to complete. The dashboard displays generically titled surveys and an estimation of the average time to complete the survey. Participants do not see the topic or survey name, so that they enter the survey with minimal topic bias. Thus, potential participants in this study did not get a specific survey invitation. The beginning of the survey contained the informed consent. The women could elect to leave the survey when they saw the informed consent document or at any time during the survey.

Participants

The survey participants were English-speaking women, ≥ 65 years, residing in the US. Efforts were made to recruit a

sample that had a racial balance similar to that of the population of women > 65 years in the US. Therefore, multiple women were excluded from participating in the survey because some stratification categories filled quickly while other categories filled at a slower rate.

Quantification of variables

Items assessing select demographic variables and existing previously developed questionnaires were compiled into the survey form.

Demographic variables

Age was measured as the self-reported age. Race was measured as self-report of the following races: American Indian or Alaskan Native, Asian, Black, White, and Native Hawaiian or other Pacific Islander. Women's ethnicity was classified into Hispanic or non-Hispanic. Respondents could elect to provide no information on race, indicate another race not listed in the item, or report more than one race. Women's educational level was also measured as follows: grade school, high school diploma, trade certification, some college, Associate's degree, Bachelor's degree, Master's degree, and Doctoral degree.

Self-rated health was measured by one item with five options (i.e., poor, fair, good, very good, and excellent), which were scored 1 to 5, to describe the status of participants' overall health. Body mass index (BMI) was calculated from participants' reported height and weight using the formula: bodyweight in kilograms divided by height in meters squared. The following categories were used in the descriptive statistics: underweight ≤ 18.5, normal weight = 18.5–24.9, overweight = 25–29.9, and obese = ≥ 30. Actual BMI values were used in the inferential statistics. Questions about the effect of the pandemic on urinary frequency and leakage were asked at the end of the questionnaire.

Urinary urge cues

The 42-item Urinary Cues Questionnaire, version 2, contained 37 items from a previous version of the questionnaire [8] and 5 new items. Participants rated each of the cues according to how frequently they had the urge to urinate in the presence of the cue. Five response alternatives ranged from *never* to *always* and were scored 1 to 5. Eight items represented unlikely cues judged to be relatively random occurrences or situations that are unlikely to be associated with urination, such as *When you run into a friend in a public place*. This set of items was used to assess acquiescence bias. Three items were indicative of stress UI, such as *When you are lifting something heavy*. Both unlikely cues and stress cues were excluded from a principal-axis factor analysis conducted on the remaining 31 cues. A single factor of 28 items best represented the data. Three items did not load above 0.40 on this factor and were removed. Cronbach's alpha for the remaining 28 items was 0.948. Using a paired samples *t* test, average item scores for the 28 items [M = 2.25 (0.643)] were compared to average item scores for the eight unlikely cues [M = 1.57 (0.536)]. The results showed highly significant differences between the item means ($t(337) = 38.34$, $p < 0.001$), indicating that unlikely cues were associated with urinary urges less often than the cues in the 28-item set and that acquiescence responding was not an important factor. The 28 items were summed to produce the Urinary Cues Total Score.

Toileting behaviors

The Toileting Behaviors-Women's Elimination Behaviors (TB-WEB) scale was developed to explore variations in women's toileting behaviors [15]. These behaviors were conceptualized as a chain of behaviors that include seeking and accessing the toilet, adopting a toileting posture or position, and emptying urine into the toilet. The TB-WEB has five subscales that are scored on a Likert-type scale: premature voiding (5 items), straining voiding (4 items), place preference for voiding (4 items), delayed voiding (3 items), and position preference for voiding (2 or more items depending on culture-specific factors). Women select one of five points, i.e., 1 = never to 5 = always. One item in the place preference for voiding subscale was inadvertently omitted from our questionnaire. The sums of four subscales, i.e., place preference for voiding, premature voiding, straining voiding, and delayed voiding, were tallied for an overall total score. Cronbach's alpha for the total score (15 items) was 0.84. High scores indicated behaviors in the subscale were used at a high frequency. Responses for each preferred posture or position for voiding were not included in the total score.

Outcome measures: overactive bladder and urinary incontinence scores

Our study's overactive bladder questionnaire, International Consultation on Incontinence Questionnaire Overactive Bladder Short Form (ICIQ-OAB-SF), contains a total of eight items. Four items (daily frequency of urination, nocturia, the frequency of rushing to the toilet to urinate, and leak frequency) were scored and summed for the OAB Total Score. The four remaining items concern the amount of bother of each symptom. The bother items do not contribute to the OAB Total Score [16]. Cronbach's alpha for this questionnaire was 0.71.

Our study's incontinence questionnaire, ICI Questionnaire Urinary Incontinence-Short Form (ICIQ-UI-SF), is a validated and widely used four-item questionnaire used in

clinical research and practice. This instrument provides a subjective perception about the frequency of leaking urine from *Never* to *All the time*, scored 0 to 5; the amount of urine loss from *None* to a *Large amount*, scored 0 to 6; the extent to which leaking interferes with everyday life, scored from 0 to 10; and a checklist of situations in which leakage occurred. Scores on the first three items were summed to produce a Total Urinary Incontinence Score [17]. Our Cronbach's alpha for this questionnaire was 0.72

Data analysis

De-identified data were imported into SPSS version 28. The data were reviewed for incomplete survey forms, missing data, and identification of outliers. Analyses for descriptive statistics were conducted, and correlation matrices were generated to explore relationships among the variables. A series of regression analyses was performed to determine whether urinary urge cues mediated the relationships of toileting behaviors to OAB and UI.

Results

As the CONSORT diagram in Fig. 1 indicates, 2043 respondents accessed the survey, and 91% of these consented to participate. Of those who consented, 1.9% were excluded because they did not meet the age or sex criteria or because they finished the questionnaire too quickly for their data to be trusted. In addition, 79.9% were screened out when the quota for the race or ethnicity they recorded had already been met by prior participants. This resulted in a final sample of 338 eligible participants, (18.2% of those who had consented).

The upper part of Table 1 lists frequencies for the demographic and urologic variables. Black women were over-represented and White women were under-represented in the sample when compared to national statistics (22.5% versus 10.2% and 66.9% versus 83.2%, respectively [18]. Approximately 11.5% of the participants reported being Hispanic as compared to 8.2% of the US population of older women [18]. About half of the sample had a college degree (Associate's degree or higher). Most women rated their health as good to excellent ($n = 262$, 77.5%) and three (0.9%) reported needing assistance from another person to use the toilet. The majority were either overweight (26%) or obese (38.8%). Most women (66%) responded to the questionnaire by using a desktop computer and the rest used their phones.

Fifty-eight percent of the women in the study reported that they urinated < 7 times per day; 62% reported getting up less than twice per night to urinate. We used the first two items of the ICIQ-UI-SF to identify women who had UI. In our final sample of 338 women, 79 (23.4%) participants who reported both *Never* to the first item (frequency) and *None* to the second item (amount) were considered continent of urine, while 259 (76.6%) participants reported having some UI. About a third of the sample, 118 (35%), reported that they leaked a small amount about once a week or less, and 141 (42%) reported more frequent and/or larger leaks. A substantial majority of the sample reported indications of urinary urgency; 285 (84%) reported that they had to rush to the toilet occasionally or more often. Because the survey was administered during the COVID-19 pandemic, women were likely not engaging in their normal routines. When asked about the effects of the COVID-19 pandemic, 70% of the women said they had been staying home more than usual during

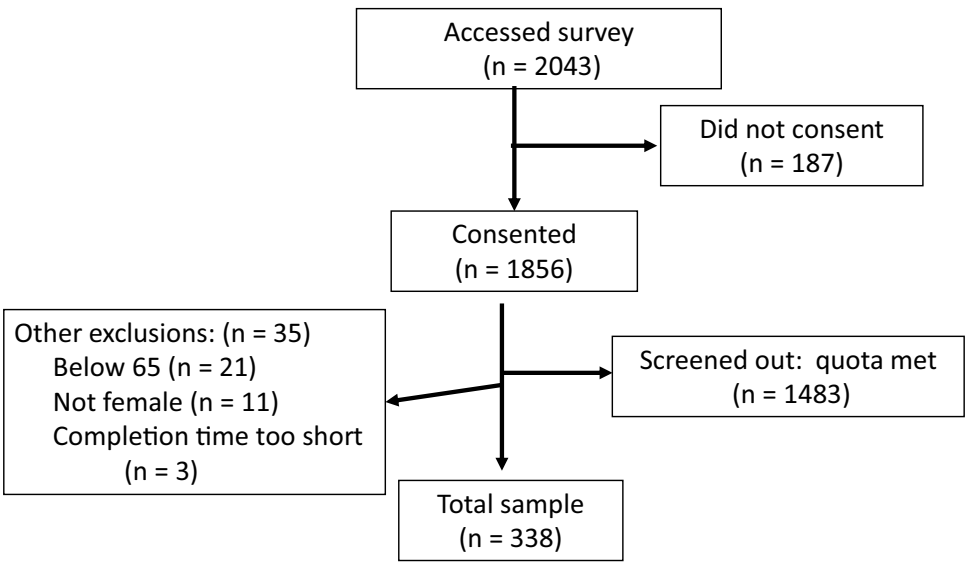

Fig. 1. CONSORT flow diagram showing participant recruitment, exclusion, and participation

Table 1. Frequency and percent for demographic characteristics and descriptive statistics for control variables, urinary cues, TB-WEB, urinary incontinence, and OAB scores, $N = 338$ women

	Frequency	Percent
Race		
American Indian or Alaskan Native	6	1.8
Asian	9	2.7
Black	76	22.5
White	226	66.9
Native Hawaiian/Pacific Islander	1	0.3
Other	1	0.3
No answer	8	2.4
More than one race	11	3.3
Ethnicity		
Hispanic	39	11.5
Not Hispanic	299	88.5
Education		
Grade school	4	1.2
High school diploma	70	20.7
Trade certification	14	4.1
Some college	80	23.7
Associate's degree	36	10.7
Bachelor's degree	71	21.0
Master's degree	58	17.2
Doctoral degree	5	1.5
Self-rated health		
Poor	4	1.2
Fair	72	21.3
Good	144	42.6
Very good	95	28.1
Excellent	23	6.8
Body mass index (missing data on one participant)		
Underweight	10	3.0
Normal weight	108	32.0
Overweight	88	26.0
Obese	131	38.8
Urinary urgency		
Never	53	15.7
Occasionally	148	43.8
Sometimes	103	30.5
Most of the time	23	6.8
All of the time	11	3.3
Urinary incontinence[a]		
No	79	23.4
Yes	259	76.6
Frequency of leakage		
Never	85	25.1
About once a week or less often	120	35.5
2 or 3 times a week	49	14.5
About once a day	39	11.5
Several times a day	40	11.8
All the time	5	1.5

Table 1. (continued)

			Frequency		Percent	
When urine leaks—check all that apply						
Never			71		21.0	
Leaks before you can get to the bathroom			198		58.6	
Leaks when you cough or sneeze			165		48.8	
Leaks when you are asleep			22		6.5	
Leaks when you are physically active/exercising			62		18.3	
Leaks when you are finished urinating and are dressed			25		7.4	
Leaks for no obvious reason			47		13.9	
Leaks all the time			3		0.9	
	Mean	SD	Min	Max	Skewness	Kurtosis
Age	70.91	5.55	65	97	1.55	3.01
Self-rated health	3.18	0.88	1	5	0.13	-0.44
BMI[b]	28.86	6.73	14	58	0.78	1.17
Urinary cues[c]	63.00	18.02	31	121	0.63	-0.02
TB-WEB[d]	22.51	8.81	2	52	0.53	0.32
UI Total[e]	5.75	5.01	0	21	0.71	-0.39
OAB Total[f]	4.57	2.81	0	1 5	0.66	0.34

[a]Participants were considered incontinent unless they answered both *Never* to "How often do you leak urine?" and *None* to "How much do you usually leak?"

[b]BMI = body mass index; missing data on one subject, N = 337

[c]Cues = total of 28 items of the Urinary Cues Scale, version 2

[d]TB-WEB = Toileting Behaviors-Women's Elimination Behaviors scale. One item on the Place domain was not included, and because women could report more than one position preference per location, position preferences were not included in the TB-WEB scores.

[e]UI Total = urinary incontinence total score on the International Consultation on Incontinence Questionnaire-Urinary Incontinence Short Form (ICIQ-UI-SF)

[f]OAB Total = Overactive Bladder total score on the International Consultation on Incontinence Questionnaire-Overactive Bladder Short Form (ICIQ-OAB-SF)

the pandemic, but 87% reported no change in frequency of urinating, and 90% reported no change in urinary leakage.

The lower part of Table 1 displays descriptive statistics for the control variables, i.e., age, BMI, and self-rated health, the independent variable (toileting behavior), the mediator (urinary urge cues), and the outcome variables (OAB and UI). All variables except age had approximately normal distributions. Age had a significant positive correlation with UI. BMI had significant positive relationships with OAB and UI and a significant negative correlation with self-rated health. Self-rated health had significant negative correlations with OAB, UI, and BMI.

Mediation analyses

To test the hypotheses that higher sensitivity to urinary urge cues mediates the relationships between toileting behavior on the one hand and OAB and UI scores on the other, we followed the process outlined by MacKinnon [14]. We carried out a series of linear regression analyses with the scores of 337 (1 participant was missing BMI data) participants. The top portion of Fig. 2 shows the standardized beta coefficients when OAB was the outcome variable. The path labeled *C* in Fig. 2 shows that the relation between toileting behavior and OAB, controlling only for age, self-rated health, and BMI, was: *beta* = 0.355, 95% CI [0.254, 0.451], $p < 0.001$. The path labeled *C*' shows that after adding the mediator, urinary urge cues, to the model, this coefficient was no longer statistically different from zero, *beta* = 0.071, 95% CI [-0.029, 0.169], $p = 0.166$, indicating that cues completely mediate the relationship between toileting behavior and OAB. Likewise, the Sobel test [14, 19] for mediation showed the indirect effect of toileting behaviors on OAB through urinary cues was significant: 8.29, SE, 0.012, $p < 0.001$. The left side of Table 2 shows the results of the multiple regression analysis with independent, mediator,

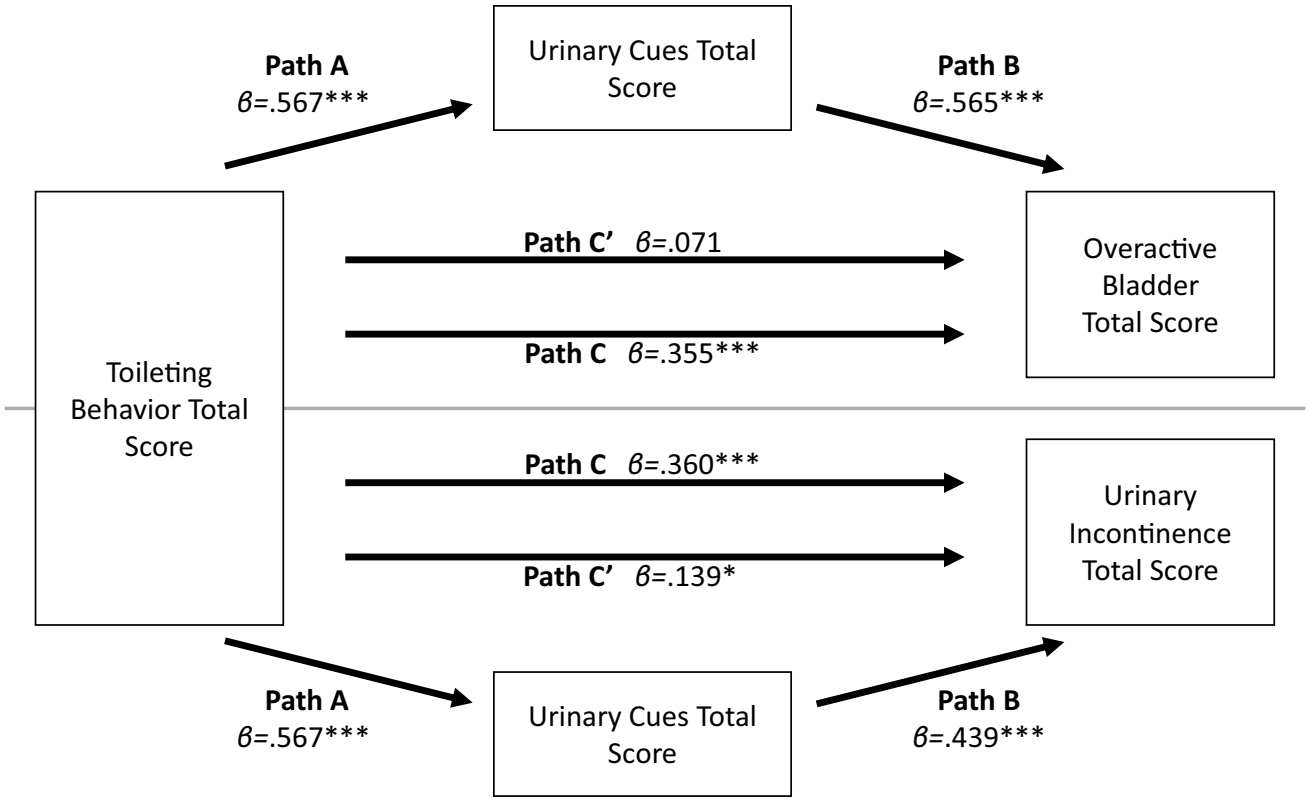

Fig. 2. Models of mediation analyses for OAB and UI. Two path diagrams model the relationships of Toileting Behavior scores to Overactive Bladder scores in the upper half and to Urinary Incontinence scores in the lower half. The **C** and **C' Paths** show the standardized regression coefficient for Toileting Behavior with Overactive Bladder as the outcome variable (upper portion of figure) and with Urinary Incontinence as the outcome variable (lower portion of figure). The regression models in the two **C Paths** include the covariates Age, Self-Rated Health, and BMI; they show Toileting Behavior as a significant ($p < 0.001$) predictor of both outcomes. The regression models in the two **C' Paths** also include the Urinary Cues score along with the covariates. In the model for Overactive Bladder, Toileting Behavior is a nonsignificant predictor after controlling for Urinary Cues. For Urinary Incontinence, Toileting Behavior becomes a less significant ($p < 0.05$) predictor after controlling for Urinary Cues. These reductions in significance are a sign of complete mediation in the case of Overactive Bladder and partial mediation in the case of Urinary Incontinence. Mediation also requires the significant relationships shown on the respective **A and B Paths**. The model in the **A Paths** predicts Urinary Cues using only Toileting Behavior: The resulting coefficient is significant ($p < 0.001$). The **B Paths**, like the **C' Paths**, include all predictors and in both cases show a significant ($p < 0.001$) coefficient for the Urinary Cues predictor. The mediation shown in these path diagrams suggests that Urinary Cues are an underlying mechanism through which Toileting Behaviors influence Overactive Bladder and Urinary Incontinence scores

Table 2. Results of multiple regression analyses with OAB and UI as outcome variables, $N = 337$

Outcome variable	OAB[a]					UI[b]				
	B	Std. error	Beta	t	Sig.	B	Std. error	Beta	t	Sig.
(Constant)	-2.999	1.706		-1.758	0.080	-12.88	3.22		-0.148	0.882
TBWEB	0.022	0.016	0.071	1.387	0.166	0.078	0.030	0.139	2.576	0.010*
Urinary cues	0.088	0.008	0.565	10.758	< 0.001*	0.121	0.015	0.439	7.862	< 0.001*
Age	0.025	0.021	0.049	1.179	0.239	0.111	0.040	0.124	2.804	0.005*
SR Health[c]	-0.242	0.144	-0.077	-1.681	0.094	-0.279	0.272	-0.050	-1.025	0306
BMI	0.019	0.018	0.045	1.045	0.297	0.077	0.034	0.104	2.274	.024*

[a]OAB: $R^2 = 0.427$, $F(5, 331) = 49.27$, $p < 0.001$

[b]UI: $R^2 = 0.354$, $F(5, 331) = 36.25$, $p < 0.001$

[c]SR Health = self-rated health

*$p < 0.05$

and control variables. The omnibus test was significant $R^2 = 0.427$, $F(5, 331) = 49.27$, $p < 0.001$. This analysis also showed that age, BMI, and self-rated health were not related to OAB after controlling for toileting behaviors and urinary cues.

The lower half of Fig. 2 shows results of a similar set of analyses with UI as the outcome variable. The direct effect of toileting behaviors on UI controlling only for age, self-rated health, and BMI, shown in path *C*, was *beta* = 0.360, 95% CI [0.259, 0.454], $p < 0.001$. When the mediator, urinary cues, was added to the model, the *beta* of toileting behaviors dropped to 0.139, 95% CI [0.033, 0.243], $p = 0.010$, but remained significantly greater than zero. This demonstrates that urinary cues partially mediate the relationship between toileting behaviors and UI. The Sobel test [19, 20] for mediation showed that the indirect effect of toileting behaviors on UI through urinary cues was significant: 6.79, SE, 0.02, $p < 0.001$. Therefore, toileting behaviors have both an indirect effect and a direct effect on UI. The right side of Table 2 shows the results of the multiple regression analysis. The omnibus test was significant: $R^2 = 0.354$, $F(5, 331) = 36.25$, $p < 0.001$. This analysis also shows that age and BMI, but not self-rated health, are significantly related to UI even after controlling for toileting behaviors and urinary cues.

Discussion

Bladder health is increasingly viewed as an important part of women's health [21], especially in light of the increased prevalence of lower urinary tract symptoms across the life course. During mid-adulthood (ages 40–59 years old), stress UI predominates, while urgency UI and/or mixed UI (the combination of stress UI and urgency UI) predominates in women ≥ 60 years old [22]. For women living in the US aged ≥ 60 years, the estimated prevalence of urgency UI (UUI) was 49.5% and of mixed UI was 31.4% [1]. The women who participated in our online survey about urinary cues and toileting behaviors were between 65 and 97 years old. Despite not soliciting women who had UI, the survey showed that 77% of participants reported having UI of any type, including stress UI, urgency UI, and mixed UI, an overall rate similar to the population estimates reported above. It did not appear that the pandemic had a large effect on self-reported behaviors or reactivity to cues.

Our mediation analyses provided support for our hypotheses. Urinary cues fully mediated the relationship between toileting behaviors and OAB. In addition, urinary cues partially mediated the relationship between toileting behaviors and UI. It appears that higher scores on the TB-WEB scale provoked higher sensitivity to urinary cues that, in turn, were associated with more intense lower urinary tract symptoms in older women. These findings are similar to those in previous reports on the relation of urinary cues to OAB but add information about their relation to UI [8–10]. In light of recent findings that visual triggers for urinary urgency specific to an individual lead to increased activity in the prefrontal cortex and limbic systems [11], our findings suggest a mechanism for how urinary cues come to affect brain-bladder connections.

In addition, toileting behaviors had a direct and indirect associations with UI, associations that have been reported by others [6]. For example, authors of previous studies found that toileting behaviors, i.e., delayed voiding and straining to void, mediated the relationship between occupational stress and OAB in both male and female operating room nurses [7]. A scoping review on toileting behaviors reported that of 17 studies in which the TB-WEB was administered, 8 studies showed that a considerable number of women engaged in premature voiding, i.e., voiding in the absence of the sensation of the need to void, and delayed voiding. Older people and those with disabilities, however, were not included in these studies [23]. The finding that toileting behaviors themselves have direct effects on UI and on urinary cue sensitivity indicate that interventions to help modify behaviors earlier in life may be warranted. Studies investigating the effects of delayed voiding, straining to void, and premature voiding over women's life stages are needed to better understand the trajectory of development of these behaviors and relationships.

In our study we included age, self-rated health, and BMI as control variables because of the previous evidence that each was associated with UI [24]. In this study we found that age was a significant predictor of UI, even though our age range was restricted to a 33-year span. The older women in this group had higher UI scores than the younger women. The effect of BMI on UI may be through its effect on stress UI and urgency UI via impaired glucose tolerance [1].

A strength of our study was the diversity of our sample. Black women were overrepresented, which is a strength given the dearth of knowledge about toileting behaviors and urinary cues in this population. Women in the sample lived in the community and were not seeking help for symptoms. Our recruitment strategy was also a strength. Women were recruited by a third party and were not aware of the subject of the survey, minimizing recruitment bias. Another strength is our theoretical approach to the understanding correlates of OAB and UI.

The study had several limitations. The group of women who had signed up to take online surveys may not represent women who are digitally unconnected or unskilled. Unfortunately, one item from the place subscale of the TB-WEB questionnaire was unintentionally omitted from the final version of the questionnaire, and scores had to be adjusted post hoc. Women may have under-reported the frequency of, or

conditions under which, they leaked urine. Also, we did not have information about employment and retirement status.

This study provides new information that toileting behaviors and urinary cue sensitivity are highly related to each other in women aged ≥ 65 years. Although the study is correlational, the interpretations of mediation analyses and our theory imply causal relationships: Toileting behaviors lead to conditioned urges, which in turn lead to OAB and UI. It is possible that the causality might go in the opposite direction. Having OAB and UI might cause unhealthy toileting behaviors. While it makes sense that OAB or UI might lead women to premature voiding (i.e., urinating without the urge to urinate to avoid urgency or leaks), it is doubtful that OAB or UI would lead to place preference (e.g., unwillingness to use public toilets), delayed voiding, or strained voiding, which are components of the TB-WEB total score. Also, OAB or UI might lead to cue sensitivity, perhaps because increased urinary frequency might strengthen Pavlovian conditioning to a variety of cues and thus increase urge cue scores. However, our mediation findings are consistent with conditioning theory and the causal explanations we offer. Further investigation into the temporal order of the onset of unhealthy toileting behaviors, the association of specific cues with urinary urges, and whether these phenomena preceded lower urinary tract symptoms could strengthen the evidence for causal relationships and give direction to interventions. Such interventions could include behavior modification techniques, such as bladder training and timed voiding and methods to extinguish or prevent urinary urge cues, such as discouraging or delaying voiding at usual times or in familiar situations.

Conclusion

Older women, unselected for OAB or UI status, responded to an online survey that inquired about urinary cues and toileting behaviors. Three quarters of the women reported UI. Urinary cues fully mediated the relationship between toileting behaviors and OAB and partially mediated the relationship between toileting behaviors and UI. These findings suggest that behavioral approaches to alter some toileting behaviors and to extinguish conditioned urgency may be needed to ameliorate the effects of highly prevalent UI in older women.

Funding Dr. Palmer's work effort prior to her retirement was funded by the First Quality and Carolina Nursing Bladder Health Initiative. Work by Dr. O'Connell and Ms. Nicholas was funded by a federal work study grant and by internal funds from Teachers College Columbia University.

Declarations

Conflicts of interest None.

Participation in this manuscript O'Connell, K.A.: Conception and design of study, data analysis and interpretation, manuscript writing

Nicholas, T. B.: Questionnaire design and implementation, data analysis, write up of analysis.
Palmer, M. H. Conception and design of study, data analysis and interpretation, manuscript writing

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