

# Urinary Incontinence and Diabetes in Postmenopausal Women

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**OBJECTIVE** — This study evaluates diabetes characteristics and other risk factors for urinary incontinence among community-dwelling postmenopausal women.

**RESEARCH DESIGN AND METHODS** — We performed a cross-sectional analysis of a population-based study of 1,017 postmenopausal women (218 with diabetes), aged 55–75 years, enrolled from a health maintenance organization. Outcomes included any incontinence and severe incontinence in the prior month.

**RESULTS** — Overall, 60% of women had any incontinence in the prior month and 8% had severe incontinence. Parity and postvoid residual bladder volume were not associated with incontinence. Oral estrogen and vaginal estrogen use were positively associated with a report of any incontinence but not severe incontinence. A history of urinary tract infection (UTI) and measures of general health were associated with both outcomes. Women with diabetes reported disproportionately more severe incontinence, difficulty controlling urination, mixed (stress and urge) incontinence, use of pads, inability to completely empty the bladder, being unaware of leakage, and discomfort with urination ( $P \leq 0.06$ ). Diabetes duration, treatment type, peripheral neuropathy, and retinopathy were significantly associated with severe incontinence in multiple regression models adjusted for age, education, and history of UTI ( $P = 0.01–0.06$ ); however, additional adjustment for BMI diminished the strength of association ( $P = 0.17–0.52$ ).

**CONCLUSIONS** — Urinary incontinence is highly prevalent among postmenopausal women. Women with diabetes are more likely to experience severe and symptomatic urinary incontinence. UTI history is a major risk factor, postvoid residual bladder volume plays no demonstrable role, and BMI confounds the relationship between diabetes and incontinence among healthy postmenopausal women.

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Urinary incontinence disproportionately affects women and is very common, with prevalence estimates as high as 69% depending upon the definition of incontinence and sample characteristics (1,2). Urinary inconti-

nence increases with age and is associated with social isolation and stigmatization, decreased quality of life, depression, and the end of independent living for some elderly women (3–5).

The current obesity and type 2 diabe-

tes epidemics have significant implications for urinary incontinence among women, because both are associated with incontinence (2). A higher BMI could theoretically increase abdominal pressure, thereby increasing bladder pressure and urethral mobility, producing the association seen between BMI and incontinence (6,7). BMI is also directly related to the development of type 2 diabetes, thus linking these two conditions. Other postulated mechanisms by which diabetes causes incontinence include microvascular damage to the innervation of the bladder and urethral sphincter, detrusor muscle and sphincter dysfunction and bladder instability, urinary retention and elevated postvoid residual urine volume contributing to overflow incontinence, chronic bacterial colonization and urinary tract infections (UTIs), and hyperglycemia (8,9). Prior studies have investigated these mechanisms generally among small samples of men and women with diabetes, often focusing on insulin-using elderly populations with age-related neurologic or urologic conditions (10–14).

Diabetes, particularly insulin-treated diabetes, is a risk factor for UTI after adjustment for confounding factors (15,16), and multiple studies suggest that diabetes is also an independent risk factor for urinary incontinence (6,17). Among community-dwelling postmenopausal women, information is limited regarding specific attributes of diabetes (such as duration, glycemic control, and diabetes complications) and their relationship to urinary incontinence after adjustment for potential risk factors.

We used baseline data from a population-based prospective study of UTI in a sample of 1,017 community-dwelling postmenopausal women, including 218 women with diabetes, to evaluate the relationships between urinary incontinence and characteristics of diabetes after adjusting for potential confounders.

## RESEARCH DESIGN AND METHODS

This cross-sectional analysis used baseline data from a prospective evaluation of UTI risk among

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**Abbreviations:** GHC, Group Health Cooperative; SF-36, 36-item short-form health survey; UTI, urinary tract infection.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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postmenopausal women, conducted within a group model health maintenance organization with ~450,000 members (Group Health Cooperative [GHC]). Women aged 55–75 years were eligible to participate if they had no natural menstrual cycle in the preceding 12 months, resided in the Pierce, King, or Snohomish counties of Washington State, and had been enrolled in GHC for at least 1 year. Members of GHC are similar in age and ethnicity to women in the surrounding Seattle-Tacoma-Bremerton region, but have slightly higher educational attainment and less representation in the highest extremes of income distribution. Compared with the U.S. population, there are fewer blacks, higher educational levels, and less representation in the lowest extreme of income distribution (18).

Women were randomly selected using GHC enrollment files. The GHC diabetes registry was also used to enrich the population with diabetic women, who were randomly selected and frequency matched according to age with the main study group. Exclusion criteria for all potential participants included residential nursing care, restriction to a wheelchair, dementia or a severe psychiatric disorder (as determined by the recruiter or reported by a participant or household member), indwelling or intermittent urinary catheterization, end-stage renal disease requiring dialysis, active malignancy other than skin cancer, acute cystitis in the preceding 90 days, or chronic antibiotic use. The Human Subjects Committees of GHC and the University of Washington approved all procedures.

### Exposure ascertainment

Data from a detailed interview and research clinic visit at baseline, in conjunction with computerized laboratory, hospital, and pharmacy records (for identification and verification of diabetes), were used to identify and measure potential risk factors.

The baseline interview assessed general medical and surgical health information, estrogen exposure (including oral estrogen with or without progesterone and vaginal estrogen cream), history of UTI, and diabetes status. Women who reported having diabetes were asked to complete a supplemental questionnaire. BMI was obtained from an HMO mammography surveillance database, based upon self-reported height and weight, us-

ing the measurement most temporally proximate to study enrollment. During the baseline research clinic visit, women submitted clean-catch midstream urine specimens that were cultured for aerobic bacteria. Vaginal introital swabs were also obtained and cultured for aerobic gram-negative rods using previously described methods (19). Lastly, postvoid residual bladder volume was measured using a portable ultrasound device (BladderScan BVI 2500+), a method that is highly correlated with catheterized volumes (20).

At baseline, diabetes presence was ascertained by self-report of physician diagnosis or inclusion in the GHC diabetes registry. This registry captures information monthly from laboratory, pharmacy, and hospital discharge summary databases, continuously updating the diabetes status of enrollees as described elsewhere (21). The presence of diabetes in women who were identified for the study from the GHC diabetes registry was confirmed by record review.

Blood was drawn for fasting glucose determination at the research clinic visit to identify previously undiagnosed diabetes. If the result was  $>125$  mg/dl, the woman was considered to have diabetes. All women who met any criterion for diabetes underwent high-performance liquid chromatography testing of HbA<sub>1c</sub> (Variant II Hemoglobin A1c; Bio-Rad, Hercules, CA). Women who reported age of diabetes onset at  $<30$  years, one or more episodes of ketoacidosis, and continuous insulin use since diagnosis were considered to have type 1 diabetes. Retinal disease and neuropathy were assessed by self-report.

### Incontinence measures

Because of the variety in incontinence definitions in the literature, we approximated a validated and internationally recommended measure of incontinence severity, the Sandvik Index (9,22), to define a primary outcome (severe incontinence), as well as a less specific assessment (any incontinence in the past month). The Sandvik Index incorporates both amount and frequency of incontinence. It is based on three levels of incontinence amount (drops, small splashes, more), which may be dichotomized into two levels: 1 = drops (from our survey, few drops/damp underwear) or 2 = more (moderately wet underwear/completely wet underwear/outer clothes wet or leak-

age to the floor). The amount (1 or 2) is multiplied by four levels of frequency (1 = less than once a month, 2 = few times a month, 3 = few times a week, 4 = every day and/or night) to yield a score of 1–2 (slight), 3–4 (moderate), or 6–8 (severe) (22). We allocated our measures of incontinence amount and frequency during the past month to those defined by the Sandvik Index to determine the number of women with severe incontinence.

Stress incontinence was considered to be loss of “control of your urine when you laugh, cough, or during physical activities,” whereas urge incontinence was defined as loss of “control of your urine because you feel the urge to urinate but cannot reach the bathroom in time.” Affirmative responses to both questions were considered mixed incontinence. To assess a woman’s subjective perception of whether her incontinence is a problem, we used an unvalidated measure: “How would you rate your difficulty controlling urination?” Response options were no problem or mild, moderate, or severe problem.

### Statistical methods

First, we characterized the study group using bivariate analyses ( $\chi^2$  tests and Fisher’s exact tests when appropriate) describing the relationship between potential risk factors for incontinence and outcome measures. Next, we further characterized incontinence among women with and without diabetes.

To evaluate the relationship between aspects of diabetes and incontinence, we constructed individual multiple logistic regression models for each diabetes characteristic, adjusting for age and factors that were associated with both diabetes at baseline and severe incontinence. These included education and history of UTI in the past year. A high proportion of missing income data precluded adjustment for this variable, which was associated with both diabetes and incontinence. To demonstrate confounding of diabetes by BMI, models were constructed with and without this covariate. Similarly, models were constructed with and without another confounder, the physical function score from the 36-item short-form health survey (SF-36).

**RESULTS**— A total of 1,017 women were eligible and agreed to participate in the study, including 799 women without diabetes and 218 women with diabetes

(65 randomly recruited from the GHC enrollment file plus 153 randomly selected from the diabetes registry). Because of the 2-year, prospective nature of the original study of UTI risk, participation rates were 34% among women without diabetes and 26% among women with diabetes. A refusal questionnaire was completed by 59% of women refusing to participate. Women declining participation were more likely to be widowed, have less than a college education, report nonwhite ethnicity, be nonusers of hormone replacement therapy, and have no history of prior UTI ( $P < 0.05$  for all). In all, 24% (289 of 1,192) of refusers responding to the refusal questionnaire had diabetes compared with 21% (218 of 1,017) of participants ( $P = 0.05$ ), but incontinence data were not obtained.

Table 1 summarizes participant characteristics. Mean age was 64 years, and a majority of participants were white, not sexually active, and taking oral estrogen. Overall, 21% of the sample had diabetes. Three subjects met the criteria for type 1 diabetes and were included with other women with diabetes for analysis purposes. Among the 218 women with diabetes, 30% had it for  $\geq 10$  years, 48% used oral hypoglycemia medication, 19% used insulin, 49% reported symptoms of peripheral neuropathy, and 17% reported retinopathy (Table 1).

Sixty percent of the total sample reported any incontinence in the past month. Table 2 demonstrates that women with and without diabetes had similar prevalence and duration of incontinence. Prevalence in the total sample was 17% for stress incontinence, 10% for urge incontinence, and 32% for mixed incontinence. Women with diabetes had less stress and urge incontinence, whereas 40% had mixed incontinence. Of the total sample, 8% had severe incontinence and 14% described difficulty controlling urination as a moderate to severe problem. Women with diabetes were significantly more likely to report urinary incontinence symptoms ( $P \leq 0.06$ ) (Table 2).

Seventy-seven percent (65 of 84) of women with severe incontinence also reported moderate to severe difficulty controlling urination, compared with 21% (77 of 369) of women with moderate and 2% (5 of 216) with slight incontinence ( $P < 0.0001$ ). Among women reporting stress incontinence, 5% (9 of 174) had severe incontinence and 9% (16 of 174)

had moderate to severe difficulty controlling urination. For urge incontinence, the corresponding numbers were 12% (13 of 106) and 21% (22 of 106). For mixed incontinence, the results were 19% (62 of 324) and 33% (108 of 324), respectively ( $P < 0.0001$  for all).

Table 1 summarizes the relationships between exposures and incontinence outcomes. None of the diabetes characteristics were associated with any incontinence in the past month. Diabetes at baseline, diabetes treatment type, duration, glucose control, peripheral neuropathy, and retinopathy were associated with severe incontinence (Table 1). Both incontinence outcomes were associated with physical function from the SF-36, a history of bladder or urinary surgery (among 102 women who had surgery, 46 reported doing so for urinary incontinence), and history of UTI in the past year (Table 1).

In Table 3, multiple regression models for each diabetes characteristic demonstrated positive associations between the characteristic and severe incontinence, except for glucose control. Odds ratios (ORs) increased from 1.0 for no diabetes to 1.7 for diet-treated diabetes, 2.1 for pill-treated diabetes, and 2.3 for insulin-treated diabetes. Similarly, ORs increased from 1.0 to 1.8 for women with diabetes without peripheral neuropathy, to 2.3 with peripheral neuropathy, and from 1.5 for women with diabetes without retinopathy to 2.8 for those with retinopathy. Once these models were adjusted for BMI, the odds of severe incontinence for each diabetes characteristic decreased, and none remained statistically significant, although the increasing trends in odds ratios persisted (Table 3). Additional adjustment for physical function from the SF-36 diminished the odds of association and was not statistically significant (data not shown).

**CONCLUSIONS** — In this sample of postmenopausal women, with supplemental sampling of women with diabetes, 60% reported recent leakage of urine. The large Norwegian Epidemiology of Incontinence in the County of Nord-Trøndelag study, which used the Sandvik severity index, found a lower prevalence of any incontinence among similarly aged women (26–30%) but a similar prevalence of severe incontinence (7–12% compared with 8% in our study) (23).

Prevalence measures of “any incontinence” vary widely throughout the literature. Multiple studies of community-dwelling peri- and postmenopausal women in the U.S. have high incontinence prevalences (7,17,24,25). Populations with higher prevalence of incontinence may have more risk factors for incontinence (e.g., higher BMI) and women in the U.S. may be influenced by direct-to-consumer advertising for incontinence pharmaceuticals, resulting in greater incontinence awareness and reporting. Additionally, participants in this prospective evaluation of UTI risk in a population enriched with women with diabetes might be more inclined to report incontinence, contributing to our high prevalence.

Although the prevalence of “any incontinence” is typically quite variable between studies, measures of severe incontinence are more consistent and range from 3 to 17% (26). We found that risk factors for women with any incontinence differ considerably from those for women with severe incontinence. Because women with severe incontinence are more likely to seek medical attention (27), risk factors for severely incontinent women are the most clinically relevant.

The prevalence of any urinary incontinence was very high and not different between women with and without diabetes. However, women with diabetes were disproportionately represented among those with more severe voiding symptoms. None of the diabetes characteristics (duration, treatment type, glucose control, or complications) were associated with “any incontinence in the past month,” but all were positively associated with severe incontinence in unadjusted models. Additionally, these characteristics (except glucose control) were independently associated with severe incontinence in multivariable models not adjusted for BMI. Although studies have found that diabetes is associated with measures of “any incontinence” (24), we did not. This measure, for our cohort, may not have identified clinically significant incontinence. Prior work suggests that the onset of diabetic cystopathy is insidious and that incontinence symptoms do not appear until late in the course of the disease (10,28). This may explain why these differences are demonstrable among more extreme measures or with assessment tools that require severe enough

Table 1—Sample characteristics and factors associated with urinary incontinence severity in the past month

	Total sample (n)	Any incontinence		Severe incontinence	
		n (%)*	P†	n (%)*	P†
Total	1,017	610 (60)		84 (8)	
Age (years)					
55–59	322	199 (62)	0.44	28 (9)	0.32
60–64	213	125 (59)		13 (6)	
65–69	215	120 (56)		15 (7)	
70–76	267	166 (62)		28 (10)	
Ethnicity					
White	888	552 (62)	0.0003	75 (8)	0.61
Other	126	57 (45)		9 (7)	
Income					
<\$35,000	342	206 (60)	0.86	41 (12)	0.003
\$35,000–<75,000	356	213 (60)		19 (5)	
≥\$75,000	144	83 (58)		8 (6)	
Highest education					
≤High school	203	118 (58)	0.14	28 (14)	0.004
College graduate	455	261 (57)		31 (7)	
Graduate/professional degree	353	226 (64)		23 (7)	
BMI					
<25 kg/m <sup>2</sup>	366	208 (57)	0.23	14 (4)	<0.0001
25–29 kg/m <sup>2</sup>	316	196 (62)		26 (8)	
>29 kg/m <sup>2</sup>	290	182 (63)		41 (14)	
Physical functioning score from SF-36‡					
0–50	143	92 (64)	0.0003	23 (16)	<0.0001
51–75	248	172 (69)		30 (12)	
76–100	626	346 (55)		31 (5)	
Diabetes at baseline					
No	799	483 (60)	0.56	52 (7)	0.0001
Yes	218	127 (58)		32 (15)	
Diabetes treatment					
No diabetes	799	483 (60)	0.34	52 (7)	0.001
Diet	70	35 (50)		10 (14)	
Pill	105	66 (63)		14 (13)	
Insulin	41	24 (59)		8 (20)	
Diabetes duration					
No diabetes	799	483 (60)	0.70	52 (7)	0.0004
<10 years	151	89 (59)		23 (15)	
≥10 years	65	36 (55)		9 (14)	
HbA <sub>1c</sub>					
No diabetes	799	483 (60)	0.07	52 (7)	0.01
≤7.5%	139	73 (53)		19 (14)	
7.6–8.5%	43	32 (74)		6 (14)	
>8.5%	30	18 (60)		4 (13)	
Diabetic peripheral neuropathy§					
No diabetes	799	483 (60)	0.13	52 (7)	0.0002
No	100	51 (51)		14 (14)	
Yes	108	69 (64)		18 (17)	
Diabetic retinopathy§					
No diabetes	799	483 (60)	0.66	52 (7)	0.001
No	166	94 (57)		19 (11)	
Yes	37	22 (59)		8 (22)	
Parity§					
0	143	76 (53)	0.20	8 (6)	0.31
1–3	636	388 (61)		52 (8)	
4+	238	146 (61)		24 (10)	

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Table 1—Continued

	Total sample (n)	Any incontinence		Severe incontinence	
		n (%)*	P†	n (%)*	P‡
History of hysterectomy§					
No	700	405 (58)	0.04	54 (8)	0.35
Yes	317	205 (65)		30 (9)	
Problems with constipation§					
No	661	391 (59)	0.52	41 (6)	0.002
Yes	351	215 (61)		42 (12)	
History of bladder or urinary surgery§					
No	915	536 (59)	0.01	66 (7)	0.0002
Yes	102	74 (73)		18 (18)	
Diuretic use (among those incontinent during past year)§					
No	523	476 (91)	0.69	62 (12)	0.34
Yes	149	134 (90)		22 (15)	
Medication to help control urination (among those incontinent during past year)§					
No	637	578 (91)	0.50	74 (12)	0.003
Yes	26	25 (96)		9 (35)	
Oral estrogen pills (past month)§					
No	444	245 (55)	0.01	35 (8)	0.84
Yes	559	357 (64)		46 (8)	
Estrogen cream (past month)§					
No	953	562 (59)	0.003	78 (8)	1.00
Yes	54	43 (80)		4 (7)	
Any vaginal symptom (dryness, discharge, itching, dyspareunia)§					
No	182	100 (55)	0.05	12 (7)	0.21
Yes	717	451 (63)		69 (10)	
Any UTI (past year)§					
No	888	515 (58)	0.001	62 (7)	<0.0001
Yes	125	92 (74)		22 (18)	
Asymptomatic bacteriuria at baseline					
No	968	578 (60)	0.46	74 (8)	0.01
Yes	46	30 (65)		9 (20)	
Vaginal colonization with <i>E. coli</i> at baseline					
No growth	751	453 (60)	0.80	54 (7)	0.07
1–3 growth	240	144 (60)		27 (11)	
4+ growth	19	10 (53)		3 (16)	
Postvoid residual bladder volume					
<50 ml	802	483 (60)	0.82	71 (9)	0.51
50–100 ml	99	57 (58)		6 (6)	
>100 ml	105	61 (58)		7 (7)	

\*n may not equal to 100% due to missing values. † $\chi^2$  (and Fisher's exact when necessary) test for differences between characteristic categories and the specified outcome. ‡From physical function domain of the SF-36 (0 = worst, 100 = best). §Items from the survey instrument: "During the last 3 months, have you had: 1) Numbness or loss of feeling in your hands or feet other than from your hands and feet falling asleep? 2) A painful sensation or tingling in your hands or feet? Do not include normal foot aches from standing or walking for long periods. 3) Decreased ability to feel hot or cold things you touch?" One or more yes considered peripheral neuropathy; "Have you ever been told that diabetes has affected the back of your eyes, that is, the retina? Have you ever had laser or photocoagulation treatment for this problem with your eyes (not including treatment for cataracts)?" Yes to either considered retinopathy; "How many full term pregnancies have you had?"; "Have you had a hysterectomy?"; "Do you have problems with constipation?"; "Have you ever had surgery of the bladder or urinary system?"; "Do you take a diuretic (water pill) that makes you urinate more often?"; "Do you take a medication to help you control urination?"; Derived from skip pattern for "Which estrogen pill (or cream) did you take in the past month?"; "Do you have problems with: vaginal dryness, vaginal discharge, vaginal itching or painful sexual intercourse?"; "How many doctor-diagnosed urinary tract (or bladder) infections have you had in the past year?" ||Defined as a baseline urine culture positive for at least 10<sup>5</sup> CFU/ml of a uropathogenic organism in the absence of urinary symptoms.

Table 2—Characteristics of urinary incontinence among women without and with diabetes

	Total sample	Without diabetes	With diabetes	P*
<i>n</i>	1,017	799	218	
Incontinence during past month				
No	407 (40)	40	42	0.56
Yes	610 (60)	60	58	
Incontinence history at baseline (length)				
None during past year	345 (34)	34	35	0.89
<1 year	201 (20)	20	18	
1–5 years	292 (29)	29	29	
>5 years	175 (17)	17	18	
Sandvik Severity Index†				
No incontinence in past year	345 (34)	34	35	0.0006‡
Slight	216 (21)	23	17	
Moderate	369 (36)	37	34	
Severe	84 (8)	7	15	
Type of incontinence				
No incontinence in past month	413 (41)	40	42	0.0007‡
Stress only	174 (17)	19	10	
Urge only	106 (10)	11	7	
Mixed	324 (32)	30	40	
Incontinence frequency				
No incontinence in past month	407 (40)	40	42	0.01‡
Once a month	164 (16)	18	10	
1–6 times a week	274 (27)	27	27	
1–4+ times a day	169 (17)	15	22	
Usual amount of urine loss				
No incontinence in past month	407 (40)	40	42	<0.0001‡
Few drops	215 (21)	24	11	
Damp underwear	300 (30)	29	32	
Underwear/clothes wet	95 (9)	8	15	
Difficulty controlling urination				
No incontinence in past month	407 (40)	40	42	0.02‡
No problem	126 (12)	14	8	
Mild problem	335 (33)	34	30	
Moderate/severe	147 (14)	13	20	
Had to wear pad due to leakage§				
No incontinence in past month	407 (40)	40	42	0.06‡
Never	336 (33)	35	26	
Occasionally	115 (11)	11	12	
Most of time/always	159 (16)	15	20	
Ability to completely empty bladder§				
No incontinence in past month	407 (40)	40	42	0.002‡
Always	246 (24)	27	15	
Most of the time	282 (28)	26	34	
Never/occasionally	81 (8)	8	10	
Unaware of leakage§				
No incontinence in past month	407 (40)	40	42	0.06‡
Never	474 (47)	48	41	
Occasionally/always	136 (13)	12	17	

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symptoms to be more objectively quantified.

In multiple regression models before adjustment for BMI, the presence of diabetes at baseline, treatment type, dura-

tion, peripheral neuropathy, and retinopathy were all independently associated with severe incontinence. Increasing trends in the relative odds of severe incontinence within each of these charac-

teristics supports the hypothesis that diabetes treatment type, neuropathy, and retinopathy may play a role in the development of severe incontinence or reflect underlying disease severity. However,

Table 2—Continued

	Total sample	Without diabetes	With diabetes	P*
Discomfort on urination§				
None	935 (92)	95	82	<0.0001
Any	79 (8)	5	18	
Postvoid residual bladder volume				
<50 ml	802 (80)	81	77	0.10
50–100 ml	99 (10)	10	9	
>100 ml	105 (10)	9	14	
Average number voids/day§	6.5 ± 0.07	6.6 ± 0.08	6.2 ± 0.14	0.01
Average number voids/night§	1.3 ± 0.03	1.2 ± 0.03	1.5 ± 0.09	0.0005
Postvoid residual	36.5 ± 2.15	33.1 ± 2.03	49.1 ± 6.65	0.02

Data are n (%), percent, or means ± SD, unless otherwise noted. \* $\chi^2$  test for the difference between diabetic and nondiabetic women for each aspect of incontinence. †Derived from amount (1 = drops/little [none/few drops/damp underwear] or 2 = more [moderately to completely wet underwear/outer clothes wet or leakage to the floor]) multiplied by frequency (1 = <monthly, 2 = monthly, 3 = weekly, 4 = daily) to equal slight (1–2), moderate (3–4), or severe (6–8). ‡Test for increasing trend among diabetic women with incontinence in past month; all P values ≤0.005, except unaware of leakage when P = 0.02. §Items from the survey instrument: “How often during the past month have you worn a pad or other item to absorb leaking urine?”; “Do you feel as though you are able to completely empty your bladder?”; “Do you lose control of urine but are not aware when it happens? (That is, you simply notice your underwear or clothes are wet)”; “Do you ordinarily have pain or discomfort with urination?”; “How many times do you have to urinate while you are awake during an average day (or during an average night) (without a bladder infection)?”

BMI in this population of diabetic women ultimately confounds these effects. Fifty-six percent of women with diabetes in our sample had BMIs ≥30 kg/m<sup>2</sup>, compared with 21% of women without diabetes (P < 0.0001). Further research is needed to determine whether diabetes characteristics of women with type 1 diabetes (who are less likely to be overweight) or of women with more advanced type 2 diabetes are risk factors for incontinence independent of BMI.

Prior studies demonstrated higher postvoid residual bladder volume among women with diabetes (28), and it has been associated with diabetic cystopathy in selected populations (29). Postvoid residual bladder volume was higher among women with diabetes than among those without. However, the mean volume of 49 ml is not close to the range typically considered clinically significant (100–200 ml), and we found no relationship between postvoid residual bladder volumes and any or severe incontinence.

UTIs are more common among women with diabetes and are routinely associated with incontinence, supported in this study for any and severe incontinence outcomes. Women with *Escherichia coli* vaginal colonization or asymptomatic bacteriuria were more likely to have severe incontinence, which suggests a possible mechanism.

Although parity is an important risk factor for urinary incontinence (30), our results are consistent with the observation that the effects diminish and become neg-

ligible with older age (7,17). Multiple randomized controlled trials suggested worsening or no effect of estrogen upon urinary incontinence (31,32). However, estrogen cream was recommended in a 1996 guideline for incontinence treatment (33) and is increasingly used for vaginal symptoms since the Women’s Health Initiative discouraged routine oral

estrogen use (34). Estrogen cream use was positively associated with any incontinence in our sample. Confounding by indication is possible. We found that 72% (51 of 71) of women using estrogen cream in the past year did so because of symptoms of vaginal dryness; however, further evaluation of this purported treatment is warranted.

Table 3—Individual multiple regression models of diabetes characteristics and severe urinary incontinence

	No BMI adjustment		BMI adjustment	
	OR (95% CI)	P	OR (95% CI)	P
Diabetes at baseline				
Yes vs. no	2.0 (1.2–3.2)	0.01	1.5 (0.8–2.5)	0.17
Diabetes treatment				
Diet	1.7 (0.7–3.6)	0.06	1.3 (0.5–2.8)	0.52
Pill	2.1 (1.1–3.8)		1.5 (0.8–2.9)	
Insulin	2.3 (0.9–5.4)		1.7 (0.6–4.1)	
Diabetes duration				
<10 years	1.9 (1.1–3.3)	0.03	1.4 (0.8–2.6)	0.36
≥10 years	2.1 (0.9–4.4)		1.6 (0.7–3.4)	
HbA <sub>1c</sub>				
≤7.5%	1.9 (1.0–3.4)	0.7	1.4 (0.7–2.6)	0.76
7.6–8.5%	1.5 (0.5–3.9)		1.2 (0.4–3.0)	
>8.5%	1.7 (0.5–4.7)		1.2 (0.3–3.6)	
Diabetic peripheral neuropathy				
No	1.8 (0.5–4.7)	0.02	1.4 (0.7–2.7)	0.26
Yes	2.3 (1.2–4.1)		1.7 (0.9–3.2)	
Diabetic retinopathy				
No	1.5 (0.8–2.6)	0.06	1.1 (0.6–2.0)	0.43
Yes	2.8 (1.0–6.8)		1.9 (0.7–4.8)	

Each model adjusted for age, education, any UTI in the past year (as categorized in Table 1). Reference group is no diabetes.

Our results are cross-sectional, limiting the ability to fully evaluate temporal sequence, particularly for diabetes and BMI. Participant accrual from a study of UTI may have resulted in a higher-than-expected prevalence of urinary incontinence. Additionally, the prospective nature of the original study resulted in low participation rates, particularly among women with diabetes. If nonparticipants with diabetes were more ill, our estimate of incontinence in this group would be artificially low. Incontinence outcomes were self-reported; because women with diabetes may be less aware of mild incontinence symptoms (28), our ability to detect differences would be limited. Self-reported height and weight typically result in underestimation of BMI (35), thus the effect of BMI in this population may be greater than our analysis indicates. Similarly, diabetes duration, peripheral neuropathy, and retinopathy were also self-reported measures and may also be underreported, limiting our ability to detect their effects.

Study strengths include enrichment of this large population-based sample with women with diabetes and detailed information regarding diabetes characteristics. The approximation to a validated measure of incontinence severity demonstrated associations that were not apparent using a more general measure. Another strength was the ability to evaluate and adjust for a wide variety of confounding factors, including clinical measures of postvoid residual bladder volume, bacterial vaginal colonization, asymptomatic bacteriuria, and UTI, that are pertinent for women with diabetes.

In summary, urinary incontinence affects a majority of postmenopausal women. Women with diabetes have more severe incontinence and are more likely to use pads, be unable to completely empty the bladder, be unaware of leakage, and have discomfort with urination. Postvoid residual bladder volume plays no role in urinary incontinence among community-dwelling postmenopausal women, whereas BMI is the predominant factor associated with severe incontinence among diabetic women and is potentially modifiable with intervention.

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