First-Time Urinary Tract Infection and Sexual Behavior

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We studied the relation between sexual and health behaviors of women and first-time urinary tract infection (UTI). The study population was women using a university health service who were unmarried, had no UTI history, and who had engaged in sexual activity at least once. We found 86 cases of UTI, defined as one or more urinary symptoms and ≥1,000 colony-forming units per ml urine of a known pathogen. We randomly sampled 288 controls from the student body. Vaginal intercourse increased the risk of UTI; this risk was further increased with condom use. After adjusting for vaginal intercourse with other birth control methods and recentness of current sexual partnership, a single sex act with a condom in the past 2 weeks increased UTI risk by 43%. Having a sex partner for less than 1 year *vs* 1 year or more, after adjustment for frequency of vaginal intercourse and birth control method, was associated with about twice the risk of UTI [odds ratio (OR) = 1.97; 95% confidence interval (CI) = 1.04–3.74]. After adjusting for frequency of vaginal intercourse, regular drinking of cranberry juice was protective against UTI (OR = 0.48; 95% CI = 0.19–1.02), whereas drinking carbonated soft drinks appeared to be associated with increased risk (OR = 2.37; 95% CI = 0.75–7.81). Using deodorant sanitary napkins or tampons was associated with a slight increase in risk of UTI (OR = 1.51; 95% CI = 0.74–3.06). Blacks had five times greater risk of UTI than whites after adjusting for frequency of vaginal intercourse (OR = 5.2; 95% CI = 1.89–24.63). We observed only modest differences in health behavior between racial groups. (Epidemiology 1995;6:162–168)

Keywords: sexual behavior, urinary tract infections, health habits, women's health, race, menstrual protection, cranberry juice, beverages, ascorbic acid, contraceptives.

Urinary tract infection (UTI) causes frequent, painful urination, an urgent need to urinate, and occasionally blood in the urine. Approximately 50% of all women have had a UTI by their late 20s.[1] Self-reported UTI history increases dramatically between the age groups 14–17 and 18–24, from 12.5 to 37.8%; this increase roughly corresponds to the age at which most women initiate sexual activity.[1] Although an association of UTI with recent, frequent vaginal intercourse is strongly supported in the literature,[2–5] few studies have examined the effects of digital stimulation, or oral or anal intercourse, lifetime number of sex partners, and duration of current sexual partnership. The pattern of association of UTI with other sexual behaviors might help determine whether sexual activity introduces indigenous flora into the urinary tract or is a source of new uropathogens.

Contraceptive method and sexually transmitted disease protection (condom and spermicide use) may also increase UTI risk. Several studies have found an association of UTI with diaphragm use.[2–7] At least one study has implicated spermicide use.[8,9] Most of these studies used oral contraceptives as the reference group. Associations with other birth control methods are less well described. Evidence for other potential risk factors, such as toileting habits, menstrual protection, diet, or clothing, is weak.[3,6,10]

Virtually all studies of behavioral risk factors for UTI are potentially biased by the use of clinic rather than population-based controls. Women using medical care—even for routine check-ups—are likely to have different sexual behavior and contraceptive practices than less regular users.

Once a woman has a first UTI, her risk of another is dramatically increased. Approximately 25% of all women with first UTI will have a recurrence within 6 months.[11] Women with UTI may change their behavior in response to infection. Therefore, any associations observed between suggested behaviors and repeated UTI may reflect a behavior change following initial infection. For example, Foxman and Chi[3] found that women with previous UTI are more likely to report drinking cranberry juice than women with first UTI or clinic controls. By limiting cases to women with first UTI, we can be more certain that the health behaviors under study are associated with acquiring UTI and are not behavior changes in response to prior UTI.

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Methods

Study Population

We studied never-married women with no history of UTI who had engaged in sexual activity at least once, did not have diabetes, were not currently pregnant, and had not been catheterized during the previous 2 weeks. We defined sexual activity as vaginal or anal intercourse, receptive oral sex, and/or digital stimulation by self or a partner.

Case and Control Definitions

All female students with no UTI history referred to the University Health Service Laboratory for urinalysis and urine culture were offered the opportunity to participate. Cases were enrolled between September and December of 1992 and 1993 to facilitate a 6-month follow-up. The University Health Service provides free health care to all students and is centrally located. All cases had a clinical diagnosis of UTI, one or more urinary symptoms, and a urine culture exhibiting $\geq$1,000 colony-forming units (cfu) of a known uropathogen per ml of urine.

Potential controls consisted of 1,000 female students, stratified by year in school, randomly selected from a list of all students registered at the University of Michigan during the fall term, 1992. We included as controls all women completing the questionnaire who met the study criteria. Cases and controls were offered a small incentive for participation.

Measuring Instruments

Participants completed a 10- to 20-minute self-administered questionnaire regarding medical and sexual history and current health behaviors. Cases completed the study questionnaire in the laboratory or while waiting to see a health care provider; controls received the questionnaire by mail. Urine from potential cases was streaked for quantification of bacteria on a split blood agar/MacConkey plate using a calibrated loop. Gram-negative enteric bacteria were identified using the API 20E system.

Data Analysis

We estimated odds ratios (ORs) and calculated exact 95% confidence intervals (CIs) using EPI Info.[12] We chose as cutpoints the 50th and 90th percentiles of the combined case and control samples for each type of sexual activity. For age, lifetime number of sex partners, years sexually active, and voiding habits, we chose as cutpoints the 25th and 75th percentiles of the combined case and control samples. Days since first sexual activity with current sex partner (recentness of current sexual partnership) were empirically divided into three categories based on natural breaks in the distribution: no current partnership, partnership of less than 1 year, and partnership of 1 year or more. As some women used more than one birth control method, we created mutually exclusive categories for analysis based on the observed joint distributions.

We stratified all exposure-disease associations by (1) frequency of vaginal intercourse, (2) recentness of current sexual partnership, (3) condom use, and (4) race. We then calculated Mantel-Haenszel summary ORs and exact 95% CIs. Small numbers precluded stratification by more than one variable at a time; therefore, we also modeled UTI risk using logistic regression. Covariates included (1) the log transform of frequency of vaginal intercourse, (2) the log of frequency of vaginal intercourse multiplied by the proportion of times the woman reported using a condom with vaginal intercourse, (3) the log of frequency of vaginal intercourse multiplied by the proportion of times the woman reported using a diaphragm, cervical cap, spermicide, or sponge, and (4) recentness of current sex partner. To get unconfounded estimates of the OR for other exposure variables, we fit additional models, one for each exposure variable, that included the variables listed above plus the added exposure variable. We calculated adjusted ORs and 95% CIs based on parameter estimates, variances, and covariances from the logistic regression analysis.[13] Multiple regression analyses were performed using PC-SAS 6.0.[14]

Results

Study Population

A study representative screened 925 women presenting for urinalysis for eligibility in the study. We eliminated 628 women (585 had prior UTI; 2 were currently pregnant, 34 were not available for follow-up, and 7 were older than 40 years). Following screening, the 297 potentially eligible women were offered enrollment; 190 of these women consented, for a response rate of 64%. Of those consenting, 104 were excluded (82 had no growth on urine culture, 12 had no clinically diagnosed UTI, and 10 failed to meet study population criteria), leaving 86 cases.

Of the 1,000 potential controls sampled, 952 had an accurate local address. Of these, the response rate was 63.3%, the rate varying somewhat by year in school. Of the 603 questionnaires returned, 315 (52%) did not meet study eligibility criteria (190 had UTI history; 47 had never engaged in sexual activity; 10 had recent catheterization, were pregnant, were breast feeding, or had diabetes; 31 were not single; and 37 had missing data for one or more of the eligibility criteria), leaving 288 controls.

Although we defined a UTI as urinary symptoms in the presence of 1,000 cfu per ml urine of a known uropathogen, 76% of all cases had pure cultures of at least 100,000 cfu per ml of urine. Excluding cases with less than 100,000 cfu per ml of urine made no substantial difference in study results, so the analyses presented here include all cases. The most common infecting organism was *Escherichia coli* (86%). Presenting symptoms included urinary frequency (89%), urgency (84%), painful urination (82%), hematuria (38%), fever (7%), chills (11%), back pain (25%), and flank pain (13%). Two cases were clinically diagnosed as pyelonephritis.

TABLE 1. Age and Sexual Characteristics and Crude Association with First UTI among Sexually Active College Women with First-Time UTI (N = 86) and Population Controls (N = 288)

	Cases		Controls			
Characteristic*	Number	%	Number	%	OR	95% CI
Age (years)						
18–19	23	27	63	23	1.00	Referent
20–21	44	52	140	51	0.86	0.46–1.63
≥22	18	21	74	26	0.67	0.31–1.42
Years sexually active						
<1.5	21	25	62	24	1.00	Referent
1.5 –4.4	41	48	132	51	0.92	0.48–1.78
>4.4	23	27	63	25	1.08	0.51–2.28
Lifetime number of sex partners						
None reported	1	1	24	8		
1–5	66	77	189	66	1.00	Referent
≥6	19	22	75	26	0.73	0.38–1.33
Frequency of vaginal intercourse past 2 weeks						
None	6	7	188	65	1.0	Referent
1–5 times	47	55	70	24	21.04	8.39–62.22
≥6 times	33	38	30	10	34.47	12.59–106.93
Recentness of current sex partner						
No partner	4	5	152	53	0.07	0.02–0.22
<1 year	59	69	76	26	2.03	1.08–3.84
≥1 year	23	27	60	21	1.00	Referent

* Age missing for 1 case and 11 controls; years sexually active missing for 1 case and 31 controls.

Only 50 (58%) cases stated that the University Health Service was their usual source of health care, indicating that our sample might represent many or all cases of first-time UTI occurring among single, sexually active women ages 18–39 years at the University, not just that among regular users of the Health Service.

Demographic Variables and Sexual History

Cases and controls were balanced by age and had similar lifetime sexual histories (Table 1). Increasing age was associated with a decreased risk of first UTI. Years sexually active had no apparent association with UTI; having six or more lifetime sex partners compared with one to five was associated with a decreased risk of UTI, but the confidence intervals are wide (OR = 0.73; 95% CI = 0.38–1.33). Both frequency of vaginal intercourse and recentness of current sex partner were strongly associated with first UTI (Table 1). Blacks had five times the risk of UTI as whites after adjusting for either frequency of vaginal intercourse or recentness of current sex partner (Tables 2 and 3).

Sexual Behavior

All but one case (99%) and 75% of controls had engaged in sexual activity during the previous 2 weeks (Table 4). Condoms, with or without some other birth control method, were used frequently by both cases and controls.

Tables 2 and 3 show the distribution of types of sexual behavior stratified by frequency of vaginal intercourse and recentness of current sex partner, respectively. All types of sexual behavior were associated with increased UTI risk, as was recentness of current sex partner and condom use. Various sexual activities were highly correlated, with vaginal intercourse usually combined with digital stimulation and/or receptive oral sex. Engaging in vaginal intercourse alone or in combination with some other sexual behavior *vs* digital stimulation and/or receptive oral sex alone was associated with a 9-fold increase in risk of UTI (Table 3).

After adjusting for recentness of sexual partnership and birth control method in a logistic regression model, we found that engaging in vaginal intercourse once *vs* not at all increased risk of UTI by 90% (OR = 1.90;

TABLE 2. Associations between Race, Recentness of Current Sexual Partner, Condom Use, and First-Time UTI, Stratified by Frequency of Vaginal Intercourse among Sexually Active College Women with First-Time UTI (N = 86) and Population Controls (N = 288)

	Frequency of Vaginal Intercourse, Past 2 Weeks													
	None				1 –5 Times				≥6 Times					
	Cases		Controls		Cases		Controls		Cases		Controls			
Characteristic*	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	OR_{MH}	95% CI
Race														
White	1	(17)	152	(82)	34	(72)	56	(80)	25	(76)	23	(77)	1.00	Referent
Black	3	(50)	19	(10)	8	(17)	3	(4)	3	(9)	1	(3)	5.23	1.89–24.63
Other	2	(33)	15	(8)	5	(11)	11	(16)	5	(15)	6	(20)	1.04	0.41–2.53
Recentness of current sex partner														
No partner	3	(50)	149	(79)	0	(0)	2	(3)	1	(3)	1	(3)	0.22	0.03–1.46
<1 year	1	(17)	27	(14)	35	(75)	27	(39)	23	(70)	22	(73)	2.10	1.12–4.31
≥1 year	2	(33)	12	(6)	12	(26)	41	(59)	9	(27)	7	(23)	1.00	Referent
Condom use														
None	5	(83)	178	(97)	23	(49)	37	(53)	20	(61)	22	(73)	1.00	Referent
1–4 times	1	(17)	5	(3)	19	(40)	31	(44)	3	(9)	4	(13)	1.05	0.50–2.21
≥5 times	0	(0)	0	(0)	5	(11)	2	(3)	10	(30)	4	(13)	3.16	1.02–10.27†

* Race missing for 2 controls.
† Confidence interval calculated using the method of Cornfield, as exact limit was undefined.

TABLE 3. Associations between Race, Frequency of Various Sexual Activities, Condom Use, and First-Time UTI, Stratified by Recentness of Current Sexual Partner among Sexually Active College Women with First-Time UTI (N = 86) and Population Controls (N = 288)

	Recentness of Current Sex Partner													
	No Partner				<1 Year				≥1 Year					
	Cases		Controls		Cases		Controls		Cases		Controls			
Characteristic*	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	OR_{MH}	95% CI
Race														
White	1	(25)	121	(81)	42	(71)	60	(79)	17	(74)	50	(83)	1.00	Referent
Black	2	(50)	18	(12)	8	(14)	3	(4)	4	(17)	2	(3)	5.09	1.80–18.49
Other	1	(25)	11	(7)	9	(15)	13	(17)	2	(9)	8	(13)	1.05	0.43–2.44
Frequency of vaginal intercourse past 2 weeks														
None	3	(75)	144	(98)	1	(2)	27	(36)	2	(9)	12	(20)	1.00	Referent
1–5 times	0	(0)	2	(1)	35	(59)	27	(36)	12	(52)	41	(68)	8.08	3.00–42.40
≥6 times	1	(25)	1	(1)	23	(39)	22	(29)	9	(39)	7	(12)	16.59	4.69–84.04
Frequency of receptive oral intercourse past 2 weeks														
None	4	(100)	140	(95)	25	(42)	34	(45)	10	(44)	29	(48)	1.00	Referent
1–2 times	0	(0)	8	(5)	22	(37)	27	(36)	5	(22)	25	(42)	0.90	0.45–1.76
≥3 times	0	(0)	0	(0)	12	(20)	15	(20)	8	(35)	6	(10)	1.66	0.75–3.78†
Frequency of digital stimulation past 2 weeks														
0–1 time	2	(50)	109	(74)	5	(8)	8	(11)	7	(30)	10	(17)	1.00	Referent
2–7 times	2	(50)	31	(21)	36	(61)	47	(62)	10	(44)	46	(77)	0.81	0.33–1.93
≥8 times	0	(0)	8	(5)	18	(31)	21	(28)	6	(26)	4	(7)	1.56	0.53–4.61
Anal intercourse past 2 weeks	0	(0)	2	(1)	4	(7)	1	(1)	0	(0)	2	(3)	2.17	0.34–12.38
Receptive oral intercourse or digital stimulation only	2	(67)	46	(94)	1	(2)	26	(35)	2	(9)	12	(20)	1.00	Referent
Any vaginal intercourse	1	(33)	3	(6)	58	(98)	49	(65)	21	(91)	48	(80)	9.27	3.42–39.60
Condom use														
None	3	(75)	150	(99)	31	(53)	54	(71)	14	(61)	38	(63)	1.00	Referent
1–4 times	0	(0)	1	(1)	17	(29)	20	(26)	6	(26)	19	(32)	1.23	0.62–2.40
≥5 times	1	(1)	1	(1)	11	(19)	2	(3)	3	(13)	3	(5)	6.54	2.16–26.22

* Race missing for 2 controls, oral intercourse missing for 4 controls, digital stimulation missing for 4 controls, anal intercourse missing for 4 controls.
† Confidence interval calculated using the method of Cornfield, as exact limit was undefined.

95% CI = 1.43–2.52) (Table 5). Because we estimated the OR using the log transformed frequency of vaginal intercourse, the effect of additional sex acts appears less than multiplicative. Vaginal intercourse one time with a condom in the past 2 weeks compared with vaginal intercourse using oral contraceptives or no birth control method increased risk of UTI by 43% (OR = 1.43; 95% CI = 1.09–1.89). Diaphragm, cervical cap, spermicide, or sponge use once compared with oral contraceptives or no birth control method increased risk of UTI threefold, although the confidence interval is wide (OR = 3.28; 95% CI = 0.88–12.22).

Duration of sexual partnership also modified UTI risk. A sex partner of less than 1 year's duration compared with 1 year or more increased risk of UTI nearly twofold (OR = 1.97; 95% CI = 1.04–3.74). Sex partners of shorter duration had similar risks. By contrast, no current partner compared with a partner of 1 year or more decreased risk (OR = 0.28; 95% CI = 0.08–0.99).

Other health behaviors also were associated with UTI risk (Table 6). After adjusting for frequency of vaginal intercourse, we found a decreased risk of UTI for habitual vitamin C users (OR = 0.68; 95% CI = 0.36–1.27) and habitual cranberry juice drinkers (OR = 0.48; 95% CI = 0.19–1.02).

Discussion

As has been reported in several previous studies, UTI was associated with sexual activity.[2–6] Vaginal intercourse is hypothesized to facilitate entrance of potential uropathogens into the urethra through physical transfer, increased secretions, and trauma.[15] Recentness of partnership as a risk factor may reflect not only more frequent vaginal intercourse during a "honeymoon" period, but also exposure to potential uropathogens. Apparent heterosexual transmission of UTI from female to male has been reported.[16–18]

Because of the well-known association of UTI with sexual behavior, women with UTI may be more likely to recall details of sexual activity than controls. By asking

TABLE 4. Birth Control Methods Used during the Past 2 Weeks and Crude Association with UTI by Sexually Active College Women with First-Time UTI (N = 86) and Population Controls (N = 288)

Birth Control Method*	Cases		Controls		OR	95% CI
	Number	%	Number	%		
Not sexually active previous 2 weeks	1	1.2	70	24.7	0.04	0.00–0.26
Sexually active, no method	5	6.1	86	30.4	0.16	0.05–0.46
Oral contraceptives only	23	28.1	63	22.3	1.00	Referent
Diaphragm, cervical cap, spermicide, or sponge only	9	11.0	8	2.8	3.08	0.92–10.30
Condoms only	21	25.6	33	11.7	1.74	0.79–3.83
Condoms plus another method	23	28.1	23	8.1	2.74	1.21–6.19

* Mutually exclusive categories. Data on birth control method missing for 4 cases and 5 controls.

most of the questions for a relatively short time period (the last 2 weeks), we feel we minimized recall bias. Furthermore, the estimates of lifetime number of sex partners and age at first intercourse are consistent with estimates found from other studies of sexual behavior in the same population.[19]

Only one previous study reported an association of condom use with UTI, and that study was based on a small sample.[2] Condom use among college students has risen considerably over the past several years, from 6% in 1975 to 25% in 1989,[20] facilitating its identification as a risk factor. Twenty percent of the controls in this study had used a condom during the previous 2 weeks, a number comparable with that from other recent estimates among college students at the same University.[19] By contrast, 54% of the cases had done so.

Condom use, especially without lubrication, may increase the trauma associated with vaginal intercourse. Trauma to the urogenital area may in itself cause urinary symptoms without infection. One study reported that 19% of women whose partner used a latex condom reported discomfort associated with condom use.[21] Most women have significant bacteriuria following vaginal intercourse.[4,22] Thus, it is possible that women whose partners use condoms are more likely to have symptoms due to trauma rather than tissue invasion, with the transient bacteriuria resulting from intercourse. Use of spermicidal lubricants might increase risk of UTI by suppressing growth of hydrogen peroxide-producing lactobacilli in the vagina, which reduces colonization resistance.[9] The active ingredient in spermicides, nonoxynol-9, appears to enhance bacterial adherence to epithelial cells, favoring persistence of *E. coli*.[9] Other explanations include allergic reactions to latex or lubricants.

Cranberry juice is a known folk remedy for UTI. A recent study[23] indicated that it may reduce pyuria and

TABLE 5. Associations between First-Time UTI and Sexual Behavior during the Previous 2 Weeks among Sexually Active College Women; Each Factor Is Adjusted for Frequency of Vaginal Intercourse, Birth Control Method, and Recentness of Current Sex Partner in a Logistic Regression Model (86 Cases and 288 Controls Had Complete Data for All Covariates)

Health Behavior during Past 2 Weeks (Frequency and Referent)	Coefficient	Variance	OR	95% CI
Vaginal intercourse	0.9261	0.04352		
1 time *vs* none*			1.90	1.43–2.52
5 times *vs* none*			5.26	2.53–10.94
Vaginal intercourse with a condom	0.5209	0.04144		
1 time *vs* none*			1.43	1.09–1.89
5 times *vs* none*			2.54	1.24–5.20
Vaginal intercourse with diaphragm, cervical cap, spermicide, or sponge (1 time *vs* none)*	1.7141	0.93652	3.28	0.88–12.22
Digital stimulation (ever *vs* none)	0.2154	0.615629	1.24	0.27–5.77
Receptive oral sex (ever *vs* none)	−0.4217	0.10615	0.66	0.35–1.24
No current sex partner (compared with ≥1 year)	−1.2664	0.40943	0.28	0.08–0.99
Sex partner <1 year (compared with ≥1 year)	0.6801	0.10578	1.97	1.04–3.74

* Log transformed frequency plus 1.

TABLE 6. Health Behavior during the Past 2 Weeks and Association with First UTI, Adjusted for Frequency of Vaginal Intercourse among Sexually Active College Women with First-Time UTI (N = 86) and Population Controls (N = 288)

Health Behavior*	Cases		Controls			
	Number	%	Number	%	OR_{MH}	95% CI
Habitual vitamin C use	27	31.4	116	40.3	0.68	0.36–1.27
Habitual cranberry juice use	11	13.1	76	26.4	0.48	0.19–1.02
Coffee or tea consumption	58	68.2	199	69.3	0.83	0.42–1.58
Soda consumption	80	94.1	255	88.5	2.37	0.75–7.81†
Cigarette smoking	12	14.3	36	12.5	0.99	0.40–2.39
Frequency of voiding per day						
<4 times	23	28	61	22	0.95	0.45–1.96
4–5 times	41	49	132	47	1.0	Referent
≥6 times	19	23	90	32	0.72	0.32–1.57
Menstrual protection						
Sanitary napkins only	19	22.4	68	23.6	1.0	Referent
Tampons only	25	29.4	68	23.6	0.57	0.22–1.49
Both napkins and tampons	41	48.2	152	52.8	0.57	0.25–1.28
Deodorant napkins or tampons	23	26.7	69	24.0	1.51	0.74–3.06

* At most, 5 controls and 2 cases had missing values for any one variable.
† Confidence interval calculated using the method of Cornfield, as exact limit was undefined.

bacteriuria in the elderly. Our findings suggest that regular cranberry juice consumption may also reduce risk of UTI in sexually active young women.

Very few published studies have examined incidence and risk factors for UTI among minorities. One study reported an overall higher rate of bacteriuria among black than among white working women.[24] Blacks do have a different distribution of blood types than whites,[25] and ABO and secretor status has been associated with UTI risk.[26,27] Furthermore, virulence characteristics of uropathogens prevalent among blacks might differ from those found among whites. Differential participation by blacks might also explain the association but would imply that blacks with UTI (cases) would be more likely to participate than blacks with no UTI history (controls). Among controls, the proportion of blacks (8%) is similar to that found in the University as a whole (10%).[28]

Sexual activity may increase risk of UTI in two disparate ways. First, trauma, secretions, and manipulation may serve to move uropathogens found in the indigenous bowel flora to the urinary opening or into the urinary tract. Birth control method may modify these effects by increasing trauma (for example, diaphragm or condom use) or enhancing the growth of potential uropathogens in the vagina or periurethral area (for example, spermicide use). Second, intimate contact associated with sexual activity may expose a woman to additional uropathogens. Most research to date has focused on the former explanation; the association of first UTI with recentness of current sex partner found in this study suggests that the latter explanation may be a fruitful area for future research.

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