Sexual Intercourse and Risk of Symptomatic Urinary Tract Infection in Post-Menopausal Women

Elya E. Moore, PhD^{1,2,7}, Stephen E. Hawes, PhD¹, Delia Scholes, PhD^{1,3}, Edward J. Boyko, MD, MPH^{1,4,5}, James P. Hughes, PhD⁶, and Stephan D. Fihn, MD, MPH^{2,4}

¹Department of Epidemiology, University of Washington School of Public Health and Community Medicine, Seattle, WA, USA; ²Health Services Research & Development Center of Excellence, VA Puget Sound Health Care System, Seattle, WA, USA; ³Center for Health Studies, Group Health Cooperative, Seattle, WA, USA; ⁴Department of Medicine, University of Washington, Seattle, WA, USA; ⁵Seattle Epidemiologic Research and Information Center, VA Puget Sound Health Care System, Seattle, WA, USA; ⁶Department of Biostatistics, University of Washington School of Public Health and Community Medicine, Seattle, WA, USA; ⁷Murdoch Childrens Research Institute, Royal Children's Hospital, Victoria, Australia.

BACKGROUND: Sexual intercourse increases the risk of symptomatic urinary tract infections (UTI) in young women, but its role among post-menopausal women is unclear.

OBJECTIVE: To determine whether recent sexual intercourse, as documented by daily diaries, is associated with an increased risk of symptomatic UTI in post-menopausal women.

DESIGN: A 2-year prospective cohort study conducted from 1998 to 2002.

PARTICIPANTS: One thousand and seventeen randomly selected post-menopausal women enrolled at Group Health Cooperative (GHC), a Washington State HMO.

MEASUREMENTS AND MAIN RESULTS: Women were asked to enter daily diary information on vaginal intercourse, medication use, and genito-urinary symptoms. The outcome of interest, symptomatic UTI, was defined as a positive urine culture $\geq 10^5$ CFU/mL of a uropathogen and the presence of ≥ 2 acute urinary symptoms. Nine hundred thirteen women returned diaries and were included in this study. Seventy-eight women experienced 108 symptomatic UTIs, and 361 (40%) reported sexual intercourse in their diaries. There was an increased hazard for UTI 2 calendar days after the reporting of sexual intercourse in the diaries (adjusted hazard ratio [HR], 3.42, 95% CI 1.49–7.80), while there was no evidence for an increased hazard associated with intercourse at other times. When the UTI criterion was relaxed from $\geq 10^5$ CFU/mL to $\geq 10^4$ CFU/mL, adding 9 UTI events to the analysis, the HR for UTI 2 days after intercourse changed slightly to 3.26 (95% CI 1.43–7.43).

CONCLUSIONS: Our data suggest that, as with younger women, recent sexual intercourse is strongly associated with incident UTI in generally healthy post-menopausal women.

KEY WORDS: coitus; diaries; postmenopause; urinary tract infections.

J Gen Intern Med 23(5):595–9
DOI: 10.1007/s11606-008-0535-y
© Society of General Internal Medicine 2008

INTRODUCTION

Most studies of urinary tract infection (UTI) in women have been conducted with pre-menopausal women or older, debilitated women. Few investigators have studied this problem in otherwise healthy, post-menopausal women, even though they constitute approximately 30% of the adult female US population,¹ and experience more than 1.5 million UTIs annually.² The epidemiology of UTI in post-menopausal women differs from that in pre-menopausal women.^{3,4} In non-institutionalized post-menopausal women, prior UTI, incontinence, and diabetes increase the risk of UTI,² while in young women, sexual intercourse, exposure to spermicides, and prior UTI are important risk factors.^{5–8} Although sexual intercourse is a strong predictor of UTI among younger women,^{5–9} studies in post-menopausal women have yielded inconsistent and weak associations.^{3,4,10} However, these studies may have been limited by inadequate measurement of sexual activity, given that daily assessments of sexual intercourse near the time of infection were instrumental in delineating a time- and dose-dependent relationship in pre-menopausal women.^{7,11} This is also of clinical concern, since there is evidence that a substantial proportion of older women continue to be sexually active.¹² To more rigorously address the possible role of this risk factor in older women, we used daily diary information collected as part of a prospective cohort study among community-dwelling post-menopausal women.

METHODS

Study Design

The details of this 2-year, prospective, observational study of post-menopausal women have been described previously.^{2,13,14} Briefly, women aged 55 to 75 were randomly selected from enrollment files from Group Health Cooperative (GHC), a large health maintenance organization in the Pacific Northwest. These women had been continuously enrolled at GHC for the previous

Received June 11, 2007

Revised September 12, 2007

Accepted January 28, 2008

Published online February 12, 2008

year, had no menstrual cycle in the preceding 12 months, resided in Pierce, King, or Snohomish counties in Washington State, and had no debilitating illness. Exclusion criteria were residential nursing care, use of a wheelchair, indwelling bladder catheter, end-stage renal disease, or an active malignancy. The GHC diabetes registry was used to increase the proportion of persons with diabetes in the study sample to approximately 20%. Participants were asked to make baseline and annual visits during 2 years of follow-up, and to maintain a daily study diary. Subjects who completed the baseline visit and at least 1 month of diaries were included in this analysis. This is the first report to utilize data from these diaries. All subjects provided informed consent prior to enrollment. The study was approved by the Human Subjects Committees of the University of Washington and GH.

Evaluation of Subjects and Exposures

At entry, participants completed a questionnaire regarding demographic characteristics, general and urinary health, hormone use, physical function, and prior sexual behavior. All participants not identified from the diabetes registry had a fasting plasma glucose test at baseline to detect undiagnosed diabetes, defined as a level ≥ 125 mg/dL.

Using checkboxes, participants were asked to record information daily about vaginal discharge, itching, irritation, or odor; urinary burning, pain, frequency, or urgency; incontinence; vaginal intercourse, dyspareunia, post-coital urination; and pharmaceutical use (oral/patch and vaginal estrogens, antibiotics) in a monthly diary throughout the 2-year follow-up.

Ascertainment of Outcome: Symptomatic Urinary Tract Infection

We defined the presence of a UTI on the basis of a midstream, clean-catch, urine specimen yielding $\geq 10^5$ CFU/mL of a uropathogen as confirmed by culture, plus at least 2 acute urinary symptoms: dysuria, urgency, or urinary frequency. The presence of symptoms was determined by interview. Asymptomatic bacteriuria was not evaluated as an outcome. We identified UTIs in 2 ways. First, participants were asked to report new UTI symptoms to study personnel, at which time they were interviewed and asked to promptly mail a urine specimen for laboratory verification. Urine specimens were collected using a Dipslide® (Unipath, Ogdensburg, New York) home testing kit, supplied to the participants at enrollment. In day-to-day use, the sensitivity and specificity of this method to detect $\geq 10^5$ CFU is 73% and 94%, respectively.¹⁵ Second, we systematically reviewed computerized clinical records for codes identifying a diagnosis of acute cystitis with laboratory culture results. Identification of culture-confirmed, acute cystitis in the computerized database was verified for the presence of at least 2 symptoms via telephone interview.

UTIs that were confirmed to be symptomatic via interview were included in the analysis. Since women were not questioned about the onset of their symptoms, urinary symptoms recorded in the diary were incorporated into the UTI onset definition to more accurately approximate this date. In the event that “burning or painful urination” was recorded in the diary up to 7 days prior to the date of a positive urine culture, the earliest report of this symptom within this window was used to define

the infection onset date. We selected “burning or painful urination” rather than other UTI symptoms, because among post-menopausal women these symptoms are common in the absence of a UTI.¹⁶ If burning was not reported in the diary during this window, infection onset date was defined as the date of urine culture. Cultures that were positive with the same microorganism within 2 weeks of an earlier culture were considered to be persistent rather than a new infection.¹⁷

Statistical Analysis

The primary exposure of interest was sexual intercourse as reported in the daily diary. Study time was defined as calendar days on study beginning with the first diary entry after the baseline visit and ending with the last entry. When diaries were incomplete, subject time for periods corresponding to the missing entries were excluded. To focus on the clinically relevant time period, we limited the analysis to the month of diaries prior to the time a UTI was diagnosed. Reports of intercourse on a given day were followed forward for the occurrence of a UTI, relative to women who did not report intercourse on that day. Intercourse was treated as a time-dependent yes/no variable and was assessed at 3, non-mutually exclusive times based on days prior to the date of onset: any intercourse occurring 1 day prior, any intercourse 2 days prior, and any intercourse occurring 3–30 days prior to UTI onset. The rationale for these cutoffs was based on a previous study of young women, which found a large increase in risk of UTI within 2 days after sexual intercourse.⁹ Based on the pathogenicity of *Escherichia coli*, we focused our exposure of interest as intercourse on the second day rather than the first day prior to UTI onset within this 2-day window.¹⁸

We used the Anderson-Gill (AG) extension of the Cox proportional hazards model to estimate the hazard ratio (HR) for UTI, which allowed and accounted for the occurrence of multiple outcomes in an individual subject.^{19,20} The proportional hazards assumption was evaluated by testing the statistical significance of interaction terms created for each independent variable with time. All final models met the proportional hazards assumption. All models were adjusted for diabetes status and all absolute rates were weighted to account for the over-sampling of diabetics in the cohort design.

Other potentially confounding variables that we evaluated included age, physical function category, marital status, race, level of education, income, douching, smoking status, vaginal dryness, hormone replacement therapy, hysterectomy, incontinence, and UTI history. A variable was considered a confounder if it caused a change of $\geq 10\%$ to the HR for intercourse on day 2.²¹

We repeated the final model using a colony count of $\geq 10^4$ CFU/mL as a more sensitive but less specific criterion for UTI diagnosis. We additionally performed an analysis restricted to women who reported at least 1 acute urinary symptom in the diary within 7 days of the laboratory date to evaluate potential bias due to diary non-adherence. All analyses were performed with SAS 9.1 (SAS Institute, Cary, NC, USA).

RESULTS

Diary Results

Between 1998 and 2002 we enrolled 1,017 women of whom 218 (21%) were diabetic.^{2,13,14} Of the enrollees, 913 (90%) completed

at least 1 monthly diary, of whom 169 (19%) were diabetic. Diary completion rates were 83% at 12 months and 50% at 24 months. Women who completed diaries were similar to those who did not with regard to marital status, education level, smoking status, reported use of hormone replacement therapy, intercourse frequency, and lifetime number of urinary tract infections. The two groups differed in that women who completed diaries were older, more frequently white, of higher physical function and less likely to have diabetes (Table 1). Completing diaries was not associated with having a UTI during follow-up (Chi-square $p=0.17$).

There were 18,387 months of completed diaries contributing to follow-up. The average diary follow-up time was 1.7 years. Sexual intercourse was recorded at least once by 361 women (40%), of whom 141 (39%) reported an average intercourse frequency less than once a month, 67 (19%) once to twice a month, 53 (15%) twice to 3 times a month, 30 (8%) 3 to 4 times a month, and 70 (19%) more than 4 times a month.

Incidence of Urinary Tract Infection

Thirty (22%) of the 138 total UTI events were excluded from the analysis because there were no diary entries to determine sexual intercourse on or during the month preceding the corresponding UTI date. Thus, 108 symptomatic, culture-confirmed UTIs with $\geq 10^5$ CFU/mL among 78 women were included in the final analysis. Sixty-five symptomatic UTIs were identified via dip-slide, while 43 were detected through review of clinical records. All UTIs were followed up by interview to verify the presence of at least 2 symptoms. Of the 108 confirmed UTIs with at least 2 symptoms, 91 had an acute urinary symptom recorded in the diaries within 7 days of laboratory confirmation, while 17 had

Table 1. Baseline Characteristics of Women Who Did and Did Not Complete Diaries*

	Women Who Completed Diaries (Total = 913)	Women Who Did Not Complete Diaries (Total = 104)
	N (%)	N (%)
Mean Age (SD)	64.3 (6.3)	62.8 (6.0)
Married/Live as Married	572 (63)	63 (61)
White vs Other	813 (89)	75 (73)
Education		
$\leq$ High School	177 (19)	26 (25)
Some College/College Grad	411 (45)	44 (43)
$\geq$ Some Grad School	320 (35)	33 (32)
Sex in Previous Year	404 (44)	37 (36)
Hormone Use in Previous Yr	567 (62)	56 (54)
Physical Function Score†		
95–100	265 (29)	18 (17)
85–94	222 (24)	19 (18)
70–84	223 (24)	18 (17)
0–69	201 (22)	49 (47)
Diabetes‡	169 (19)	49 (47)
Number UTIs in Lifetime		
0	300 (33)	42 (40)
1–3	313 (34)	30 (29)
4+	299 (33)	32 (31)
Cigarette Smoker	56 (6)	9 (9)

*Per data from study baseline questionnaire

†Physical function was measured using the physical function subscale of the 36-item short form (SF-36)

‡As indicated by diabetes registry or confirmed by fasting plasma glucose test at baseline ≥ 125 mg/dL

Table 2. Risk of Urinary Tract Infection Associated with Intercourse: Multivariable Cox model

Risk of UTI	Hazard Ratio* 95% C.I.†
One calendar day after intercourse‡	1.01 (0.30–3.37)
Two calendar days after intercourse‡	3.42 (1.49–7.80)
Between 3 and 30 calendar days after intercourse‡	0.95 (0.52–1.72)

*Controlling for diabetes status at baseline and during follow-up

†Confidence intervals (CI) adjusted for correlation between UTI within women

‡Intercourse variables (yes/no) were non-mutually exclusive, time-dependent, and mutually adjusted

symptoms only noted upon personal interview. Of those who experienced a UTI, 59 women had one UTI, 12 women had 2, 3 women had 3, and 4 women had 4. *E. coli* was the predominant uropathogen, identified in 83 (77%) of the 108 infections, while the remaining UTIs were caused by *Klebsiella* species (6%), *Proteus* species (6%), *Enterococcus* (4%), group B *Streptococcus* (3%), *Enterobacter* species (3%), *Citrobacter freundii* (1%), and unspiculated gram-negative rods (1%). *E. coli* continued to predominate when analyses were restricted to the first UTI and when UTI was defined as $\geq 10^4$ CFU/mL.

Painful or burning urination was recorded in the diary within a 7-day period of laboratory verification for 72 of the 108 UTIs. Fifty-one women complained of burning prior to the date of lab verification and 21 complained of burning on this date. For the remaining 36 UTIs, there was no report of burning in the diary within 7 days of the laboratory verification. Compared to painful or burning urination, the reporting of other UTI symptoms in the diary within the 7 days prior to laboratory verification was less frequent (urine loss = 48 UTIs, urinary frequency = 63 UTIs, and urinary urgency = 69 UTIs).

Based on the 108 UTI events, the incidence of UTI, weighted for over-sampling of diabetic women, was 0.07 UTI per person-year. This rate did not vary meaningfully when calculated using all 1,017 enrollees irrespective of diary use (138 UTIs). After limiting the analysis to the first UTI per woman (78 episodes), the estimated incidence was 0.06 UTI per person-year.

Timing of Sexual Intercourse and Risk of Incident Urinary Tract Infection

After adjusting for intercourse on other days of the month, the HR for UTI was 3.30 (1.44–7.58) 2 days after the reporting of intercourse in the diary compared with no reporting of intercourse. Further adjustment for diabetes changed this HR slightly (HR 3.42, 95% CI 1.49–7.80) (Table 2). The risk for UTI was higher among diabetic women compared to women without diabetes (HR 1.97, 95% CI 1.11–3.50). The risk of UTI was not elevated 1 day after intercourse or between 3 and 30 days after intercourse (HR 1.01, 95% CI 0.30–3.37 and HR 0.95, 95% CI 0.52–1.72, respectively). These relationships did not vary substantially after adjustment for other potential confounders, such as hormone replacement therapy, age, physical function, marital status, race, education, income, and smoking status. When we repeated these analyses using a diagnostic threshold of $\geq 10^4$ CFU/mL rather than $\geq 10^5$ CFU/mL with acute urinary symptoms, there were 83 women experiencing 117 UTIs. The risk of UTI 2 days after intercourse was similar to what is

presented above after including these additional UTI events (HR 3.26, 95% CI 1.43–7.43), while intercourse on other days remained unassociated with the risk of UTI.

When we limited the analysis to the 91 UTIs for which an acute urinary symptom was recorded in the diaries within 7 days of laboratory confirmation (thus omitting 17 infections with symptoms elicited by interview but not recorded in any diary entry), the hazard ratio for UTI on the second day after intercourse was 4.24 (95% CI 1.80–9.99), while the risk associated with intercourse on other days was not significantly elevated.

DISCUSSION

In this sizeable, population-based, prospective study of community-dwelling post-menopausal women, we observed a 3 to 4-fold increase in risk of symptomatic UTI on the second day after sexual intercourse. This risk varied minimally when we applied a less specific definition of UTI, included subjects who omitted entering UTI symptoms into their diaries, or adjusted for potential confounders. We did not observe an increased risk of UTI associated with intercourse 1 day after or 3 or more days after intercourse. In addition, our results indicate that the pathogenesis of acute UTI in community-dwelling post-menopausal women resembles that of younger women, with over 75% of infections caused by *E. coli*.²²

These findings add considerably to previous studies in post-menopausal women, which have shown absent or only moderately increased risks of UTI after sexual intercourse.^{2–4,10} A previous report in this same study population, which evaluated a baseline assessment of sexual intercourse in the previous month, did not identify a relationship between sexual intercourse and UTI (HR 1.0, 95% CI 0.6–1.5).² Other studies employed similar imprecise measurements of sexual intercourse: for example, sexual intercourse in the past 6 months (odds ratio [OR] 1.2, 95% CI 1.0–1.4),¹⁰ in the past 2 weeks (OR 0.9, 95% CI 0.3–2.9)³, and average sexual intercourse events per week (OR 1.4, 95% CI 1.1–1.9).⁴ These studies did not collect data on exposure and outcome concurrently, making it challenging to evaluate the precise timing between sexual intercourse and UTI in the detailed fashion of the present study, and which has been previously described in pre-menopausal women.^{7,9}

Hooton and colleagues employed diaries to collect information on sexual intercourse from 2 cohorts of young, sexually active women, 1 of which was drawn from the same health maintenance organization (HMO) as the present study. Among 448 women aged 18–40 years from the HMO cohort, the estimated risk of symptomatic UTI increased with the number of days during the previous week on which intercourse occurred (HR for 1 day, 1.24; HR for 2 days, 1.91; HR for 3 days, 2.96).⁷ In the current study, we were unable to evaluate the effect of frequency of intercourse during the week prior to the onset of infection due to the lower level of sexual activity among our participants. However, we were able to evaluate hazard ratios for UTI associated with intercourse on a specific day. A study of young, sexually active women using a clinic-based, case-control design reported a strong association between intercourse within the previous 2 days and risk of UTI (adjusted OR, 58.1, 95% CI 11.9–284.1), but risks during the first versus the second day period after intercourse were not individually reported.⁹ Thus, we examined the first and second day prior to UTI onset separately in our data. We hypothesized that the second day prior to the UTI

onset would be the most clinically relevant exposure period from the standpoint of allowing sufficient time for *E. coli* to bind to host tissue, ascend into the urinary tract, establish bacteriuria, and elicit an inflammatory host response.¹⁸ That we did not observe an increased risk of UTI associated with intercourse 1 day after or 3 or more days after intercourse is consistent with this theory.

Strengths of our study included its large sample size, population-based sampling, prospective design, excellent participant retention, and confirmation of UTI by culture. In addition, the use of diaries as a primary mode of data collection provided an accurate method for the concurrent measurement of potentially sensitive exposures such as sexual intercourse.^{23,24} In our study, the proportion of women who reported intercourse in the previous 12 months at baseline via questionnaire was similar to the proportion who reported intercourse within the first 12 months after baseline via diaries (43% and 40%, respectively), suggesting high internal validity for our diary-based reporting of sexual intercourse during study follow-up.

There were also potential limitations to the study. Correct classification of exposure and outcome depended on accurate completion of diary information. Although only 10% of participants made no diary entries and more than half completed all of their diaries for the 2-year follow-up period, there were differences between women who did and did not complete diaries with regard to ethnicity, age, self-reported physical function, and diabetes status. The difference in the proportion of diabetic women with and without diary data (19% vs 47%, respectively) was of particular concern, given the established relationship between diabetes and UTI risk.^{13,26} However, the estimated incidence rate of UTI was 0.07 per person-year both among those who completed diaries and in the entire cohort. Moreover, completing a diary was not associated with having a UTI during follow-up, and the proportion of women who reported intercourse in the previous year was similar between those women who did and did not complete diaries. Thus, the exclusion of women who failed to complete diaries may not have posed a significant source of bias.

It is possible that partial reporting could have biased our results because the primary method for designating the date of UTI onset relied, at least partially, on prompt and accurate recording of symptoms in the diary. Sixteen percent of positive cultures were not preceded by any previously recorded urinary symptom. It is possible that these women may have also failed to record intercourse, since when we limited the analysis to UTIs for which a urinary symptom was recorded in the diary, the association between intercourse and subsequent UTI risk 2 days later increased.

Finally, the study population was comprised predominantly of women who were more likely to be educated, white, and have a high level of physical functioning relative to the general US population of women of similar ages.^{1,26} However, the frequency of sexual intercourse in our study cohort was comparable to what has been reported in large surveys of women of similar age,^{12,27,28} suggesting that these findings might be generalizable to other healthy post-menopausal women. In addition, by only including culture-confirmed UTIs, we potentially excluded UTIs with diagnoses based solely on urinalysis or symptoms, possibly affecting the generalizability of our results. However, the UTI rate observed here was similar to that reported in a random-digit-dialing survey of women of similar age.²⁹ Plus, limiting the analysis to culture-confirmed UTIs was critical due

to the high background rate of asymptomatic bacteriuria and urinary symptoms in this population.³⁰

Overall, our data provide evidence that, as with younger women, sexual intercourse is strongly associated with UTI in post-menopausal women, supporting a common mechanism for infection among women of widely varying ages. This finding emphasizes the clinical importance of inquiring about recent sexual intercourse when treating post-menopausal women for symptomatic urinary tract infections. Women who have recurrent infections associated with sexual activity may be candidates for post-coital antimicrobial prophylaxis.

ACKNOWLEDGMENTS: This work was funded by the National Institute of Health (T32AI07140, RO1 DK43134, K23DK02660 (KG)). Additional support was provided by the Center for Health Studies (CHS) at the Group Health Cooperative (GHC) and the Health Services Research & Development Center of Excellence and the VA Puget Sound Health Care System (HSR&D) in Seattle, Washington. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs. The authors acknowledge Linn Abraham for her data management and statistical programming assistance. We also thank Dr. Walter Stamm for his thoughtful comments on this manuscript. A segment of this project was presented at the Infectious Disease Society of Obstetrics and Gynecology conference in Carmel, California in August, 2006.

Conflict of Interest: None disclosed.

Corresponding Author: Elya E. Moore, PhD; Murdoch Childrens Research Institute, Royal Children's Hospital, Flemington Road, Parkville, Victoria 3052, Australia (e-mail: elya.moore@mcri.edu.au).

REFERENCES

1. US Census Bureau. Female population by age, race, Hispanic or Latino origin: 2000. Available at: <http://www.census.gov/population/cen2000/phc-t9/tab03.pdf>. Accessed December 6, 2006.
2. Jackson SL, Boyko EJ, Scholes D, Abraham L, Gupta K, Fihn SD. Predictors of urinary tract infection after menopause: a prospective study. *Am J Med*. 2004;117(12):903-911.
3. Foxman B, Somsel P, Tallman P, et al. Urinary tract infection among women aged 40 to 65: behavioral and sexual risk factors. *J Clin Epidemiol*. 2001;54(7):710-718.
4. Hu KK, Boyko EJ, Scholes D, et al. Risk factors for urinary tract infections in postmenopausal women. *Arch Intern Med*. 2004;164(9):989-993.
5. Foxman B, Frerichs RR. Epidemiology of urinary tract infection: I. Diaphragm use and sexual intercourse. *Am J Public Health*. 1985;75(11):1308-1313.
6. Foxman B, Frerichs RR. Epidemiology of urinary tract infection: II. Diet, clothing, and urination habits. *Am J Public Health*. 1985;75(11):1314-1317.
7. Hooton TM, Scholes D, Hughes JP, et al. A prospective study of risk factors for symptomatic urinary tract infection in young women. *N Engl J Med*. 1996;335(7):468-474.
8. Scholes D, Hooton TM, Roberts PL, Stapleton AE, Gupta K, Stamm WE. Risk factors for recurrent urinary tract infection in young women. *J Infect Dis*. 2000;182(4):1177-1182.
9. Strom BL, Collins M, West SL, Kreisberg J, Weller S. Sexual activity, contraceptive use, and other risk factors for symptomatic and asymptomatic bacteriuria. A case-control study. *Ann Intern Med*. 1987;107(6):816-823.
10. Brown JS, Vittinghoff E, Kanaya AM, Agarwal SK, Hulley S, Foxman B. Urinary tract infections in postmenopausal women: effect of hormone therapy and risk factors. *Obstet Gynecol*. 2001;98(6):1045-1052.
11. Nicolle LE, Harding GK, Preiksaitis J, Ronald AR. The association of urinary tract infection with sexual intercourse. *J Infect Dis*. 1982;146(5):579-583.
12. Lindau ST, Schumm LP, Laumann EO, Levinson W, O'Muircheartaigh CA, Waite LJ. A study of sexuality and health among older adults in the United States. *N Engl J Med*. 2007;357(8):762-774.
13. Boyko EJ, Fihn SD, Scholes D, Abraham L, Monsey B. Risk of urinary tract infection and asymptomatic bacteriuria among diabetic and nondiabetic postmenopausal women. *Am J Epidemiol*. 2005;161(6):557-564.
14. Jackson SL, Scholes D, Boyko EJ, Abraham L, Fihn SD. Urinary incontinence and diabetes in postmenopausal women. *Diabetes Care*. 2005;28(7):1730-1738.
15. Winkens, Nelissen-Arets H, Stobberingh E. Validity of the urine dipstick under daily practice conditions. *Fam Pract*. 2003;20(4):410-412.
16. Sampsel CM, Harlow SD, Skurnick J, Brubaker L, Bondarenko I. Urinary incontinence predictors and life impact in ethnically diverse perimenopausal women. *Obstet Gynecol*. 2002;100(6):1230-1238.
17. Hooton TM. Recurrent urinary tract infection in women. *Int J Antimicrob Agents*. 2001;17(4):259-268.
18. Svanborg C, Godaly G. Bacterial virulence in urinary tract infection. *Infect Dis Clin North Am*. 1997;11(35):13-529.
19. Anderson PK, Gill RD. Cox's regression model for counting processes: a large sample study. *Ann Stat*. 1982;10:1110-1120.
20. Lin DY. Cox regression analysis of multivariate failure time data: the marginal approach. *Stat Med*. 1994;13(21):2233-2247.
21. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. *Am J Epidemiol*. 1993;138(11):923-936.
22. Ronald A. The etiology of urinary tract infection: traditional and emerging pathogens. *Am J Med*. 2002;113(Suppl 1A):14S-19S.
23. Armstrong BK, White E, Saracci R. Methods of Exposure Measurement. In: *Principles of Exposure Measurement in Epidemiology*. Oxford: Oxford University Press; 1992:22-45.23.
24. Hornsby PP, Wilcox AJ. Validity of questionnaire information on frequency of coitus. *Am J Epidemiol*. 1989;130(1):94-99.
25. Boyko EJ, Fihn SD, Scholes D, Chen CL, Normand EH, Yarbrow P. Diabetes and the risk of acute urinary tract infection among postmenopausal women. *Diabetes Care*. 2002;25(10):1778-1783.
26. McHorney CA, Kosinski M, Ware JE Jr. Comparisons of the costs and quality of norms for the SF-36 health survey collected by mail versus telephone interview: results from a national survey. *Med Care*. 1994;32(6):551-567.
27. NCOA National Council on the Aging. Healthy Sexuality and Vital Aging: Executive Summary. Washington, D.C.; 1998.
28. Patel D, Gillespie B, Foxman B. Sexual behavior of older women: results of a random-digit-dialing survey of 2,000 women in the United States. *Sex Transm Dis*. 2003;30(3):216-220.
29. Foxman B, Barlow R, D'Arcy H, Gillespie B, Sobel JD. Urinary tract infection: self-reported incidence and associated costs. *Ann Epidemiol*. 2000;10(8):509-515.
30. Van Voorhis BJ. Genitourinary symptoms in the menopausal transition. *Am J Med*. 19 2005;118(12 Suppl 2):47-53.