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# Risk Factors Associated with Acute Pyelonephritis in Healthy Women

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## Abstract

**Background—**Although most cases of acute pyelonephritis occur in otherwise healthy women, data on risk factors for this condition are lacking.

**Objective—**To evaluate infection characteristics, incidence, and risk factors associated with acute pyelonephritis in a sample of women.

**Design—**Population-based case–control study.

**Setting—**Group Health Cooperative, a prepaid health plan in Washington.

**Participants—**788 nonpregnant women, 18 to 49 years of age. Case-patients ($n$ = 242) were women with pyelonephritis who were identified from computerized databases. Controls were 546 similar-age women with no pyelonephritis diagnosis in the previous 5 years who were randomly selected from enrollment databases. Response rates for case-patients and controls were 73% and 64%, respectively.

**Measurements—**Characteristics of infection and potential risk factors for pyelonephritis, ascertained through computer-assisted telephone interview and computerized databases.

**Results—**7% of case-patients were hospitalized. *Escherichia coli* was the infecting pathogen in 85% of cases. In multivariable models, factors associated with pyelonephritis risk were frequency of sexual intercourse in the previous 30 days (odds ratio, 5.6 [95% CI, 2.8 to 11.0] for ≥3 times per week), recent urinary tract infection (UTI) (odds ratio, 4.4 [CI, 2.8 to 7.1]), diabetes (odds ratio,



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4.1 [CI, 1.6 to 10.9]), recent incontinence (odds ratio, 3.9 [CI. 2.6 to 5.9]), new sexual partner in the previous year (odds ratio, 2.2 [CI, 1.4 to 3.6]), recent spermicide use (odds ratio, 1.7 [CI, 1.1 to 2.8]), and UTI history in the participant's mother (odds ratio, 1.6 [CI, 1.1 to 2.5]). Risk factors for selected subgroups (patients ≤ 30 years of age, patients > 30 years of age, patients with no UTI history, and inpatients) were also evaluated.

**Limitations—**Potential recall bias, reliance on automated case definition criteria, and limited data on diabetes and incontinence variables.

**Conclusions—**Few nonpregnant, community-dwelling women younger than 50 years of age with pyelonephritis are hospitalized. As with cystitis in reproductive-age women, sexual behaviors and patient and family history of UTI are associated with increased pyelonephritis risk. Diabetes and incontinence also seem to independently increase the risk for pyelonephritis.

A cute pyelonephritis, a potentially severe infection of the upper urinary tract, is estimated to account for more than 250 000 office consultations with physicians and nearly 200 000 hospital admissions annually in the United States (1, 2). The vast majority of these infections occur in women, and most of these women are treated in ambulatory care settings (3). While numerous studies have evaluated factors predisposing to acute cystitis, most studies of pyelonephritis have been treatment studies or descriptive studies that focused on hospitalized patients (3– 6). To date, pyelonephritis in community-dwelling, healthy adults has not been extensively investigated, and, to our knowledge, risk factors have not been evaluated. We thus undertook a population-based, case–control study to increase our understanding of the epidemiology of acute pyelonephritis in adult women 18 to 49 years of age. Specifically, we evaluated whether the risk factors that predispose women to acute cystitis also predispose them to pyelonephritis and whether additional exposures are associated with upper urinary tract infection. The estimated incidence of infection and, among case-patients, the infecting organisms and their antimicrobial susceptibility profiles were also of interest.

## Methods

### Study Setting and Participants

We performed our study at Group Health Cooperative, Seattle, Washington, a mixed-model health maintenance organization. During study recruitment (April 2000 to October 2001), approximately 87 000 of 475 000 enrollees in Group Health Cooperative were women between 18 and 49 years of age (our target population). Group Health Cooperative's Human Subjects Committee reviewed and approved all study procedures.

We selected potential cases of pyelonephritis by using the health plan's computerized enrollment, ambulatory care, inpatient, and laboratory databases. Each month we selected all women 18 to 49 years of age who had received a diagnosis of acute pyelonephritis (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM], codes 590.1 [acute pyelonephritis, without lesion of renal medullary necrosis], 590.11 [acute pyelonephritis, with lesion of renal medullary necrosis], or 590.8 [pyelonephritis, unspecified]) and who had a positive urine culture ($\geq 10^3$ colonies of a urinary pathogen, as previously defined [7]). Because laboratory data were not available for some inpatients who were treated in affiliate hospitals, we also selected any additional inpatients with acute pyelonephritis as their primary reason for hospitalization. We reviewed 58 randomly chosen medical records of cases selected in this manner and found that 57 (98%) patients had a diagnosis of pyelonephritis, defined as a diagnosis of pyelonephritis recorded in the chart, at least 1 symptom or sign of pyelonephritis (fever, chills, severe back or flank pain, nausea or vomiting, or costovertebral angle tenderness), and antibiotic treatment consistent with

pyelonephritis. Most reviewed patients also had other symptoms of urinary tract infection (UTI).

We selected potential controls concurrently each month by sampling randomly from age-eligible women in Group Health Cooperative enrollment files; controls were frequency-matched to the case-patients by 5-year age groups.

We sent potential participants a letter that described the study and invited them to participate in a telephone interview. Interviewers began calling 1 week thereafter. During telephone screening, we excluded women who were pregnant within 12 months of the reference date (the diagnosis date for case-patients and the midpoint of the sampling month for controls), who had ever received kidney dialysis, who had had problems with their bladder or kidneys that required surgery (such as urogenic bladder or reflux) or kidney stones that did not pass or were not removed before the reference date, or who were nonambulatory at the reference date. We excluded potential control participants who reported a diagnosis of pyelonephritis within 5 years of the reference date.

We identified 386 potential case-patients during recruitment, 54 (14%) of whom were not eligible. Of the remaining 332 women, 242 (73%) agreed to participate and were interviewed, 46 (14%) declined to participate, and 44 (13%) could not be contacted. Of the 242 case-patients, 18 (7.4%) were hospitalized. We randomly selected 960 similar-age women from the enrollment database as potential controls, 109 (11%) of whom were ineligible. Of the 851 women remaining, 546 (64%) were interviewed, 163 (19%) declined, and 142 (17%) could not be contacted.

## Data Collection

After providing oral consent, participants received a 15- to 25-minute structured interview that was conducted by using computer-assisted telephone interviewing software (Raosoft, Inc., Seattle, Washington), which allowed all responses to be entered directly into a computer database. We programmed item wording, skip patterns, and range checks into the instrument to minimize errors and standardize administration. We pretested the instrument for length, flow, and comprehension. After training in the study instrument (interviewers were already experienced in epidemiologic interviewing), the project manager monitored interviewers for accuracy and completeness during initial fielding by an audit telephone line and continued periodic monitoring throughout the study. The interview included items on demographic characteristics, sexual behavior, contraceptive practices, genitourinary infection history, history of other medical conditions, and other behaviors (contraceptive practices, personal and family genitourinary infection history, history of other health conditions, and other health habits). We also asked case-patients about signs and symptoms close to their index pyelonephritis episode and collected data on infecting organism and antimicrobial susceptibility from Group Health Cooperative automated laboratory files.

## Statistical Analysis

We characterized the study group on selected variables of interest by case–control status, further characterizing the case group by symptoms and infecting organisms. We assessed data on potential risk factors of interest for their univariate association with the study outcome, pyelonephritis, by calculating odds ratios and 95% CIs. We developed multivariable logistic regression models to identify independent risk factors for pyelonephritis from univariately associated exposures and to evaluate their relative contributions. We considered variables for the models by incorporating exposures that were important in earlier studies of cystitis in this or similar populations and, in addition, considered other variables that seemed to be associated with pyelonephritis in our data set.

When several variables were highly correlated, principally sexual activity and UTI history variables, we selected 1 variable for inclusion in the model. Substitution of other related variables into the final model did not substantially alter the results. We also examined how the risk factors in the final model for the entire study group performed in selected subgroups of interest: 2 age subgroups (age ≤ 30 years and age > 30 years), women who reported no previous UTI history, and inpatients.

Because we selected this study group from a defined population, an estimated incidence of pyelonephritis may be derived with some assumptions. We determined the numerator (the estimated number of case-patients) by applying the proportion of women eligible among the contacted and screened case-patients (242 of 296 participants [81.8%]) to the remaining potential case-patients (participants who declined or could not be contacted [$n = 90$]), which yielded an estimated total number of 316 case-patients over the 19-month sampling interval. To estimate the denominator (the number of at-risk enrollees), we identified the total number of age-eligible women enrolled at the midpoint of recruitment ($n = 86\,738$) and applied the proportion of women eligible among participating controls (546 of 655 participants [83.4%]) to this estimate, which yielded an estimated 72 306 women who were eligible and at risk for pyelonephritis. We expressed the estimated rate (number of cases/at-risk women) as an annual incidence rate.

### Role of the Funding Source

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## Results

### Study Sample Characteristics

Case-patients and controls were similar with respect to age and ethnicity (Table 1). Case-patients were likely to be less educated, to report an annual household income less than $40 000, to have a history of UTI, and to report being in fair or poor health. Case-patients who were hospitalized ($n = 18$) were similar in age to the larger case-patient group but were less likely to be white (61% vs. 80%, respectively) (data not shown). The estimated annual incidence of pyelonephritis was 27.6 cases per 10 000 persons: (316/72 306)/19 months × 12 months × 10 000 = 27.6 cases per 10 000 persons.

The 2 most frequently reported symptoms among case-patients within 2 weeks of their index infection were severe back or flank pain (86%) and fever (77%); 95% of case-patients reported 1 or both of these symptoms. Many case-patients also reported cystitis symptoms (83% reported dysuria, frequency, or urgency). In the 231 case-patients with urinary isolates available, *Escherichia coli* was the causative uropathogen for 85% of infections (Table 2). Other causative organisms were *Staphylococcus saprophyticus* (3.4%), *Klebsiella species* (1.7%), *Enterobacter* species (1.3%), Proteus mirabilis (1%), and other (7.6%). Among inpatients for whom culture data were available, *E. coli* was the causative uropathogen for 6 of the 7 infections. Among E. coli isolates tested, 99% were susceptible to ciprofloxacin; 91% each to nitrofurantoin, ceftriaxone, and gentamicin; 85% to trimethoprim–sulfamethoxazole; 60% to ampicillin; and 57% to first-generation cephalosporins (Table 2).

### Risk Factors for Pyelonephritis

Many previously identified risk factors for acute and recurrent cystitis, such as sexual and contraceptive exposures and UTI history, were also associated with pyelonephritis in univariate analyses (Table 3). Sexual intercourse history variables (any sexual intercourse,

sexual intercourse in the previous 12 months, and recent frequent sexual intercourse) were among the most strongly associated variables. Other sexual and contraceptive factors associated previous 12 months, several sexual partners, oral or rectal sex in the previous month, and recent spermicide exposure.

Past, recent, and family histories of UTI were also strongly associated with pyelonephritis (Table 3).

Diabetes was not a prevalent condition, but case-patients were more than 4 times as likely to be diabetic. Among hospitalized case-patients, 16.7% reported having diabetes, compared with 5.8% of nonhospitalized case-patients. Forty-six percent of case-patients versus 22% of controls reported difficulty holding their urine in the previous month (ascertained with the following question: “Did you ever have difficulty holding your urine when you coughed, laughed, or sneezed?” [during the 30 days before the reference date]). History of chlamydial infection, recent antibiotic use, douching, or current smoking at the reference date was also associated with pyelonephritis (Table 3).

### Multivariable Models of Risk Factors

The final multivariable model for factors independently associated with pyelonephritis included frequency of sexual intercourse in the previous 30 days, a new sexual partner in the previous 12 months, spermicide use in the previous 12 months, UTI in the previous 12 months, a history of UTI in the participant's mother, a history of diabetes, and difficulty holding urine during the previous 30 days (Table 4, *model 1*). Pyelonephritis risk increased nearly 6-fold for recent frequent sexual intercourse and more than 4-fold for UTI history and diabetes. Two additional variables, rectal sex and education, were marginally associated with pyelonephritis when included in this model. Odds ratios were 2.5 (95% CI, 1.0 to 6.3; $P = 0.052$) for rectal sex (considerably reduced from univariate odds) and 1.5 (CI, 1.0 to 2.4; $P = 0.065$) for education (data not shown). Other variables examined but not multivariably associated with pyelonephritis risk were oral sex, smoking, douching, antibiotic use in the previous 30 days, marital status, and income.

The sizeable study group also allowed us to examine risk factors for pyelonephritis in several subgroups of interest (Table 4, *models 2 to 4*). Results in these subgroups were, generally, similar to those in the main model. Frequent sexual intercourse continued to be strongly and consistently associated in all models. In women 30 years of age or younger, incontinence continued to be strongly associated with pyelonephritis (odds ratio, 7.2 [CI, 3.4 to 15.0]; $P = 0.026$ for the 2-way interaction between age group and incontinence). In women older than 30 years of age, an age group that has received little study relative to younger and postmenopausal women, sexual intercourse frequency, UTI history, and diabetes were exposures with strong associations, although 2-way tests of interaction were not statistically significant.

A history of UTI (past or recent) was a predominant risk factor for pyelonephritis (Table 3 and Table 4, *model 1*). However, several other exposures in the model, such as sexual intercourse or spermicide exposure, may have increased risk for earlier UTIs. Thus, we also examined pyelonephritis risk in the women reporting no UTI history (Table 4, *model 4*). In this group, frequent sexual intercourse was the strongest predictor (odds ratio, 10.5 [CI, 3.8 to 29.1]), and participant's mother's history of UTI was somewhat more strongly associated with pyelonephritis than in the main model.

The inpatient subgroup ($n = 18$) was too small for us to reliably evaluate in the full multivariable model. However, we examined the factors in the first model for their univariate association with inpatient case status and found that, although not always

statistically significant, most point estimates were similar to those for the larger study group. An exception was diabetes history, which had the strongest univariate association. In a model that included the other 2 univariately associated variables (previous UTI and difficulty holding urine), the odds ratio for diabetes history was 11.5 (CI, 2.3 to 57.6) (data not shown).

## Discussion

The characteristics of and risk factors for acute pyelonephritis in otherwise healthy community-dwelling women are largely unevaluated (3). We designed our study to address some of the gaps in our knowledge of this common and potentially serious infection.

We found that only 7% of nonpregnant women with a diagnosis of acute pyelonephritis were hospitalized. *Escherichia coli* was the predominant infecting organism (85% of case-patients), similar to proportions reported for cystitis in this health plan and community (9–11). Approximately 85% of *E. coli* isolates were susceptible to trimethoprim–sulfamethoxazole, a figure similar to that reported in Group Health Cooperative patients with cystitis (10) but higher than that observed among ambulatory care patients with pyelonephritis from the western United States (68%) (6). Susceptibility to fluoroquinolones was 99% and 91% for gentamicin and ceftriaxone but was considerably lower for first-generation cephalosporins (57%); this finding supports the recommendation of fluoroquinolones for empirical treatment of acute pyelonephritis (8). The estimated annual incidence of pyelonephritis in this defined population, approximately 28 per 10 000 women, was about triple the available incidence estimates for similar-age hospitalized women (2, 4).

Most risk factors we identified for pyelonephritis univariately and in multivariable models were notably similar to those in young adult women with acute and recurrent cystitis and asymptomatic bacteriuria (Tables 3 and 4) (9, 11, 12–17). In multivariable assessments, sexual intercourse frequency in the past 30 days was a strong and consistent risk factor in the main model and in all subgroups examined (Table 4). These associations have been reported for sporadic and recurrent cystitis (9, 11–17). A new sexual partner in the previous 12 months and spermicide exposure, independent of sexual intercourse, also predicted increased pyelonephritis risk and have been reported as risk factors for cystitis outcomes as well (9, 11, 13, 14, 17). The mechanical action of sexual intercourse may facilitate entry of *E. coli* strains into the bladder, and both sexual intercourse and spermicide use alter the normal lactobacillus-dominant vaginal flora and facilitate *E. coli* colonization of the vagina (18, 19). Uropathogenic *E. coli* strains may, in some cases, be acquired by sexual transmission (16). These exposures, by facilitating entry of *E. coli* into the bladder, may initiate events leading to cystitis, pyelonephritis, or both.

Rectal sex was infrequently reported but was marginally associated with pyelonephritis after adjustment for vaginal intercourse and the other variables in the final model. An earlier study of cystitis also reported a univariate association with rectal sex (14). This behavior, if a part of sexual activity, may confer risk through the direct transfer of urologic pathogens from the fecal flora to the vagina. This and other more prevalent, strongly associated sexual behaviors, such as sexual intercourse frequency, new sexual partners, and spermicide use, are potentially modifiable behaviors that may contribute to pyelonephritis prevention.

A history of UTI, any and recent, has been a consistently reported risk factor for subsequent cystitis in both young adult and postmenopausal women (9, 11, 17, 20– 23). A previous UTI may predispose to subsequent UTI through behavioral, microbiological, or genetic factors. Our previous study of recurrent UTI also found increased risk in participants with mothers who had a UTI history, suggesting a role for genetic or long-term environmental exposures

(17). Both a personal and family history of UTI were strongly associated with pyelonephritis risk in this data set (Table 4).

Diabetes was not a highly prevalent condition in our study group (3.2% overall) but was among the stronger risk factors. In studies of hospitalized patients with pyelonephritis, Nicolle and colleagues (4) reported higher rates of hospitalization in Manitoba, Canada, for diabetic women, although Foxman and colleagues (2) did not observe this in U.S. patients. Diabetes, particularly pharmacologically treated diabetes, has been reported as a risk factor for cystitis in postmenopausal women (20–22). The mechanisms through which diabetes may predispose to UTI are not yet understood, but 1 study has reported an increased prevalence of asymptomatic vaginal *E. coli* colonization among postmenopausal diabetic women who are receiving insulin treatment (24). Colonization may be mediated by greater adherence of type 1 fimbriated *E. coli* to uroepithelial cells of diabetic women or may be related to impaired cytokine secretion and reduced polymorpho-nuclear inflammatory response (25). Additional studies of these phenomena in women with diabetes would be informative and may lead to useful prevention strategies.

A surprisingly high proportion of participants overall (29.5%) reported difficulty holding urine in the previous 30 days, and this was consistently and statistically significantly associated with increased pyelonephritis risk (Table 4). Risk was independent of UTI history and diabetes status and was seen in both age groups and among women with no UTI history. Of interest, in our study group, incontinence was most strongly associated with pyelonephritis in women 30 years of age or younger. Raz and colleagues (5) noted incontinence as a common sign or symptom in women hospitalized for pyelonephritis, but incontinence was infrequently reported for those younger than 50 years of age. Incontinence has also been reported as a risk factor for cystitis in peri- and postmenopausal women (21–23, 26). In 1 study, urge incontinence was associated with UTI in postmenopausal women (21). Our survey item addresses stress incontinence, the most common type of incontinence across all ages (27). Further study of urinary incontinence (duration, type, proximity to infection, frequency, and amount) would help determine whether this is a marker for a related factor, is a symptom of early upper urinary tract infection, or is acting to increase pyelonephritis risk.

Strengths of our study are its size, which allowed us to examine and quantify the independent contribution of several risk factors in the study group as a whole and in subgroups of interest; the inclusion of a population-based comparison group, thereby avoiding the potential biases of clinic- or hospital-based controls; and identification of laboratory-confirmed cases in a defined population. Our sampling frame also allowed for a rate estimation and determination of the proportion of ambulatory versus hospitalized patients.

Limitations of our study include the potential for recall bias, as our participants were asked to remember back from an identified reference date. However, we identified most cases within 4 to 6 weeks of infection. Thus, most reference dates were in the recent past, and participants were usually asked to recall events proximal in time to that date (usually within 1 year or 1 month). Our only source of information on family history of UTI, our variable with the most missing data, came from participant self-report. Our case definition criteria relied on an automated algorithm, and some case-patients may not have had pyelonephritis. However, our chart review provided strong evidence for the accuracy and validity of this approach. We also did not collect detailed data on diabetes duration, treatment, and control, and our data on incontinence were limited. Given their possible importance in women with pyelonephritis, the potential pathophysiologic roles of these variables merit further exploration. Finally, we could not obtain the urinary isolates from these patients to evaluate

the potential role of microbial virulence determinants. In summary, our investigation found the predominant risk factors, the spectrum of infecting organisms, and antimicrobial susceptibility patterns for patients with pyelonephritis to be similar to those described for women with cystitis. These findings support the view that the pathogenesis of pyelonephritis usually involves ascent of infecting organisms through the bladder to the kidneys. Thus, the development of a symptomatic or asymptomatic bladder infection—attributable to many of the same risk factors— is probably the initial step in the pathogenic process culminating in acute pyelonephritis. The host and microbial factors that underlie progression from bladder to kidney infection require further investigation. Two conditions, diabetes and incontinence, were associated with increased pyelonephritis risk independent of other identified risk factors and may offer insights into why infection occurs in some women.

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**Context**

Little information is available about risk factors for pyelonephritis among healthy, community-dwelling women.

## Contribution

In a population-based case–control study of women with pyelonephritis 18 to 49 years of age, intercourse history variables, including frequency, new sexual partners, and spermicide use, were strongly associated with pyelonephritis. Personal and family histories of urinary tract infection, presence of diabetes, and stress incontinence were also associated with pylonephritis on multivariable analysis. *Escherichia coli* was the predominant infecting organism.

### Implications

Risk factors for pyelonephritis were similar to those for acute and recurrent cystitis and asymptomatic bacteriuria, supporting the concept that pyelonephritis is usually caused by the ascent of organisms from the bladder.

## Table 1

### Participant Characteristics by Case–Control Status*

| Variable | Case-Patients (*n* = 242) | Controls (*n* = 546) | *P* Value |
|---|---|---|---|
| Age, % | | | >0.2 |
| 18–30 y | 47.1 | 42.7 | |
| 31–49 y | 52.9 | 57.3 | |
| Mean age ± SE, *y* | 32.1 ± 9.7 | 33.2 ± 9.9 | 0.18 |
| Race or ethnicity, % | | | >0.2 |
| White | 79.3 | 78.4 | |
| Asian | 8.3 | 7.3 | |
| Black | 4.6 | 4.4 | |
| Other | 7.9 | 9.9 | |
| Unmarried, % | 58.1 | 50.6 | 0.19 |
| High school education or less, % | 30.3 | 22.2 | 0.01 |
| Household income < $40 000, % | 44.3 | 36.7 | 0.05 |
| Self-reported fair or poor health, % | 15.7 | 7.3 | <0.001 |
| History of pregnancy, % | 66.9 | 59.7 | 0.05 |
| Previous UTIs, % | | | <0.001 |
| 0 | 31.0 | 50.7 | |
| 1–4 | 43.5 | 37.2 | |
| ≥5 | 25.5 | 12.1 | |

* UTI — urinary tract infection.

## Table 2

### Causative Organism and Antimicrobial Susceptibility in 231 Women with Pyelonephritis*

| Antimicrobial Agent | Causative Organism Susceptible to Antimicrobial Agent, *n* (%)† | | | |
|---|---|---|---|---|
| | ***Escherichia coli* (*n* = 199 [85%])** | ***Staphylococcus saprophytics* (*n* = 8 [3%])** | **Other‡ (*n* = 27 [12%])** | **Total§ (*n* = 234 [100%])** |
| Ampicillin | 111 (60) | – | 3 (33) | 114 (59) |
| Ceftriaxone | 168 (91) | – | 8 (100) | 176 (91) |
| Cephalothin | 113 (57) | 4 (50) | 5 (56) | 122 (56) |
| Ciprofloxacin | 189 (99) | – | 9 (90) | 198 (99) |
| Gentamicin | 175 (91) | 8 (100) | 10 (100) | 193 (91) |
| Nitrofurantoin‖ | 173 (91) | 8 (100) | 4 (40) | 185 (89) |
| Trimethoprim–sulfamethoxazole | 165 (85) | 8 (100) | 7 (78) | 180 (85) |

*"Susceptibility" is neither resistance nor intermediate resistance. Missing data are not included in denominator.

†Causative organisms were *Escherichia coli* (*n* = 199 [85%]), *Staphylococcus saprophyticus* (*n* = 8 [3%]), and other (*n* = 27 [12%]), yielding a total of 234 causative organisms.

‡"Other" includes *Proteus mirabilis, Klebsiella* species, *Enterobacter* species, and *Enterococcus* species.

§*n* = 234 organisms (3 women with 2 organisms).

‖Not indicated for treating pyelonephritis (8).

## Table 3
## Association of Selected Variables with Pyelonephritis*

| Variable† | Case-Patients, % (*n* = 242) | Controls, % (*n* = 546) | Odds Ratio (95% CI) | *P* Value |
|---|---|---|---|---|
| **Unmarried** | 58.1 | 50.6 | 1.4 (1.0–1.8) | 0.05 |
| **Parity** | | | | |
| 1 | 12.0 | 14.3 | 1.0 (0.6–1.6) | |
| ≥2 | 46.3 | 37.6 | 1.4 (1.0–2.0) | 0.07 |
| **Sexual activity** | | | | |
| Ever had sexual intercourse | 98.8 | 91.2 | 7.6 (2.4–24.7) | <0.001 |
| Sexual intercourse in the previous 12 mo | 95.4 | 82.5 | 4.4 (2.3–8.4) | <0.001 |
| Sexual intercourse in the previous 30 d | | | | |
| >3 times/wk | 53.4 | 54.9 | 3.3 (1.9–5.8) | <0.001 |
| ≥3 times/wk | 39.3 | 20.2 | 6.7 (3.7–11.9) | <0.001 |
| ≥5 sexual partners in lifetime | 55.1 | 44.4 | 1.5 (1.1–2.1) | 0.01 |
| New sexual partner in the previous 12 mo | 32.9 | 15.8 | 2.6 (1.8–3.7) | <0.001 |
| ≥2 sexual partners in the previous 12 mo | 24.2 | 12.5 | 2.2 (1.5–3.3) | <0.001 |
| Oral sex in the previous 30 d | 62.5 | 46.0 | 2.0 (1.4–2.7) | <0.001 |
| Rectal sex in the previous 30 d | 7.7 | 1.9 | 4.4 (2.0–9.6) | <0.001 |
| **Contraceptive practices** | | | | |
| Any spermicide use in the previous 12 mo | 28.7 | 17.2 | 1.9 (1.3–2.8) | <0.01 |
| Spermicide-coated condoms in the previous 12 mo | 26.5 | 15.8 | 1.9 (1.3–2.8) | <0.001 |
| Any spermicide use in the previous 30 d | 15.2 | 10.8 | 1.5 (1.0–2.4) | 0.12 |
| Oral contraceptive use in the previous 12 mo | 24.8 | 24.7 | 1.0 (0.7–1.4) | >0.2 |
| **Genitourinary infection history** | | | | |
| Age ≤ 15 y at first UTI | 10.2 | 8.6 | 1.2 (0.7–2.0) | >0.2 |
| Any previous UTI | 69.4 | 49.7 | 2.3 (1.7–3.2) | <0.001 |
| UTI in the previous 12 mo | 36.4 | 9.1 | 5.7 (3.9–8.5) | <0.001 |
| UTI in the previous 30 d | 17.5 | 1.7 | 12.5 (6.0–26.1) | <0.001 |
| **Family history** | | | | |
| History of UTI, mother | 38.6 | 21.6 | 2.3 (1.6–3.2) | <0.001 |
| History of UTI, sister‡ | 42.4 | 33.6 | 1.5 (1.0–2.2) | 0.06 |
| History of UTI, any child‡ | 30.9 | 19.6 | 1.8 (1.2–2.9) | 0.01 |
| **History of other health or medical conditions** | | | | |
| Diabetes | 6.6 | 1.6 | 4.2 (1.8–9.7) | <0.001 |
| Difficulty holding urine in the previous 30 d§ | 45.9 | 22.2 | 3.0 (2.1–4.1) | <0.001 |
| Chlamydial infection | 12.8 | 7.9 | 1.7 (1.0–2.8) | 0.03 |
| Other STD | 28.1 | 30.8 | 0.9 (0.6–1.2) | >0.2 |
| Hypertension | 9.9 | 6.4 | 1.6 (0.9–2.8) | 0.09 |
| Any antibiotic use in the previous 30 d | 15.8 | 8.1 | 2.1 (1.3–3.4) | <0.01 |
| **Other health habits** | | | | |
| Douching in the previous 30 d | 15.7 | 9.4 | 1.8 (1.1–2.8) | 0.01 |

| Variable[†] | Case-Patients, % (*n* = 242) | Controls, % (*n* = 546) | Odds Ratio (95% CI) | *P* Value |
|---|---|---|---|---|
| Smoking in the previous 30 d | 36.8 | 24.8 | 1.8 (1.3–2.4) | <0.001 |
| Alcohol consumption in the previous 30 d | 71.4 | 67.0 | 1.2 (0.9–1.7) | >0.2 |

[*] STD = sexually transmitted disease; UTI = urinary tract infection.

[†] For most variables, data were missing because of unknown reasons or because participants declined to answer for ≤2% of participants. Variables with higher percentages of missing values were income (3% missing); sexual intercourse frequency in the previous 30 d (3% missing); oral sex in the previous 30 d (3% missing); rectal sex in the previous 30 d (2% missing); spermicide use in the previous 12 mo (3% missing); and history of UTI, mother (8% missing).

[‡] Among participants with sister or child.

[§] Assessed as: “Did you ever have difficulty holding your urine when you coughed, laughed, or sneezed?” (during the 30 d before the reference date).

## Table 4

## Factors Associated with Pyelonephritis: Multivariable Models*

| Factor | Model 1 (All Participants)† Odds Ratio (95% CI) | Model 2 (Participants Age 18-30 y)‡ Odds Ratio (95% CI) | Model 3 (Participants Age > 30 y)§ Odds Ratio (95% CI) | Model 4 (Participants with No UTI History)‖ Odds Ratio (95% CI) |
|---|---|---|---|---|
| **Sexual intercourse in the previous 30 d** | | | | |
| None | Referent | Referent | Referent | Referent |
| <3 times/wk | 2.9 (1.5–5.5) | 3.6 (1.4–9.2) | 3.2 (1.2–8.6) | 2.5 (0.9–6.9) |
| ≥3 times/wk | 5.6 (2.8-11.0)¶ | 6.0 (2.3–15.7)** | 6.4 (2.2-18.4)¶ | 10.9 (3.9-30.4)¶ |
| **New sexual partner in the previous 12 mo** | | | | |
| No | Referent | Referent | Referent | Referent |
| Yes | 2.2 (1.4–3.6)** | 1.7 (0.9–3.2) | 3.5 (1.6–7.5)** | 2.2 (1.0–4.8) |
| **Spermicide exposure in the previous 12 mo** | | | | |
| No | Referent | Referent | Referent | Referent |
| Yes | 1.7 (1.1-2.8)†† | 1.8 (0.9–3.3) | 1.5 (0.7–3.2) | 1.8 (0.9–4.0) |
| **UTI in the previous 12 mo** | | | | |
| No | Referent | Referent | Referent | Not in model |
| Yes | 4.4 (2.8-7.1)¶ | 2.4 (1.2–4.7)†† | 7.7 (3.9-15.5)¶ | |
| **Mother with UTI history** | | | | |
| No | Referent | Referent | Referent | Referent |
| Yes | 1.6 (1.1-2.5)†† | 2.0 (1.1-3.9)†† | 1.7 (1.0–2.9) | 3.2 (1.5–6.8)** |
| **Diabetes** | | | | |
| No | Referent | Referent | Referent | Referent |
| Yes | 4.1 (1.6–10.9)** | 2.3 (0.4–15.4) | 5.2 (1.6–17.5)** | 1.4 (0.04–4.0) |
| **Difficulty holding urine in the previous 30 d** | | | | |
| No | Referent | Referent | Referent | Referent |
| Yes | 3.9 (2.6-5.9)¶ | 7.2 (3.4-15.0)¶ | 3.0 (1.8-5.1)¶ | 3.7 (1.7-8.1)¶ |

*Models are based on women with complete data for all variables. Model 1 is missing 13%; model 2 is missing 13.5%; model 3 is missing 11.8%; and model 4 is missing 12.1%. UTI = urinary tract infection.

†Model 1: 205 case-patients and 484 controls; adjusted for age (18–30 y and 31–49 y).

‡Model 2: 92 case-patients and 208 controls.

§Model 3: 113 case-patients and 276 controls. Model 4: 60 case-patients and 245 controls; adjusted for age (18–30 y and 31–49 y).

‖Model 4: 60 case-patients and 245 controls; adjusted for age (18–30 y and 31–49 y).

¶$P < 0.001$.

**$P < 0.01$.

††$P < 0.05$.