MAJOR ARTICLE

Trichomonas vaginalis Infection in Male Sexual Partners: Implications for Diagnosis, Treatment, and Prevention

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(See the editorial commentary by Van Der Pol on pages 23–5)

Background. *Trichomonas vaginalis* causes a common sexually transmitted infection (STI) in women, yet trichomoniasis in male sexual partners is not well recognized. Nucleic acid amplification tests can increase detection of *T. vaginalis* in men compared with culture.

Methods. We conducted a prospective, multicenter study to evaluate *T. vaginalis* infection among male partners of women with trichomoniasis and factors associated with infection by recruiting patients from 3 public clinics in the United States. Male partners were tested for concordant *T. vaginalis* infection, defined as a positive urethral culture, urine culture, or urine polymerase chain reaction (PCR) result. A subset of men also provided a semen sample for *T. vaginalis* culture and PCR. Factors associated with concordant infection were determined from bivariable and multivariable analyses.

Results. We enrolled 540 women with trichomoniasis (diagnosed using wet mount microscopy and/or culture) and 261 (48.4%) of their male partners. *T. vaginalis* infection was detected in 177 (71.7%) of 256 male partners (95% confidence interval [CI], 66.0%–77.3%), of whom 136 (77.3%) were asymptomatic. A vaginal pH of >4.5 in a woman was independently associated with infection in the male partner (adjusted odds ratio, 2.5; 95% CI, 1.0–6.3). Younger male age (20–29 and 30–39 years) was also found to be an independent risk factor for concordant trichomoniasis.

Conclusions. The majority of male partners of women with trichomoniasis were infected; however, few factors predicted infection. *T. vaginalis* causes a highly prevalent STI, necessitating vastly improved partner management, application of sensitive nucleic-acid based testing, and better clinical recognition.

Trichomonas vaginalis causes an estimated 174 million sexually transmitted infections (STIs) annually worldwide [1], yet the protozoan receives limited attention in clinical practice and STI-control efforts. Among women, the prevalence of trichomoniasis is estimated to have a range of 3%–48% [2– 4], and vaginitis is a frequent manifestation. However, *T. vaginalis* infection is seldom diagnosed in men, primarily because of insensitive diagnostic tests [5].

T. vaginalis has been associated with adverse outcomes in women, including pelvic inflammatory disease, cervical intraepithelial neoplasia, and preterm delivery [6–8]. In addition to urethritis, untreated *T. vaginalis* infection may result in epididymitis, prostatitis, and infertility in men [9]. Trichomoniasis may also increase transmission of HIV by 2- to 3-fold [10, 11].

Investigations conducted >40 years ago reported *T. vaginalis* infection in up to 45% of male partners of infected women and 100% of female partners of infected men [12–16]. However, these studies frequently involved marital partners, few subjects, and microscopy and culture detection. Although considered the "gold standard" for *T. vaginalis* diagnosis, cultures are limited by low sensitivity and the requirement of microscopic evaluation up to 5 days after inoculation. Nucleic acid amplification tests (NAATs) for detection of *T. vaginalis*

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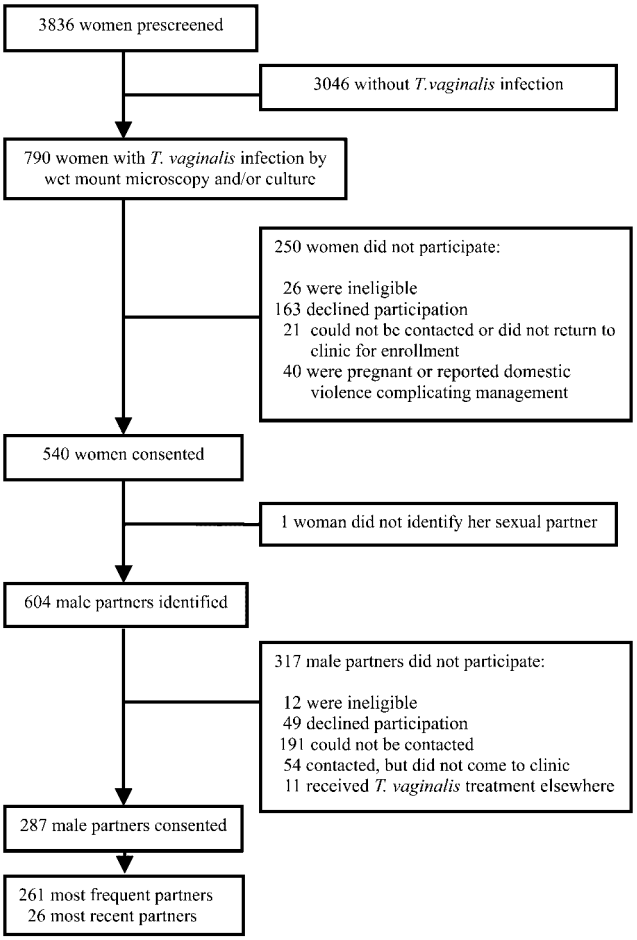

Figure 1. Flow chart of study patients recruited from sexually transmitted disease clinics and enrolled in a study of *Trichomonas vaginalis* infection.

have been developed, with sensitivities ranging from 85% to 100% [17–19]. The extent of concordant *T. vaginalis* infection among sexual partners in the United States has not been estimated using NAATs.

We conducted a prospective, multicenter study of women with trichomoniasis and their male partners who presented to sexually transmitted disease (STD) clinics in the United States to determine the proportion of concordant *T. vaginalis* infection using cultures and PCR of male urethral, urine, and semen specimens. Clinical and behavioral data were evaluated to ascertain possible associations with concordant trichomoniasis among sexual partners.

PATIENTS AND METHODS

Study population. We conducted a prospective, cross-sectional study in 3 health department STD clinics located in Durham and Raleigh, North Carolina, and Birmingham, Alabama. Women were prescreened by vaginal Gram stain, wet mount microscopy (WM), and *T. vaginalis* culture if they were ⩾18 years old, spoke English, and had no history of prescreening or study enrollment. Women with positive WM results were immediately recruited; women whose WM results were negative but whose *T. vaginalis* culture yielded positive results were contacted and recruited during the return visit. Infected women were eligible if they reported having had vaginal sex in the past 60 days and no metronidazole use in the previous 4 weeks.

Enrolled women with trichomoniasis were asked to provide the names and locating information of their most frequent and most recent sexual partners. The "most frequent" partner was the partner with whom the woman had the greatest number of sexual encounters in the preceding 60 days; the "most recent" sexual partner was the partner with whom the subject last had sex prior to enrollment. Women were asked to notify partners using standard notification cards. Partners who did not come to the clinic within 48 h were contacted by research personnel for evaluation and treatment. Male partners who presented to the clinics with the women or within 30 days of their partners' enrollment were recruited. Eligible male partners were ⩾18 years of age and spoke English.

Women provided verbal consent for the prescreening process; all enrolled subjects provided written informed consent. The study was approved by and conducted in accordance with the ethical standards of the institutional review boards of the University of North Carolina at Chapel Hill and the University of Alabama at Birmingham.

Clinical data and specimen collection. Women underwent routine evaluations, including vaginal WMs and testing for *Chlamydia trachomatis, Neisseria gonorrhoeae,* and syphilis. Chlamydia testing was targeted to women aged ⩽25 years at one clinic [20]. HIV testing by EIA was routinely offered to all clinic patients. Vaginal swabs were collected from women to perform Gram stains and *T. vaginalis* InPouch cultures (Biomed Diagnostics) during the prescreening period. Research personnel collected data from medical records and administered questionnaires regarding women's symptoms, sexual behaviors, and relationships.

Men underwent standard evaluation, including urethral Gram stain and syphilis serologic testing, and were offered HIV testing. An additional urethral specimen was obtained for immediate *T. vaginalis* culture inoculation. Approximately 20 mL of first-catch urine was collected for *T. vaginalis* culture and PCR and for *N. gonorrhoeae* and *C. trachomatis* PCR (Roche Diagnostics). Semen specimens, which were collected before the commencement of treatment from men who could provide a specimen within 24 h of enrollment, was tested for *T. vaginalis* by culture and PCR. Questionnaires were administered to male subjects regarding symptoms and sexual behaviors.

Laboratory analyses. Vaginal smears were sent to the University of Alabama at Birmingham for Gram staining, and patterns of vaginal flora were interpreted using the criteria of

Table 1. Demographic characteristics of women with trichomoniasis and their male partners enrolled in the study.

Characteristic	No. (%) of subjects		
	All women (n = 540)	Women with partners (n = 261)	Male partners (n = 261)
Age, years			
<20	54 (10.0)	25 (9.6)	14 (5.4)
20–24	143 (26.5)	67 (25.7)	62 (23.8)
25–29	94 (17.4)	41 (15.7)	52 (19.9)
30–39	145 (26.9)	77 (29.5)	65 (24.9)
⩾40	104 (19.3)	51 (19.5)	68 (26.0)
Race/ethnicity			
Black	503 (93.2)	247 (94.6)	255 (97.7)
White	32 (5.9)	12 (4.6)	2 (0.8)
Hispanic	2 (0.4)	1 (0.4)	4 (1.5)
Asian/Pacific Islander	0 (0.0)	0 (0.0)	0 (0.0)
Other	3 (0.6)	1 (0.4)	0 (0.0)
Marital status			
Single, never married	389 (72.0)	180 (69.0)	182 (69.7)
Separated, divorced, or widowed	100 (18.5)	50 (19.2)	34 (13.0)
Married	51 (9.4)	31 (11.9)	45 (17.2)
Education			
<12 years of education	9 (1.7)	3 (1.2)	9 (3.4)
High school or equivalent	368 (68.2)	179 (68.6)	170 (65.1)
Some college or higher degree	163 (30.2)	79 (30.3)	80 (30.7)

Nugent et al. [21]. *T. vaginalis* cultures were read daily up to 5 days after inoculation. A positive culture result was defined as the presence of ⩾1 motile trichomonads at any reading day; a negative culture result was defined as the absence of motile trichomonads at all readings. *T. vaginalis* PCR was performed at the University of North Carolina at Chapel Hill and the University of Alabama at Birmingham by research personnel blinded to WM and culture results. Oligonucleotide primers TVK3 and digoxigenin-labeled TVK7 were used to amplify a multiple-copy target sequence in the *T. vaginalis* genome. PCR products were detected using the digoxigenin ELISA detection kit (Roche Diagnostic Systems) and ELISA controls, as described elsewhere; the laboratory methods are also described in detail elsewhere [22].

Data analyses. Clinical and laboratory data were double-entered into an SAS database (SAS Corporation). We estimated the prevalence of *T. vaginalis* infection among women who were prescreened. We conducted descriptive analyses of the study population by determining frequencies of demographic and clinical characteristics. Variables with >20% missing data were not included in the multivariable analyses.

Because all enrolled women in the analyses were infected, we defined the primary study outcome as concordant *T. vaginalis* infection in the male partners, as determined by a positive urethral swab culture, urine culture, or urine PCR result. Among a subset of male partners who provided a semen sample for *T. vaginalis* culture and PCR, a secondary outcome was concordant trichomoniasis indicated by any specimen that yielded positive results. We calculated 2-sided 95% CIs for the prevalence of trichomoniasis and concordance using exact binomial methods.

We identified factors potentially associated with concordant infection from previously reported associations with trichomoniasis. Continuous variables were categorized using clinically meaningful cut points. We conducted bivariable analyses for female, male, and "partner factors" to determine associations with concordant infection, and we calculated prevalence ORs with 95% CIs. Partner factors were determined from women who were questioned about characteristics of their sexual relationships. We conducted multivariable analyses using unconditional logistic regression. Factors with a P value <.20 in the bivariable analysis were entered into a multiple logistic regression model. To describe potential associations of factors with concordant *T. vaginalis* infection, we estimated adjusted prevalence ORs (AORs) with 95% CIs from the regression procedure.

RESULTS

During the period from November 2001 through July 2003, a total of 3836 women were prescreened for trichomoniasis in

Table 2. Presenting symptoms, signs, and coinfections among women and their male partners with *Trichomonas vaginalis* infection.

Characteristics	Women (n = 261)	Male partners (n = 177)
Symptom		
Asymptomatic or no symptoms	70 (26.8)	136 (76.8)
Vaginal or penile discharge	153 (58.6)	21 (11.9)
Vaginal itching or penile tingling	86 (33.0)	13 (7.3)
Vaginal odor or smell	95 (36.4)	NA
Dysuria or painful urination	21 (8.0)	13 (7.3)
Lower abdominal pain	49 (18.8)	2 (1.1)
Sign		
Normal vaginal/cervical or urethral examination findings	23 (8.9)	125 (70.6)
Purulent, mucopurulent, or yellow-green vaginal/urethral discharge	82 (31.5)	14 (7.9)
White or clear vaginal/urethral discharge	137 (52.5)	37 (20.9)
Purulent or mucopurulent cervical discharge	21 (8.0)	NA
Strawberry cervix	14 (5.4)	NA
Fishy vaginal odor	120 (46.9)	NA
Abnormal vaginal pH (>4.5)	200 (82.0)	NA
Abnormal urethral Gram stain finding[a]	NA	60 (33.9)
Coinfection or coexisting condition, *n/N* (%)[b]		
None[c]	34/119 (34.5)	49/65 (75.4)
Bacterial vaginosis[d]	134/251 (53.4)	NA
Chlamydia trachomatis[e]	27/208 (13.0)	19/174 (10.9)
Neisseria gonorrhoeae[e]	28/256 (10.9)	18/175 (10.3)

NOTE. Data are no. (%) of subjects with specific characteristics, unless otherwise indicated. Infection among the male partners was defined as urethral culture, urine culture, or PCR positive for *T. vaginalis*. NA, not applicable.

[a] Defined as ⩾5 polymorphonuclear cells per high-power field.

[b] The denominators vary depending on the availability of specimens collected from female and male subjects.

[c] Defined as test results negative for bacterial vaginosis, *C. trachomatis, N. gonorrhoeae,* syphilis, and HIV.

[d] Defined as vaginal Gram stain score of ⩾7 by the criteria of Nugent et al. [21].

[e] For women, testing for *C. trachomatis* was conducted by EIA, DNA hybridization, or ligase chain reaction; testing for *N. gonorrhoeae* was conducted by culture or DNA hybridization.

the 3 STD clinics (figure 1). A total of 790 women with *T. vaginalis* infection were identified by WM and/or culture results, resulting in an estimated prevalence of 20.6%. Five hundred forty infected women (68.4%) were enrolled, the majority of whom identified only 1 man as their most frequent and most recent sexual partner. Because of the small number of most recent partners enrolled (figure 1), subsequent analyses were limited to the 261 most frequent partners to ensure that the statistical assumption of independence was met.

Demographic characteristics. Most of the enrolled women with trichomoniasis and their partners were black in race/ethnicity and not married (table 1). The median age was 29 years (range, 18–69 years) for women and 30 years (range, 18–79 years) for men. Demographic characteristics of the 261 women whose sexual partners were enrolled were similar to those of women whose partners were not enrolled.

Clinical characteristics of women with trichomoniasis. Among the 261 infected women with enrolled partners, 153 (58.6%) reported vaginal discharge, and 70 (26.8%) were asymptomatic (table 2). The majority of women (82.0%) had a high vaginal pH (>4.5). Approximately one-half of the women had concomitant bacterial vaginosis, defined as a Nugent score ⩾7 on the vaginal Gram stain. One hundred forty-two women (54.4%) underwent HIV testing, and HIV infection was diagnosed in 1.4%.

One hundred seventy-nine women with enrolled partners (68.6%) reported having 1 sexual partner in the previous 60 days. Women reported a median relationship duration of 2 years (range, 1 day to 40 years) and an average of 3 episodes of vaginal intercourse per week with their most frequent partners. More than one-half of the women (58.6%) reported a history of trichomoniasis.

T. vaginalis *infection among male sexual partners.* The proportion of specimens that tested positive for *T. vaginalis* from the male partners varied by specimen type and detection method (figure 2). Urine PCR detected more *T. vaginalis* infections in men than any other method. Of the 247 male partners who provided specimens for urethral culture, urine culture, and PCR, 177 (71.7%; 95% CI, 66.0%–77.3%) had trichomoniasis, compared with 40 men (15.6%; 95% CI, 11.2%–

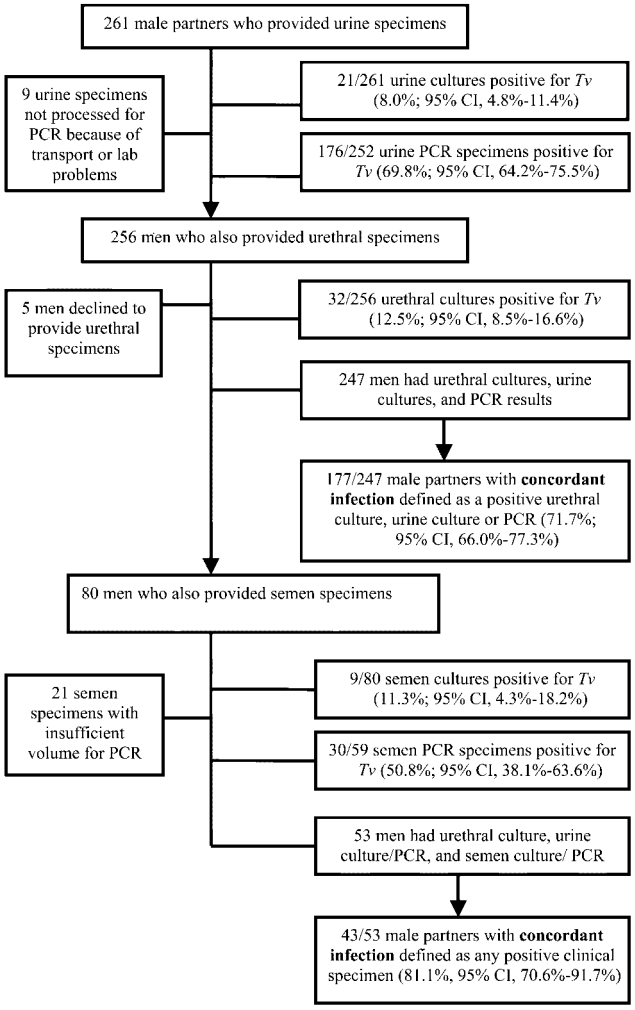

Figure 2. Rate of positivity for specimens tested for *Trichomonas vaginalis (Tv)* and concordant infection among male sexual partners.

20.1%) who were identified by urethral or urine culture results alone. Among 53 men who also provided semen, 81.1% (95% CI, 70.6%–91.7%) had concordant *T. vaginalis* infection, defined as any specimen that yielded positive results.

Clinical characteristics of male partners with trichomoniasis. Among 177 men with trichomoniasis, 136 (76.8%) were asymptomatic, and a minority reported penile discharge (table 2). Thirty-seven infected men (20.9%) had a urethral discharge, and 60 (33.9%) had ⩾5 WBCs per high-power field on the urethral Gram stain indicative of urethritis. Approximately 10% of men were coinfected with either *C. trachomatis* or *N. gonorrhoeae*. Sixty-nine men (39.0%) underwent HIV testing; none were found to be HIV positive.

Ninety-three men (52.5%) with *T. vaginalis* infection reported having had ⩾1 sexual partner in the past 60 days. Almost one-half (48.6%) reported a history of gonorrhea, and 20.7% reported prior diagnosis or treatment for trichomoniasis.

Bivariable analyses. Women with trichomoniasis who had a vaginal pH >4.5 were twice as likely to have infected male partners (table 3). Other factors among women, including age, marital status, symptoms, vaginal/cervical findings, douching, and number of sexual partners, were not significantly associated with concordant infection. Trichomoniasis in the male partner was not predicted by a suspected higher organism burden in the woman (indicated by WM detection or rapid *T. vaginalis* growth in culture). Concordant bacterial vaginosis, gonorrhea, or chlamydia in a woman was not associated with concordant infection in the male partner.

Male circumcision was associated with almost a 2-fold increased likelihood of trichomoniasis. Other factors among men, including age, marital status, urethral signs or symptoms, number of sexual partners, and coinfections, were not significantly associated with trichomoniasis. Urination within 30 min after sex (perceived as "cleaning" the urethra) was reported by 72% of male partners but was not protective against *T. vaginalis* infection.

Partners with a shorter time interval (0–1 day) between the female and male subjects' enrollment dates were twice as likely to have concordant infection as partners with a time interval >7 days. However, concordant *T. vaginalis* infection was not associated with other partner factors, including the duration of the sexual relationship, number of sexual acts, sex during menstruation, use of hormonal birth control, or condom use.

Multivariable analyses. After controlling for other variables, an abnormal vaginal pH in the woman remained independently associated with concordant *T. vaginalis* infection in the male partner (AOR, 2.5; 95% CI, 1.0– 6.3; $P = .05$) (table 3). Younger age of men was independently associated with concordant trichomoniasis. Compared with men aged ⩾40 years, the odds of *T. vaginalis* infection were nearly 4-fold higher among male partners who were aged 30–39 years ($P = .02$). Circumcision in the male partner and a shorter time interval between partners' enrollment dates were not independently associated with concordant *T. vaginalis* infection after adjustment for other factors.

DISCUSSION

Trichomoniasis is a common genitourinary infection, with high prevalence rates among women [1, 4, 23]. Although trichomoniasis is not a reportable disease, the Centers for Disease Control and Prevention estimated that there were 221,000 physician visits for trichomoniasis by women 15–44 years of age in the United States in 2004 [24]. Although *T. vaginalis* has been established as an STI for nearly half a century, women with vaginitis are not routinely tested, and men rarely have trichomoniasis diagnosed in most clinic practices. A study conducted among physicians at a clinic for vulvovaginal disorders found that 42% did not perform microscopy in their evaluation [25]. Even among US public health laboratories, which are a critical component of STI control, only 6% perform *T. vaginalis*

Table 3. Bivariable and multivariable analysis of factors potentially associated with concordant *Trichomonas vaginalis* infection among male partners.

Factor[a]	*n*/*N*[b]	Unadjusted OR (95% CI)[c]	Adjusted OR (95% CI)[d]
Factors for women			
Age, years			
>40	34/47	1	…
30–39	50/72	0.9 (0.4–2.0)	…
20–29	76/104	1 (0.5–2.3)	…
<20	17/24	0.9 (0.3–2.8)	…
Marital status			
Married	23/28	1	1
Single, never married	119/172	0.5 (0.2–1.4)	0.3 (0.1–2.3)
Separated, divorced, or widowed	35/47	0.6 (0.2–2.0)	0.5 (0.1–4.6)
Symptoms of vaginitis[e]			
No	50/73	1	…
Yes	127/174	1.2 (0.7–2.3)	…
Vaginal pH			
⩽4.5	16/24	1	1
>4.5	148/192	2.2 (1.1–4.6)	2.5 (1.0–6.3)
Vaginal Gram stain score[f]			
0–3	11/14	1	…
4–6	67/97	0.6 (0.2–2.3)	…
⩾7	92/127	0.7 (0.2–2.7)	…
Cervical examination finding			
Absence of any cervical findings	98/143	1	1
Presence of cervical discharge, erythema, friability, or strawberry cervix	79/104	1.5 (0.8–2.6)	2.0 (0.9–4.4)
T. vaginalis detection			
Positive by culture only	24/40	1	1
Positive by wet mount and culture	144/195	1.9 (0.9–3.8)	0.8 (0.4–1.6)
T. vaginalis culture positivity			
Positive after reading day 1	49/73	1	…
Positive on reading day 1	119/162	1.4 (0.7–2.5)	…
Coexisting bacterial vaginosis[g]			
No	78/111	1	…
Yes	92/127	1.1 (0.6–2.0)	…
Coinfection with *Chlamydia trachomatis*			
No	132/172	1	1
Yes	17/27	0.5 (0.2–1.2)	0.4 (0.1–1.2)
Coinfection with *Neisseria gonorrhoeae*			
No	151/215	1	…
Yes	21/27	1.5 (0.6–3.9)	…
History of prior *T. vaginalis* infection			
No	75/97	1	1
Yes	98/145	0.6 (0.3–1.1)	0.9 (0.3–2.8)
No. of new sexual partners in the past year			
0	72/96	1	1
1	66/84	1.2 (0.6–2.5)	1.5 (0.6–3.8)
⩾2	39/67	0.5 (0.2–0.9)	1.0 (0.4–2.4)
Factors for men			
Age, years			
⩾40	40/63	1	1
30–39	48/62	2.0 (0.9–4.3)	3.8 (1.3–11.4)
20–29	80/108	1.6 (0.8–3.2)	2.9 (1.0–8.8)
<20	9/14	1.0 (0.3–3.5)	1.6 (0.3–9.1)
Marital status			
Married	31/40	1	1
Single, never married	119/174	0.6 (0.3–0.4)	0.5 (0.1–2.4)

(continued)

Table 3. ***(Continued.)***

Factor[a]	*n*/*N*[b]	Unadjusted OR (95% CI)[c]	Adjusted OR (95% CI)[d]
Separated, divorced, or widowed	27/33	1.3 (0.4–4.2)	2.2 (0.4–14.0)
Circumcision status			
Uncircumcised	67/104	1	1
Circumcised	110/143	1.8 (1.1–3.2)	1.2 (0.6–2.7)
Symptoms of urethritis[h]			
No	137/94	1	…
Yes	40/53	1.3 (0.6–2.6)	…
Urethral Gram stain finding			
0–4 PMNs/HPF	117/167	1	…
⩾5 PMNs/HPF	60/80	1.3 (0.7–2.4)	…
Coinfection with *C. trachomatis*			
No	155/216	1	…
Yes	19/26	1.1 (0.4–2.7)	…
Coinfection with *N. gonorrhoeae*			
No	157/220	1	…
Yes	18/24	1.2 (0.5–3.2)	…
No. of new sexual partners in the past year			
0	58/81	1	1
1	41/66	0.7 (0.3–1.3)	0.7 (0.3–1.9)
⩾2	77/99	1.4 (0.7–2.7)	1.2 (0.5–3.2)
Partner factors			
Duration of sexual relationship, years			
>2	80/111	1	…
1–2	16/21	1.2 (0.4–3.7)	…
<1	81/115	0.9 (0.5–1.6)	…
Average no. of sexual acts per week			
1	64/88	1	…
2–3	65/92	0.9 (0.5–1.7)	…
>3	43/62	0.9 (0.4–1.7)	…
Condom use in the past 2 months			
Almost every time/every single time	31/43	1	…
Some of the time	24/33	1.0 (0.4–2.9)	…
Almost none of the time	121/169	1.0 (0.5–2.1)	…
Time between enrollment of male and female subjects			
>7 days	37/60	1	1
2–7 days	63/86	1.7 (0.8–3.5)	1.5 (0.6–3.7)
0–1 day	76/97	2.3 (1.1–4.6)	1.8 (0.7–4.7)

NOTE. HPF, high-power field; PMN, polymorphonuclear cell.

[a] Other factors that were analyzed in the bivariable analyses but were not found to be significant or included in the table were as follows: factors for women: duration of the vaginal discharge, presence of abnormal vaginal discharge or erythema on examination, douching in the past 2 months, and number of sexual partners in the past 2 months; factors for men: presence of urethral discharge or erythema on examination, and number of sexual partners in the past 2 months; and partner factors: hormonal birth control use and reported sex during menstruation.

[b] Data are no. of concordant partner pairs/total no. of partner pairs in each category.

[c] Cells with the value 1 indicate that the partner pairs with this characteristic served as the referent group.

[d] Empty cells indicate that these factors had a $P > .20$ in the bivariable analyses and were therefore not included in multivariable analyses.

[e] Symptoms associated with vaginitis include vaginal discharge, vaginal odor, and vaginal itching.

[f] Vaginal Gram stain scoring was conducted by the criteria of Nugent et al. [21], with scores of 0–3 indicating normal flora and scores of 4–6 indicating intermediate vaginal flora.

[g] Bacterial vaginosis was diagnosed by the criteria of Nugent et al. [21] on the basis of a vaginal Gram stain score ⩾7.

[h] Symptoms associated with urethritis include penile discharge, penile tingling, and pain/burning with urination.

culture [26]. NAATs for *T. vaginalis* are only available in a few clinical research settings.

Recommendations for management of trichomoniasis in sexual partners [20] derive from earlier investigations involving microscopy and cultures. With use of urethral swabs, urine sediment, and prostatic fluid, *T. vaginalis* was identified in 45% of male partners of infected women in the 1960s [13]. This study involved examination of cultures after only 48 h and may have underestimated the rate of trichomoniasis among male partners, because culture results often do not become positive before 3–5 days of incubation [22]. More recently, 22% of male partners were found to have *T. vaginalis* infection using multiple culture specimens in a study involving 1 STD clinic [27].

In our multicenter study, we optimized *T. vaginalis* detection by using culture and PCR with multiple specimens obtained from the male sexual partners of women with trichomoniasis. Urine cultures detected *T. vaginalis* infection in 8% of male partners, whereas urine PCR demonstrated infection in 70%. Semen PCR also detected a high proportion of infection but was limited to a subset of men who provided specimens for analysis. Using a combination of urethral cultures, urine cultures, and urine PCR, 72% of male partners were found to have trichomoniasis—a rate that is considerably higher than previously reported estimates. A study involving NAATs among STD clinic attendees aged 15–25 years found trichomoniasis in only 7 (37%) of 19 sexual partners of infected index subjects [28], but this study was limited by a small sample size and, possibly, by the inclusion of partners with fewer sexual exposures than the men in our study.

Although other *T. vaginalis* detection methods are commercially available, these assays are currently limited to women. A point-of-care *T. vaginalis* antigen test (OSOM Trichomonas Rapid Test; Genzyme) has a reported sensitivity of 78%–83%, compared with WM [29]. A nonamplified nucleic acid–based test (Affirm VP System; Becton-Dickinson) that uses oligonucleotide probes for *T. vaginalis, Gardnerella vaginalis,* and *Candida* species from a single vaginal swab is also available, with a sensitivity of 80%–90% and specificity of 95% [30]. In men, NAATs for *T. vaginalis* can significantly increase organism detection and can be applied using noninvasive specimens [18, 19].

We examined clinical or behavioral factors that might direct targeted screening of male sexual partners for trichomoniasis. Only 12% of infected men had penile discharge, and 34% had evidence of urethritis. These findings are nonspecific and cannot distinguish trichomoniasis from other STIs. Men aged 20–29 and 30–39 years had a 2–4-fold increased risk of *T. vaginalis* infection, compared with men aged ⩾40 years, who had a smaller proportion of infection than the other 2 age groups (table 3). Although other studies have reported an association between ⩾30 years of age and trichomoniasis in men [31, 32], the behavioral and biological factors in different age groups that may increase risk for *T. vaginalis* infection are unknown.

We also sought to identify factors among sexual partners that might predict male *T. vaginalis* infection. Surprisingly, we found no relationship between the reported duration of the sexual relationship, average number of sexual acts, or condom use with concordant *T. vaginalis* infection. Others have demonstrated that condom use can significantly reduce the risk of acquiring trichomoniasis [33]. Thirty-seven percent of female subjects reported condom use with their male partners; however, the protective effect of condoms may have been underestimated by overreporting of use or by improper use.

The only factor among women that predicted *T. vaginalis* infection in the male partner was a high vaginal pH. Other female factors, including a higher organism burden in a woman indicated by WM positivity, were not significantly associated with trichomoniasis in the male partner after adjustment for other factors. *T. vaginalis* is known to produce amine during growth, resulting in an elevated pH [34]. In vitro, the organism grows optimally in an anaerobic environment with pH levels of 6.0–6.3 [35]. *T. vaginalis* can also reduce *Lactobacillus* species levels in vitro, resulting in elevated pH [36]. The mechanisms by which higher vaginal pH or alterations in *Lactobacillus* levels in women might facilitate *T. vaginalis* acquisition or transmission remain unclear.

Concomitant STIs are frequently detected in persons with trichomoniasis [28], and 10%–13% of women and their male partners with trichomoniasis in this study were coinfected with *N. gonorrhoeae* or *C. trachomatis.* These observations suggest that individuals with gonorrhea or chlamydia, which are more often diagnosed than trichomoniasis, should also undergo *T. vaginalis* evaluation.

The current study had several limitations. Although we attempted to minimize selection bias, we were unable to enroll all eligible men and women who presented to the clinics during the study period. Data analyses were limited to the most frequent sexual partners of women with trichomoniasis, and we enrolled only 48% of male partners, despite making additional partner notification efforts. Other investigators have noted spontaneous clearing of *T. vaginalis* infection in a small proportion of infected men [13]; this may have occurred in some male subjects, leading us to underestimate the rate of concordant infection. We conducted our investigation in 3 STD clinics located in the southeastern United States, which has higher STI rates than other regions of the country [24]. Therefore, our results may not be generalizable to other clinic populations.

Using PCR, we demonstrated that the majority of male partners of women with trichomoniasis were infected despite the absence of symptoms. The high prevalence of trichomoniasis in our male subjects and among men in other clinic populations [31, 32, 37] suggest that control of this epidemic will require

increased diagnosis and treatment of *T. vaginalis* infection in men. Notification and management of sexual partners of women with trichomoniasis are not routinely conducted outside of public clinics, and strategies to enhance these activities are urgently needed. In addition, *T. vaginalis* screening of at-risk men and women should be considered in light of the extent of asymptomatic disease. Substantial evidence has already accrued regarding the high prevalence of trichomoniasis and its associated morbidity, prompting concerns regarding its impact worldwide [38–40]. Improved *T. vaginalis*–control efforts are imperative and require better disease recognition, clinical application of sensitive nucleic acid–based tests, and management of sexual partners.

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