Published in final edited form as:

Sex Transm Dis. 2009 December ; 36(12): 738–744. doi:10.1097/OLQ.0b013e3181b38a4b.

Trichomoniasis and Other Sexually Transmitted Infections: Results from the 2001–2004 NHANES Surveys

Jenifer E. Allsworth, PhD¹, Jane Alyce Ratner, BS¹, and Jeffrey F. Peipert, MD, PhD¹

¹ Division of Clinical Research, Department of Obstetrics and Gynecology, Washington University in St. Louis School of Medicine, St. Louis, Missouri

Abstract

Background—To estimate the association between *Trichomonas vaginalis* infection (TV) and six sexually transmitted infections: chlamydia, gonorrhea, herpes simplex virus (Types 1 and 2), syphilis and HIV in a nationally representative sample.

Methods—We used data from the National Health and Nutrition Examination Survey (NHANES) combining the 2001–2002 and 2003–2004 waves to estimate the association between TV and STIs among women in the civilian, non-institutionalized US population. The final sample included data from 3,648 women, which when weighted, represents the experience of 65,563,298 US women between the ages of 14 and 49. Crude and adjusted relative risks were estimated using logistic regression for rare STIs (< 10%; chlamydia, syphilis and human immunodeficiency virus (HIV)) and Poisson regression for common STIs (herpes simplex virus (HSV) types 1 and 2). Statistical analyses were conducted using Stata (version 9.2).

Results—The prevalence of trichomoniasis was 3.2% with over 80% of cases asymptomatic in the past month. All STIs examined (chlamydia, gonorrhea, HSV-1, HSV-2, syphilis and HIV) were more common among women with a positive test for trichomoniasis. HSV-1 (RR = 1.20, 95% CI 1.09, 1.34) and HSV-2 (RR = 1.51, 95% CI 2.32, 3.23) were significantly associated with trichomoniasis after adjusting for race/ethnicity, age and recent sexual partners. In crude analyses, a positive treponemal test was 6 times (95% CI 2.07, 18.8) more common and HIV was 13 times (95% 2.88, 59.1) more common among women with trichomoniasis, but these estimates were greatly attenuated after adjustment for potential confounders.

Conclusion—Trichomoniasis is significantly associated with concurrent STI.

Keywords

Trichomoniasis; Sexually Transmitted Infection; Epidemiology

Introduction

Trichomoniasis, a sexually transmitted infection (STI) caused by the protozoa *Trichomonas vaginalis* (TV), is the most common curable STI in young, sexually active women.¹ Estimates from the 2001–2004 National Health and Nutrition Examination Survey (NHANES) found that 3.1% of women in the US have TV making it more common than gonorrhea and chlamydia combined.² Another nationally representative study found that 2.8% of women 18–26 years were positive for trichomoniasis.³ Trichomoniasis was more

Address correspondence to: Jenifer E. Allsworth, PhD, Assistant Professor, Division of Clinical Research, Department of Obstetrics and Gynecology, Washington University in St. Louis School of Medicine, Campus Box 8219, 4533 Clayton Avenue, Suite 100, St. Louis, Missouri 63110, allsworthj@wudosis.wustl.edu, Telephone: 314-747-6434, Fax: 314-747-4019.

common in black women with a prevalence ranging from 10.5 to 13%,^{2, 3} as well as in women who had not received education beyond high school (6.3%) and those living below the poverty level (5.4%).² TV infections differ from other STIs in that the prevalence increases with increasing age among women under the age of 50.²

Trichomoniasis has often been considered a relatively benign infection, but given its association with other STIs, particularly human immunodeficiency virus (HIV) and preterm delivery it is an important public health problem.^{3–6} For example, Klebanoff and colleagues found that treatment of TV during pregnancy significantly reduced active infection, but did not reduce preterm delivery and, in fact, may have been associated with an *increased* risk of preterm delivery.⁷ Disentangling whether TV these associations are causal or simply the result of confounding by high risk sexual behaviors or other risk factors is essential.

Coinfection of TV with other STIs is common; associations between TV infection and chlamydia, gonorrhea, syphilis, and herpes simplex virus-type 2 (HSV-2) have been described.^{3, 8, 9, 10} The correlation between increased risk of HIV transmission and TV infection has been well supported by the literature. HIV appears to be transmitted more easily with TV infection; studies have shown that treatment of TV reduces viral shedding^{11, 12} and potentially HIV transmission. Despite the risks associated with TV infection, trichomoniasis is not a reportable disease and often is not included in routine testing (although may be detected during routine Pap testing).¹³

In this study, we examined the cross-sectional association between TV and six STIs: chlamydia, gonorrhea, HSV types 1 and 2, syphilis and HIV. Our analyses used the 2001–2004 NHANES data. We hypothesized that other STIs would be associated with the presence of trichomoniasis even after controlling for important confounding factors among a representative sample of reproductive aged women.

Materials and Methods

Design and study population

We used data from the NHANES 2001–2002 and 2003–2004 surveys to estimate the association between TV and STIs among women in the civilian, non-institutionalized U.S. population. NHANES was designed to obtain nationally representative information on the health and nutritional status of the population of the US through interviews and direct physical examinations. Methods describing this survey have been published elsewhere.¹⁴ This study was approved by the Washington University School of Medicine Human Research Protection Office.

Trichomoniasis—Vaginal swabs were collected for the detection of *Trichomonas vaginalis*. Detection was completed by performing polymerase chain reaction (PCR) testing with primers from a region of the 18S rRNA gene that produces a 312 base pair product. A sample was considered positive if it yielded a 102 base pair fragment after PCR amplification that was recognized by the *Trichomonas*-specific DNA probe upon Southern blot hybridization. A small percentage of swabs (2%) were categorized as not interpretable if both *Trichomonas* and beta-globulin were negative. The sensitivity and specificity for this test both exceed 97%.¹⁵

Chlamydia—Urine samples were analyzed for the presence of *C. trachomatis* via assay with LCR TM (ligase chain reaction) amplification technology in the LCx Probe System. Urine specimens were required to be first catch and specimens that were moderately bloody or grossly mucoid were unacceptable.¹⁶ The sensitivity and specificity of this test using urine samples from women were 80.5 and 98.4%.¹⁷

Neisseria gonorrhoeae—*N. gonorrhoeae* was evaluated from the same urine sample as chlamydia. This assay used LCR TM (ligase chain reaction) amplification technology in the LCx Probe System for the direct, qualitative detection of a specific target nucleic acid sequence in the Opa gene of *N. gonorrhoeae*.¹⁶ The sensitivity and specificity of this test using urine samples from women were 84.9 and 99.4%.¹⁷

Syphilis—Multiple approaches were used for the detection of syphilis. The Captia Syphilis-G enzyme immunoassay (EIA) was used as an indirect method for the detection of IgG antibodies to *Treponema pallidum*. If positive or equivocal, the rapid plasma reagin (RPR) was used to screen for syphilis. The Serodia TP-PA test detected antibodies to the various species and subspecies of pathogenic *Treponema*. In this analysis, a test was positive if there was evidence recent or remote infection (positive or equivocal EIA plus one of the following: RPR ≥ 8 or RPR 0 to 8 and TP-PA positive).¹⁸ The sensitivity of the Captia Syphilis-G EIA test is excellent (98.3%).¹⁹ Additionally, a recent study found 97.7% agreement with the microhemagglutination assay for *Treponema pallidum*.²⁰

HIV—Specimens were tested for HIV-1 and HIV-2 antibodies using the Synthetic Peptide Enzyme Immunoassay. Specimens that were reactive in both tests were tested with the Cambridge Biotech HIV-1 Western Blot Kit (Calypse Biomedical Corporation, Rockville, MD). If the EIA and Western Blots results did not agree, the Western result was used.²¹

HSV-1 and HSV-2—Viral glycoproteins specific for HSV-2 (designated gG-2) and HSV-1 (designated gG-1) have been identified. Solid-phase enzymatic immunodot assays were used to detect antibodies reactive to these antigens,²² which has demonstrated good sensitivity and discriminates HSV-1 and HSV-2.²³ Serum samples testing positive for HSV-2 in the immunodot assay were further confirmed by a gG-2 monoclonal antibody inhibition assay.²⁴

Potential Confounders—We examined a number of potential confounders including socio-demographic characteristics and reproductive and sexual history. Confounders were identified via prior published associations or significant associations ($p < 0.05$) in univariate regression models. Age was included as a confounder due to prior published evidence of an association. Self-reported sociodemographic characteristics included in these analyses included: age (14–19, 20–29, 30–39 and 40–49), race/ethnicity (White, non-Hispanic; Black, non-Hispanic, Mexican American; or other race/other Hispanic), birthplace (US, Mexico or elsewhere), marital status (married; divorced, widowed or separated; never married; or living with a partner), education (<high school, completed high school (or GED), >high school), and poverty/income ratio (< federal poverty level (PIR < 1), PIR 1 to < 2, or PIR ≥ 2).

Reproductive history variables included: age at first intercourse, STI history, use of hormonal birth control, pregnancy history, douching and vaginal symptoms in the past month. Age at first menstruation was categorized as 7–11, 12–14, 15 years or later, or unknown. Douching was defined as any douching within the past 1 or 6 months and vaginal problems were defined as any itching, odor or discharge in the last month. History of self-reported STI was defined two ways: 1) lifetime diagnosis genital herpes or warts or 2) diagnosis of gonorrhea or chlamydia in the last 12 months. A limitation of the NHANES dataset is that it did not include questions on lifetime history of gonorrhea or chlamydia. Hormonal birth control was defined as ever used birth control pills, injectable contraception or other female hormonal contraception. Pregnancy history was described as ever pregnant, currently pregnant or self-reported delivery of a low-birth weight infant (< 5.5 pounds). NHANES also collects information on prescription medication use in the last month using a medication inventory method. We created an antibiotic use variable that was defined as any antibiotic recommended for treatment of any of the STIs analyzed in this study (amoxicillin,

ampicillin, azithromycin, ciprofloxacin, doxycycline, erythromycin, levofloxacin, metronidazole, ofloxacin, or penicillin).

Women 14–49 also completed a sexual history questionnaire that included questions on history of sexual intercourse, and lifetime and last year sexual partners. However, due to confidentiality concerns, sexual history data for individuals between the ages of 14–19 are only available at the National Center for Health Statistics Research Data Center. Therefore, all analyses including these variables were limited to women 20–49 years.

Statistical Methods: Categorical data were compared using chi-square tests. Odds ratios for associations with trichomoniasis and potential confounders were estimated using logistic regression. Crude and adjusted relative risks for the association of individual STIs and trichomoniasis were estimated using logistic regression for rare STIs (<10%; chlamydia, syphilis and HIV) and Poisson regression with robust error variance for common STIs (HSV 1 and 2).²⁵ Statistical analyses were conducted using Stata (version 9.2).²⁶ The two-year individual weights estimated by the National Center of Health Statistics and made available as part of the NHANES dataset are adjusted to the entire US population based on 2000 Census information. To accommodate the joining of 2001–2002 and 2003–2004 datasets, each adjusted to the US population; the weight for each individual was divided by 2 to provide a single estimate for the entire US population.

Results

For these analyses, women between the ages of 14 and 49 with trichomoniasis data were included. A total of 998 women were excluded from the analyses due to missing data for trichomoniasis. Women with information on trichomoniasis were at lower risk for STI than those without based on common risk factors; they were older (27.4 years (standard deviation (SD) 10.9) vs. 26.1 years (SD 10.2), $p < 0.001$), were less likely to be African-American (13% vs. 17%, $p < 0.01$), and more likely to have a high school education (53% vs. 44%, $p < 0.01$). Women in the analytic sample had more lifetime sexual partners (mean 8.7 (SD 47) vs. 6.2 (SD 9), $p = 0.11$), but this difference was not statistically significant. They also did not differ significantly in marital status, age at first sexual intercourse, number of sexual partners in the last year or in poverty status. The final sample included data from 3,648 women, which when weighted, represents the experience of 65,563,298 U.S. women between the ages of 14 and 49.

The prevalence of trichomoniasis was 3.2 percent with 85% of cases reporting no vaginal symptoms in the past month. The prevalence did not vary significantly with age, but did vary with race, country of birth, marital status, education and poverty level (see Table 1). Notably, trichomoniasis was 12 times more prevalent among African-American women. Trichomoniasis was more common among women with younger ages at first intercourse and more lifetime and last year sexual partners. The prevalence was significantly higher among those with a history of genital herpes or warts (7.5% vs. 2.9%, $p < 0.01$). Similarly, trichomoniasis was more common, but not significantly so, among women reporting gonorrhea or chlamydia in the past 12 months (9.2 vs. 3.3%, $p = 0.09$). Trichomoniasis was more common in women who had ever been pregnant or had a low birth weight infant, but there was no difference among women currently pregnant (2.8 vs. 3.2%, $p = 0.66$) compared to non-pregnant women. While trichomoniasis was not more prevalent among women reporting vaginal symptoms (3.6 vs. 3.2%), such as itching, unusual discharge or odor in the past month, the prevalence of trichomoniasis was approximately five times higher among women who had douched in the past month (10.2 vs. 2.1%; OR 5.75, 95% (CI 3.97–8.33)) or past 6 months (8.9 vs. 1.7%; OR 5.30, 95% CI (3.71–7.57)). TV was more common

among women with co-occurring STIs (Figure 1) and ranged from 4.2% among women with HSV-1 to 29.7% among HIV-positive women.

All STIs examined (chlamydia, HSV-1, HSV-2, syphilis and HIV) were more common among women with positive for trichomoniasis. The prevalence of chlamydia was 3.7% among trichomoniasis positive women and 2.2% among negative women ($p=0.21$). Chlamydia was significantly more common among TV-positive women 25 years of age and younger than TV-negative women (10.2% vs. 2.4%, $p = 0.01$), but there was no difference between those with versus without TV among older women (0.7% v s. 0.8%, $p=0.94$). The crude relative risk of chlamydia associated with TV infection was 1.79 (95% CI (0.76–4.22)). After adjustment for race/ethnicity, age and number of sexual partners in the last year, this effect was greatly attenuated and remained not significant (Table 3).

The prevalence of HSV-1 was significantly higher among TV-positive women when compared to TV-negative women (83.5% vs. 58.2%, $p<0.01$; Table 2). HSV-1 was less common among younger women, but this disparity was evident in women 14–25 as well as those 26 and older. In an unadjusted analysis the risk of HSV-1 was 43% more common in the presence of trichomoniasis. This effect was attenuated somewhat after adjustment for race/ethnicity, age and recent sexual partners, but remained statistically significant (RR = 1.20, 95% CI (1.09–1.34)).

Likewise, the prevalence of HSV-2 was higher among women who had trichomoniasis than among women who did not (65.1% and 23.8%, $p < 0.001$). As with HSV-1, HSV-2 was less common among younger women (Table 2). For HSV-2, however, the age-specific impact of trichomoniasis appeared to vary. HSV-2 was more than 4 times more common among TV-positive women (47.4% vs. 10.1%) in younger women; while in older women HSV-2 was slightly more than twice as common (67.4% vs. 28.3%). The increased risk of HSV-2 associated with TV was 2.74 (95% CI (2.32–3.23); Table 3), but this was attenuated after the adjustment for race/ethnicity, age and recent sexual partners (RR = 1.51, 95% CI (1.20–1.89)).

Due to the striking racial disparities in the prevalence of TV (discussed in detail by Sutton and colleagues²) we were also interested in examining these associations stratified by race/ethnicity. Unfortunately, given the constraints of the sample size and complex survey design, we were not powered to conduct adjusted analyses, but were able to examine univariate associations (data not shown). Of note, there were too few events among non-Hispanic white and Mexican American women to make inferences about chlamydia, gonorrhea, past syphilis or HIV infection. For all racial groups, women with TV had significantly rates of HSV-2 than those without. A similar finding was observed for HSV-1 for White and Black women, but not Mexican American women. Among Mexican American women 82.5% women with TV were positive for HSV-1 compared with 80.8% among those without TV).

Finally, the prevalences of both a positive treponemal test (3.5% vs. 0.6%, $p < 0.001$) and HIV (2.4% vs. 0.2%, $p < 0.001$) were significantly higher among women with trichomoniasis (Table 2). Small sample size prohibited us from examining this association among younger women, but these findings both persisted among women 26 years and older. In crude analyses, a positive treponemal test was 6 times (95% CI (2.07–18.8)) and HIV was 13 times (95% CI (2.88–59.1)) more common among women with trichomoniasis (Table 3). After adjustment, these effects were significantly attenuated, but again, small sample size limited our inferences from these models.

Discussion

In this analysis of a representative sample of women in the US, the prevalence of trichomoniasis was 3.2% with more than 80% of cases reporting no vaginal symptoms. TV infection was associated with co-infection with HSV-1, HSV-2, HIV, and with having syphilis in the past. The associations between trichomoniasis and HSV-1 and HSV-2 remained statistically significant after adjusting for race/ethnicity, age, and number of sexual partners in the past year.

Co-infection of HSV-2 and TV has been shown in the past. In a prospective cohort study of female sex workers in Kenya, the association of HSV-2 and trichomoniasis was examined and the incidence risk ratio for TV infection with HSV-2 was 2.3.²⁷ Interestingly, there are no other studies, to our knowledge, that have shown an association between TV and HSV-1. The association between trichomoniasis and HSV-1 is modest after adjustment, however, this is likely an underestimate of the true association because diagnosis of HSV-1 was determined through serological testing. Serological testing does not allow differentiation among infection sites or transmission pathways. Given that there is little biologic plausibility for the association of oral HSV-1 and vaginal trichomoniasis, it is possible that the association of genital HSV-1 and TV is even greater than our estimate. Testing the infection site and transmission pathway is important in getting a true estimate of the association as multiple recent studies have found a shifting proportion genital herpes cases attributable to HSV-1.^{28–32}

Stark racial disparities in TV prevalence have been documented in examination of this sample² as well as other population-based studies.³ Sample size prevented stratified analysis, but we found that HSV-2 was more common in TV-positive women among all racial/ethnic groups. HSV-1 was more common among TV-positive women among White and Black women, but not Mexican American women. The rate of HSV-1 for Mexican American was high compared to White and Black women and similar irrespective of TV status, but comparable to estimates generated from NHANES.³¹

The association between chlamydia and TV infection also proves to be interesting. When looking at all women in our analysis there was not a clear association between these two infections, however when categorized by age, an important risk factor for chlamydial infection, the younger and higher risk age group (14 – 25) showed a statistically significant correlation of TV infection with chlamydia. It is possible that when combined with the low prevalence group of women 26 years of age and older, the effect estimate was attenuated, not accurately reflecting the prevalence in either age group. In a study by Datta and colleagues that used an earlier wave of NHANES (1999–2001) similar dampening of chlamydia rates were seen. Their results showed that in women aged 14 – 19 the prevalence of chlamydia was 4.6%, but among older aged women chlamydia prevalence was found to 1.9% with an overall rate of 2.5%.³³

A relationship between trichomoniasis and syphilis as well as HIV was also seen. However, upon adjusting for race/ethnicity and age the relationship was no longer significant. This may be due to small sample size and confounding factors that play a role in HIV and syphilis transmission and acquisition. The correlation of TV infection and HIV has been well-documented and therefore may still be clinically important regardless of confounders. As additional waves of NHANES data are released this should be studied further.

It is hypothesized that TV infection may lead to easier acquisition of HIV or that TV and HIV co-infection may increase transmission to sexual partners. Infection with TV recruits a local cellular immune response leading to an increased number of white blood cells in the genital region and also often causes lesions in the genital region; the presence of white blood

cells and lesions can increase acquisition allowing for easier entry of HIV and also having an increased number of target cells. This may also work to increase viral shedding by making viral exiting easier.^{34, 35} The association could possibly be due to immunosuppression associated with HIV that may lead to becoming infected with TV more readily.⁴

One of the strengths of our study is that the data are generalizable to the population of reproductive aged females in the US. Women eligible for this analysis were at slightly lower risk for STI based on demographic characteristics and lifetime number of sexual partners than the entire sample, possibly reflecting participation bias. As most studies of coinfection with TV are in higher risk populations, such as women attending STI clinics, this study provides important information on women in the general population who may be low risk for STIs or may not seek health care. Finally, the method used to diagnose trichomoniasis was PCR detection, which is the most sensitive measure of TV infection.³⁶

Our study was cross-sectional in design and therefore it was not possible to establish temporality between trichomoniasis and concurrent STI. Therefore, it cannot be established whether TV leads to increased infection with other STIs, or if the other STIs increase TV infection. There are multiple possible mechanisms through which TV may increase the risk of subsequent STI. TV may increase infection through genital lesions and/or recruitment of white blood cells to the site of infection. TV may increase vaginal pH reducing defense mechanisms against sexually transmitted infections.³⁷ An additional, non-causal explanation could be that STIs are concurrent due to sexual risk factors that increase the overall risk of infection. Moreover, as a cross-sectional study we have limited information on recent receipt of antibiotics, which may explain the low prevalences of chlamydia and gonorrhea which are screened for during routine care and easily treated. Another potential limitation could include non-differential misclassification of STIs, particularly of chlamydia (which has a sensitivity of 80.5 and specificity of 98.4, respectively) that may have biased the results towards the null. Moreover, as a number of the STIs examined were not curable, this study may be influenced by incidence-prevalence bias, a form of selection bias. Certain demographic and reproductive characteristics at the time of the survey may (e.g. age or number of recent sexual partners) have changed since the time of viral infection. And finally, due to the rare outcomes of HIV and syphilis, there was inadequate power to determine whether or not inferences could be made about TV co-infection.

Trichomoniasis is the most common STI. It is typically asymptomatic and is associated with concurrent STIs among women in the general population. The associations we have found in this cross-sectional association were modest, but given that non-differential misclassification may have led to underestimation of associations and the prevalence of genital herpes infections, there may be significant public health impact. Given this association it is important to rethink whether this infection should be included in targeted STI screening in high-risk women. The implications for adverse outcomes with TV suggest that more routine testing for TV infection should be considered. Recognizing this infection may help prevent further infection with other STIs and may help avoid adverse reproductive outcomes.

Acknowledgments

This research was supported in part by a Midcareer Investigator Award in Women's Health Research (K24 HD01298), by a Clinical and Translational Science Awards (UL1RR024992), and by Grant Number KL2RR024994 from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH) and NIH Roadmap for Medical Research. Its contents are solely the responsibility of the authors and do not necessarily represent the official view of NCRR or NIH. Information on NCRR is available at <http://www.ncrr.nih.gov/>. Information on Re-engineering the Clinical Research Enterprise can be obtained from <http://nihroadmap.nih.gov/clinicalresearch/overview-translational.asp>.

References

1. Weinstock H, Berman S, Cates W. Sexually transmitted disease among American youth: Incidence and prevalence estimates, 2000. *Perspect Sex Reprod Health*. 2004; 36:6–10. [PubMed: 14982671]
2. Sutton M, Sternberg M, Koumans EH, et al. The prevalence of *Trichomonas vaginalis* infection among reproductive-age women in the United States, 2001–2004. *Clin Infect Dis*. 2007; 45(10): 1319–1326. [PubMed: 17968828]
3. Miller WC, Swygard H, Hobbs MM, et al. The prevalence of trichomoniasis in young adults in the United States. *Sex Transm Dis*. 2005; 32(10):593–598. [PubMed: 16205299]
4. Schwebke JR, Burgess D. Trichomoniasis. *Clin Microbiol Rev*. 2004; 17(4):794–803. [PubMed: 15489349]
5. Laga M, Manoka A, Kivuvu M, et al. Non-ulcerative sexually transmitted diseases as risk factors for HIV-1 transmission in women: results from a cohort study. *AIDS*. 1993; 7(1):95–102. [PubMed: 8442924]
6. Fouts AC, Kraus SJ. *Trichomonas vaginalis*: reevaluation of its clinical presentation and laboratory diagnosis. *J Infect Dis*. 1980; 141(2):137–143. [PubMed: 6965976]
7. Klebanoff MA, Carey JC, Hauth JC, et al. Failure of Metronidazole to Prevent Preterm Delivery among Pregnant Women with Asymptomatic *Trichomonas vaginalis* Infection. *N Engl J Med*. 2001; 345:487–493. [PubMed: 11519502]
8. Lo M, Reid M, Brokenshire M. Epidemiological features of women with trichomoniasis in Auckland sexual health clinics: 1998–99. *N Z Med J*. 2002; 115(1159):U119. [PubMed: 12362164]
9. Shuter J, Bell D, Graham D, et al. Rates of and risk factors for trichomoniasis among pregnant inmates in New York City. *Sex Transm Dis*. 1998; 25(6):303–307. [PubMed: 9662764]
10. Gottlieb SL, Douglas JM Jr, Foster M, et al. Incidence of herpes simplex virus type 2 infection in 5 sexually transmitted disease (STD) clinics and the effect of HIV/STD risk-reduction counseling. *J Infect Dis*. 2004; 190(6):1059–1067. [PubMed: 15319854]
11. Kissinger P, Amedee A, Clark RA, et al. *Trichomonas vaginalis* treatment reduces vaginal HIV-1 shedding. *Sex Transm Dis*. Jan; 2009 36(1):11–16. [PubMed: 19008776]
12. Wang CC, McClelland RS, Reilly M, et al. The effect of treatment of vaginal infections on shedding of human immunodeficiency virus type 1. *J Infect Dis*. Apr 1; 2001 183(7):1017–1022. [PubMed: 11237825]
13. Van der Pol B. *Trichomonas vaginalis* infection: the most prevalent nonviral sexually transmitted infection receives the least public health attention. *Clin Infect Dis*. 2007; 44(1):23–25. [PubMed: 17143810]
14. Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Analytic and Reporting Guidelines. http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/nhanes_analytic_guidelines_dec_2005.pdf
15. Jordan JA, Lowery D, Trucco M. TaqMan-based detection of *Trichomonas vaginalis* DNA from female genital specimens. *J Clin Microbiol*. 2001; 39(11):3819–3822. [PubMed: 11682492]
16. Laboratory Procedure Manual: Urinary Chlamydia and Urinary Gonorrhea. NHANES Laboratory Procedures. National Center for Health Statistics, Centers for Disease Control and Prevention; 2004.
17. Van Der Pol B, Ferrero DV, Buck-Barrington L, et al. Multicenter evaluation of the BDProbeTec ET System for detection of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* in urine specimens, female endocervical swabs, and male urethral swabs. *J Clin Microbiol*. 2001; 39(3):1008–1016. [PubMed: 11230419]
18. Syphilis (IgG), Syphilis Rapid Plasma Reagin (RPR), and *Treponema pallidum* Particle Agglutination (TP-PA). . NHANES Laboratory Procedures. Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control and Prevention; 2006.
19. Lefevre JC, Bertrand MA, Bauriaud R. Evaluation of the Captia enzyme immunoassays for detection of immunoglobulins G and M to *Treponema pallidum* in syphilis. *J Clin Microbiol*. 1990; 28(8):1704–1707. [PubMed: 2203809]

20. Pope V, Fears MB, Morrill WE, et al. Comparison of the Serodia Treponema pallidum particle agglutination, Captia Syphilis-G, and SpiroTek Reagin II tests with standard test techniques for diagnosis of syphilis. *J Clin Microbiol.* 2000; 38(7):2543–2545. [PubMed: 10878040]
21. Laboratory Assessment: Lab 3 - HIV Antibody Test Result, CD4+ T Lymphocytes, and CD8+ T Cells. NHANES Laboratory Procedures. National Center for Health Statistics, Centers for Disease Control and Prevention; 2006.
22. Lee FK, Pereira L, Griffin C, et al. A novel glycoprotein for detection of herpes simplex virus type 1-specific antibodies. *J Virol Methods.* 1986; 14(2):111–118. [PubMed: 3021801]
23. Ashley RL, Militoni J, Lee F, et al. Comparison of Western blot (immunoblot) and glycoprotein G-specific immunodot enzyme assay for detecting antibodies to herpes simplex virus types 1 and 2 in human sera. *J Clin Microbiol.* 1988; 26(4):662–667. [PubMed: 2835389]
24. Herpes, I; Herpes, II. NHANES Laboratory Procedures. Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control and Prevention; 2006.
25. McNutt LA, Wu C, Xue X, et al. Estimating the relative risk in cohort studies and clinical trials of common outcomes. *Am J Epidemiol.* May 15; 2003 157(10):940–943. [PubMed: 12746247]
26. Stata [computer program]. Version. College Station, TX:
27. Kaul R, Nagelkerke NJ, Kimani J, et al. Prevalent herpes simplex virus type 2 infection is associated with altered vaginal flora and an increased susceptibility to multiple sexually transmitted infections. *J Infect Dis.* 2007; 196(11):1692–1697. [PubMed: 18008255]
28. Cowan FM, Copas A, Johnson AM, et al. Herpes simplex virus type 1 infection: a sexually transmitted infection of adolescence? *Sex Transm Infect.* Oct; 2002 78(5):346–348. [PubMed: 12407237]
29. Ribes JA, Steele AD, Seabolt JP, et al. Six-year study of the incidence of herpes in genital and nongenital cultures in a central Kentucky medical center patient population. *J Clin Microbiol.* 2001; 39(9):3321–3325. [PubMed: 11526170]
30. Roberts CM, Pfister JR, Spear SJ. Increasing proportion of herpes simplex virus type 1 as a cause of genital herpes infection in college students. *Sex Transm Dis.* 2003; 30(10):797–800. [PubMed: 14520181]
31. Xu F, Sternberg MR, Kottiri BJ, et al. Trends in herpes simplex virus type 1 and type 2 seroprevalence in the United States. *JAMA.* 2006; 296(8):964–973. [PubMed: 16926356]
32. Coyle PV, O'Neill HJ, Wyatt DE, et al. Emergence of herpes simplex type 1 as the main cause of recurrent genital ulcerative disease in women in Northern Ireland. *J Clin Virol.* 2003; 27(1):22–29. [PubMed: 12727525]
33. Datta SD, Sternberg M, Johnson RE, et al. Gonorrhea and chlamydia in the United States among persons 14 to 39 years of age, 1999 to 2002. *Ann Intern Med.* 2007; 147(2):89–96. [PubMed: 17638719]
34. Cohen MS, Hoffman IF, Royce RA, et al. Reduction of concentration of HIV-1 in semen after treatment of urethritis: implications for prevention of sexual transmission of HIV-1. AIDS CAP Malawi Research Group. *Lancet.* 1997; 349(9069):1868–1873. [PubMed: 9217758]
35. Sorvillo F, Kerndt P. Trichomonas vaginalis and amplification of HIV-1 transmission. *Lancet.* 1998; 351(9097):213–214. [PubMed: 9449891]
36. Wendel KA, Erbeling EJ, Gaydos CA, et al. Trichomonas vaginalis polymerase chain reaction compared with standard diagnostic and therapeutic protocols for detection and treatment of vaginal trichomoniasis. *Clin Infect Dis.* 2002; 35(5):576–580. [PubMed: 12173132]
37. Das S, Sabin C, Allan S. Higher vaginal pH is associated with Chlamydia trachomatis infection in women: a prospective case-controlled study. *Int J STD AIDS.* Apr; 2005 16(4):290–293. [PubMed: 15899081]

Figure 1.
Prevalence of Trichomoniasis and upper limit of 95% confidence interval among women with other sexually transmitted infections

Table 1

Prevalence of sociodemographic characteristics and reproductive history

	TV Prevalence	Positive	Weighted col %		p-value	Odds ratio (95% CI)
Sociodemographic Characteristics						
Age					0.13	
14–19	2.3%	19.4	27.2			0.94 (0.42, 2.09)
20–29	2.2%	10.3	14.9			--
30–39	4.1%	35.2	27.2			1.81 (0.88, 3.70)
40–49	3.7%	35.3	30.7			1.61 (0.76, 3.42)
Race/ethnicity					<0.0001	
White, non-Hispanic	1.3%	27.6	68.9			--
Black, non-Hispanic	14.0%	58.5	11.9			12.3 (6.21, 24.2)
Mexican American	1.9%	5.4	9.3			1.44 (0.56, 3.72)
Other race/Hispanic	2.8%	8.5	9.9			2.15 (0.76, 6.09)
Birthplace					0.01	
United States	3.5%	95.3	86.2			--
Mexico	1.8%	2.7	5.0			0.49 (0.21, 1.15)
Elsewhere	0.8%	2.0	8.8			0.21 (0.06, 0.74)
Marital status					< 0.01	
Married	2.1%	31.1	47.8			--
Divorced/widowed/separated	6.1%	22.4	11.4			3.04 (1.33, 6.91)
Never married	3.2%	33.7	33.5			1.55 (0.96, 2.50)
Cohabiting	5.5%	12.8	7.3			2.69 (1.36, 5.33)
Education					<0.001	
Less than high school	4.6%	36.1	24.6			2.50 (1.59, 3.93)
High school/GED	4.7%	32.0	21.3			2.55 (1.36, 4.80)
More than high school	1.9%	31.0	54.2			--
Poverty to income ratio					<0.0001	
< FPL	5.7%	41.1	22.6			3.66 (2.33, 5.76)
1 – <2 times FPL	4.7%	30.6	20.4			3.02 (1.67, 5.44)

	TV Prevalence	Weighted col %		p-value	Odds ratio (95% CI)
		Positive	Negative		
2+ times FPL	1.6%	28.3	57.0	--	
Reproductive History					
Age at first intercourse				0.03	
≤ 14 years	7.1%	28.5	13.0		--
15 – 19 years	3.3%	56.1	57.7		0.44 (0.26, 0.75)
≥ 20 years	1.2%	6.2	17.6		0.16 (0.02, 1.17)
Not known	2.7%	9.2	11.8		0.36 (0.15, 0.83)
Lifetime sexual partners				0.01	
None	0.4%	0.4	3.5		--
1 to 2	1.1%	8.5	26.5		2.54 (0.28, 23.0)
3 to 5	3.8%	28.5	25.3		8.97 (1.05, 76.4)
6 to 10	4.5%	27.8	20.5		10.8 (1.23, 94.9)
11 or more	5.1%	23.7	15.4		12.3 (1.49, 101.4)
Not known	4.2%	11.1	8.9		9.99 (1.12, 88.9)
Past year sexual partners				0.02	
None	2.3%	5.6	8.3		--
1	3.1%	61.9	68.4		1.35 (0.44, 4.14)
2 or more	6.4%	23.4	11.9		2.92 (1.14, 7.47)
Not known	2.7%	9.2	11.4		1.20 (0.40, 3.58)
Ever any genital herpes or warts				<0.01	
No	2.9%	77.4	90.3		--
Yes	7.5%	22.6	9.7		2.70 (1.35, 5.39)
Gonorrhea or chlamydia in last 12 months				0.09	
No	3.3%	97.5	99.1		2.94 (0.78, 11.1)
Yes	9.2%	2.5	0.9		
Ever hormonal birth control				0.89	
No	3.1%	28.9	29.4		--
Yes	3.2%	71.2	70.6		1.03 (0.69, 1.54)
Ever pregnant				<0.001	

	TV Prevalence	Positive	Negative		p-value	Odds ratio (95% CI)
			Weighted col %			
No	1.6%	19.2	38.1			--
Yes	4.1%	80.8	61.9			2.60 (1.60, 4.20)
Currently pregnant					0.66	
No	3.2%	97.6	97.2			--
Yes	2.8%	2.4	2.8			0.85 (0.41, 1.79)
Ever low birth weight infant *					0.03	
No	3.6%	83.5	91.6			--
Yes	7.5%	16.5	8.4			2.15 (1.08, 4.31)
Douched in past 1 month					<0.0001	
No	2.1%	56.4	87.3			--
Yes	10.2%	43.6	12.7			5.30 (3.71, 7.57)
Douched in past 6 months					<0.0001	
No	1.7%	38.2	74.2			--
Yes	8.9%	56.6	19.1			5.75 (3.97, 8.33)
Vaginal symptom					0.18	
No	3.2%	84.8	86.2			--
Yes	3.6%	15.2	13.8			1.12 (0.59, 2.14)
Recent Antibiotic Use						
Antibiotics in last month						
No	3.2%	95.6	96.1		0.82	1.13 (0.38, 3.37)
Yes	3.6%	4.4	3.9			

* Among women who have ever been pregnant (N=2,206)

Table 2
Prevalence and 95% Confidence Intervals for Individual Sexually Transmitted Infections by Trichomoniasis and Age

	All women			Ages 14-25			Ages 26-49		
	TV-Positive	TV-Negative	p-value	TV-Positive	TV-Negative	p-value	TV-Positive	TV-Negative	p-value
Chlamydia (n=2,020)	3.7% (1.7, 8.2)	2.2% (1.5, 3.3)	0.21	10.2% (3.8, 24.7)	2.4% (1.5, 3.9)	0.01	0.7% (0.0, 5.1)	0.8% (0.4, 1.6)	0.94
Gonorrhea (n=2,020)	1.4% (0.1, 9.4)	0.5% (0.1, 1.4)	0.28	0	0.6% (0.2, 1.4)	0.76	1.0% (0.1, 6.6)	0.1% (0.1, 0.8)	0.07
HSV-1 (n=3,442)	83.6% (76.7, 88.7)	58.2% (55.3, 61.1)	<0.01	67.0% (47.4, 82.1)	47.5% (43.0, 52.0)	0.05	87.0% (78.2, 92.6)	63.3% (60.5, 66.1)	<0.0001
HSV-2 (n=2,615)	65.1% (55.8, 73.3)	23.8% (21.9, 25.9)	<0.001	47.4% (26.1, 69.8)	10.1% (7.3, 13.8)	<0.0001	67.4% (56.8, 76.5)	28.3% (26.0, 30.9)	<0.0001
Syphilis (n=2,613)	3.5% (1.2, 10.1)	0.6% (0.3, 0.9)	<0.001	*	*	*	3.4% (1.2, 9.8)	0.7% (0.4, 1.2)	<0.01
HIV (n=2,734)	2.4% (0.8, 7.3)	0.2% (0.0, 0.5)	<0.001	*	*	*	2.7% (0.9, 8.2)	0.3% (0.1, 0.7)	<0.001

* Inadequate sample size to estimate

Table 3

Crude and adjusted relative risk* and 95% confidence intervals of association between trichomoniasis and sexually transmitted infections

	N	Crude	Adjusted for race/ethnicity and age	Adjusted for race/ethnicity, age and number of sexual partners in past year
		RR (95% CI)	RR (95% CI)	RR (95% CI)
Chlamydia	2410	1.79 (0.76, 4.22)	1.20 (0.47, 3.05)	0.88 (0.22, 3.44)
Gonorrhea	2410	3.20 (0.35, 29.1)	2.81 (0.35, 22.4)	2.01 (0.13, 31.9)
HSV-1	4069	1.43 (1.31, 1.57)	1.22 (1.11, 1.35)	1.20 (1.09, 1.34)
HSV-2	3047	2.74 (2.32, 3.23)	1.47 (1.17, 1.85)	1.51 (1.20, 1.89)
Syphilis	3045	6.23 (2.07, 18.8)	1.35 (0.39, 4.69)	1.90 (0.55, 6.63)
HIV	3210	13.0 (2.88, 59.1)	3.17 (0.70, 14.3)	3.50 (0.69, 17.8)

* Estimates of relative risk were approximated by odds ratios estimated from logistic regression for rare outcomes (chlamydia, HIV and syphilis) and by incidence rate ratios estimated with Poisson regression for common outcomes (HSV1 and HSV2)