Prevalence and Correlates of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* by Anatomic Site Among Urban Thai Men Who Have Sex With Men

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Background: *Chlamydia trachomatis* (*CT*) and *Neisseria gonorrhoeae* (*NG*) infection are prevalent among men who have sex with men (MSM) and may infect multiple anatomic sites. We measured site-specific prevalence and correlates of *CT* and *NG* infection among Bangkok MSM Cohort Study participants.

Methods: In April 2006 to November 2010, 1744 men enrolled in the Bangkok MSM Cohort Study. Participants provided historical information and underwent physical examination. Rectal, urethral, and pharyngeal *CT* and *NG* screening were performed by nucleic acid amplification and/or culture. Logistic regression was used to identify correlates of site-specific *CT*, *NG*, and coinfection.

Results: Among 1743 participants, 19.2% were infected with *CT* and/or *NG*. *CT*, *NG*, and *CT-NG* coinfection were detected in 11.6%, 4.6%, and 2.9%, of participants, respectively. Rectal, urethral, and pharyngeal *CT* infections were detected in 9.5%, 4.5%, and 3.6% of cases. *N. gonorrhoeae* was present at these sites in 6.1%, 1.8%, and 0.5% of cases. Most infections were asymptomatic (*CT*: 95.3%, *NG*: 83.2%). Rectal *CT* and *NG* infections were mutually associated (*CT*: adjusted odds ratio [AOR], 5.4; 95% confidence interval [CI], 3.4–8.7; *NG*: AOR, 2.4; 95% CI, 1.1–5.2) and independently associated with HIV infection (*CT*: AOR, 1.6, 95% CI, 1.0–2.4; *NG*: AOR, 2.0, 95% CI, 1.3–3.1). Numerous behavioral correlates of infection were observed.

Conclusions: *CT* and *NG* infections are highly prevalent among MSM in Bangkok, most frequently affect the rectum, and are most often asymptomatic. Routine screening of asymptomatic MSM for *CT* and *NG* infection should include rectal sampling and focus on men with HIV and a history of other sexually transmitted infections.

Chlamydia trachomatis (CT) and *Neisseria gonorrhoeae* (*NG*) are curable sexually transmitted bacterial infections (STIs) prevalent in men who have sex with men (MSM).[1–7] Rectal *CT* and *NG* infections are associated with an increased risk of HIV acquisition in men, possibly due to mucosal inflammation and recruitment of HIV-susceptible lymphocytes to local tissue sites.[8–10] Men with urethral *CT* or *NG* infection may also have higher seminal plasma HIV viral loads and may therefore be more likely to transmit HIV to a sexual partner during insertive anal intercourse.[11] Treatment of urethritis in HIV-infected individuals results in a reduction in seminal plasma viral load,[12] and although direct studies have not consistently been able to establish a relationship between STD therapy and lower HIV transmission rates,[13,14] modeling studies and at least 1 randomized study suggest that treatment of STIs may result in a reduction in HIV transmission.[12,15,16] However, *CT* and *NG* infections of the rectum and pharynx are often asymptomatic,[1,7,17,18] and individuals with asymptomatic infection may not receive screening during routine clinical evaluation, potentially contributing to ongoing, unintended STI and HIV transmission.[18]

High rates of asymptomatic infection and the availability of validated nucleic acid amplification tests (NAATs) for rectal and pharyngeal specimens have prompted changes to *CT* and *NG* screening and treatment guidelines for MSM.[19] In 2010, the US Centers for Disease Control and Prevention (CDC) issued recommendations for screening at least annually for *CT* and *NG* infection of the genitourinary tract, rectum, and pharynx in sexually active MSM regardless of symptoms.[20] Similar recommendations are present in the United Kingdom and Australia.[21,22] However, several obstacles impede implementation of these recommendations, including perceived or actual cost of testing, lack of test kit availability, and insufficient awareness of the need to screen asymptomatic individuals at all relevant anatomic sites.[21,23]

These difficulties are likely to be of greater impact in settings such as Thailand, where HIV prevalence and incidence among MSM are high and where lack of epidemiological data and cost of testing may impede routine screening.[24,25] For example, in Chiang Mai, Thailand, during the course of STI screening for the Pre-Exposure Prophylaxis Initiative trial, only 4 cases of *CT* and *NG* infection were confirmed in 22 individuals, with STI symptoms consenting to evaluation, among 551 study volunteers.[24] In this study, screening was limited to symptomatic individuals and performed by Gram stain of urethral discharge, as NAAT was not available. By contrast, among HIV-infected Thai MSM attending a public STI clinic in Bangkok, routine baseline screening of the urethra and rectum by NAAT in all study volunteers demonstrated *CT* and *NG* prevalence of 10% and 13%,

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respectively.[26] Aside from this report, information on the epidemiology, correlates, and anatomic distribution of *CT* and *NG* infection among MSM in Southeast Asia is limited.

In 2006, the Thailand Ministry of Public Health–US CDC Collaboration initiated the Bangkok MSM Cohort Study (BMCS) to examine sexual health issues among Thai MSM at the Silom Community Clinic, a venue for STI screening, treatment, and HIV voluntary counseling and testing for MSM in Bangkok.[25] Previously, baseline rectal *CT* and *NG* infections were observed to be associated with prevalent and incident HIV infection.[25] Here we present the analysis of *CT* and *NG* infection and related biological and behavioral correlates at cohort entry to inform bacterial STI and HIV prevention efforts among MSM in Thailand.

MATERIALS AND METHODS

Study Population

The methods used in this study have been described elsewhere.[25] Briefly, between April 2006 and November 2010, 1744 men enrolled into the BMCS. Participants were male Thai residents of Bangkok 18 years or older reporting having penetrative oral or anal sex with men within the last 6 months. Men were recruited using convenience sampling from entertainment venues, the Internet, an HIV testing clinic, and through outreach workers. No data were collected from men who were ineligible for cohort entry (n = 200) or those eligible who declined participation (n = 33). The study protocol was approved by the Ethical Review Committee for Research in Human Subjects of the Thai Ministry of Public Health and an institutional review board of the US CDC and was performed with written informed consent of all study participants.

Study Procedures

At enrollment, participants provided baseline sociodemographic and behavioral information by audio computer-assisted self-interview. All participants then underwent physical examination, including rectal and pharyngeal swabbing, and provided first-void urine for *CT* and *NG* NAAT testing and a venous blood sample to screen for HIV; hepatitis A, B, and C antibody; syphilis; and herpes simplex virus 1 and 2 (HSV-1 and HSV-2) infection. Participants with signs or symptoms consistent with STI also underwent urethral swabbing with on-site Gram stain evaluation. Pretest and posttest counseling was provided, with HIV screening test results and any Gram stain results provided to participants at the screening visit during posttest counseling. The remaining test results were made available to participants within 2 weeks of screening. Participants with a new clinical diagnosis of *CT*, *NG*, or syphilis infection were treated; those diagnosed as having HIV infection were referred for HIV treatment and care.

Measures

The baseline questionnaire queried sociodemographic characteristics (e.g., age and educational level), cohabitation status, and employment status. Key sexual risk behaviors within the previous 4 months, such as number of casual and steady partners, frequency of receptive and insertive anal intercourse, condom use, location of sexual encounters, and participation in transactional sex, were also assessed. Recreational drug and alcohol use and pertinent health history (e.g., past symptoms or diagnosis of STI and any previous HIV testing) in the past 4 months were assessed. In addition, participants were then asked about current STI symptoms, including penile or anogenital pain, discharge, warts, vesicles, or ulcers at study visit.

Laboratory Testing

Urine and rectal swabs (Amplicor STD Swab Specimen Collection and Transport set) were tested for *CT* and *NG* by NAAT (Roche Amplicor; Roche Diagnostics, Branchburg, NJ); rectal swabs were also cultured for *NG*. Pharyngeal swabs were tested for *CT* by NAAT (Roche Amplicor) and were cultured for *NG*. In symptomatic participants or those with clinical evidence of active STI of the genitourinary tract or rectum, swab samples of the relevant site were also tested by Gram stain. *N. gonorrhoeae* cultures were performed by applying swabs directly onto modified Thayer-Martin agar plates. Plates were sent to the laboratory within 30 minutes of collection, incubated at 35 to 37°C (candle jar), and identified within 72 hours. HIV screening was performed using an oral fluid rapid diagnostic test (RDT), and positive results were confirmed with 3 RDTs on blood as described previously.[25] Participant serum samples were screened using enzyme-linked immunosorbent assay for antibody to hepatitis A (HAV; Murex Biotec, Dartford, UK), hepatitis B core (HBV core [Murex Biotec] or Diasorin [ETI-AB-COREK PLUS kit, Saluggia, Italy]), hepatitis B surface antigen (Murex Biotec or Serodia [Fujirebio, Tokyo, Japan), hepatitis B surface antibody (Murex Biotec or Serodia [Fujirebio]), hepatitis C (Murex Biotec), and HSV-1 and HSV-2 (HerpeSelect 1 and 2; Focus Diagnostics, Cypress, CA). *Treponema palidum* (TP) screening was performed using the rapid plasma regain (RPR) assay (Macro-Vue RPR 18-mm Circle Card Test; Becton Dickinson Microbiology Systems, Sparks, MD). Specimens with any measurable titer were evaluated with a TP-specific antibody RDT (Determine Syphilis TP; Abbott Laboratories, Tokyo, Japan).

Data Analysis

Participants were considered infected with *CT* if reactive by NAAT and *NG* if positive by one of the following tests: NAAT, culture, and/or Gram stain. Samples with a measurable RPR titer and reactive TP-specific antibody test were considered diagnostic for syphilis, unless a history of documented curative treatment was available. Statistical analysis was performed using SAS, version 9 (SAS Institute, Cary, NC). Descriptive statistics were generated using counts and proportions. Prevalence was calculated for *CT* and *NG* infection overall and at each of the 3 anatomic sites. Logistic regression was used to evaluate associations between site-specific *CT*, *NG*, and *CT-NG* coinfection and associated sociodemographic characteristics, key drug and sexual risk behaviors, and baseline coinfection.[27] Variables associated at the $P < 0.10$ level in bivariate analysis were entered in multivariable models, with likelihood ratio testing to determine final model inclusion (2-sided $P < 0.05$). NNS represents the number of people that need to be screened to prevent 1 death or 1 adverse event and provides an intuitive indication of the relative public health benefit of a screening program.[28] The NNS was calculated as the reciprocal of the number of MSM with asymptomatic infection detected by NAAT screening divided by the total number of asymptomatic MSM.

RESULTS

Baseline Characteristics

Urethral and pharyngeal testing data were available for 1743 of 1744 participants; 1596 (91.5%) of 1744 consented to rectal swab sampling. Mean participant age was 27 years (range, 18–56 years). One-fifth of participants (21.3 %) were HIV seropositive at enrollment (Table 1). Among HIV-infected individuals, median CD4 count at screening was 413 (range, 13–1712)

cells/mm^3 and median plasma viral load was 37500 (range, 0–2,010,000) copies/mL.

Overall and Site-Specific Prevalence of *CT*, *NG*, and *CT-NG* Coinfection

Approximately one-fifth of all participants (19.2%; n = 334) were found to be infected with *CT* and/or *NG*; 11.6% (n = 203) had *CT* only, 4.6% (n = 80) had *NG*, and 2.9% (n = 51) had *CT-NG* coinfection (Fig. 1). Among infected participants, 63.8% (n = 213) had rectal infection, 31.7% (n = 106) had urethral infection, 21.2% (n = 71) had pharyngeal infection, and 25.1% (n = 84) had infections at more than 1 site. Rectal, pharyngeal, and urethral *CT* infection was present in 9.5% (n = 151), 3.6% (n = 63), and 4.5% (n = 78) of cases, whereas *NG* infections at these sites was present in 6.1% (n = 98), 0.5% (n = 8), and 1.8% (n = 32) of cases, respectively.

Multisite and Multipathogen Infections

C. trachomatis–NG coinfection was seen in 2.3% (n = 36) of rectal and 0.2% (n = 4) of urethral samples (Fig. 1). No pharyngeal coinfections were detected (Table 3). Among participants infected only with *CT* (n = 203), 17.7% (n = 36) had multisite infections, whereas among those infected with *NG* alone (n = 80), 8.8% (n = 7) had multisite infections. Among 51 men with *CT-NG* coinfection, 78% (n = 40) were infected with both pathogens at a single site.

Symptomatic Infection

Few participants (8.7%, n = 151) reported current STI symptoms, which included penile or anal discharge or pain, anogenital ulcers, vesicles, or warts (Fig. 1). Urethritis and/or proctitis was present in 2.8% (n = 48) of participants, including 56.3% (n = 18/32) of urethral *NG* cases, 3.8% (n = 3/78) of urethral *CT* cases, 6.1% (n = 6/98) of rectal *NG* cases, and 4.6% (n = 7/151) of rectal *CT* cases. Only 5.6% (n = 2/36) of rectal coinfections were symptomatic. Among all participants infected with either pathogen, only 4.7% (n = 12) of *CT* infections and 16.8% (n = 22) of *NG* infections were identified as active cases based on symptoms, examination, and/or Gram stain during screening.

Correlates of *CT* Infection

Rectal *CT* infection was highly independently associated with rectal *NG* infection and independently associated with HIV

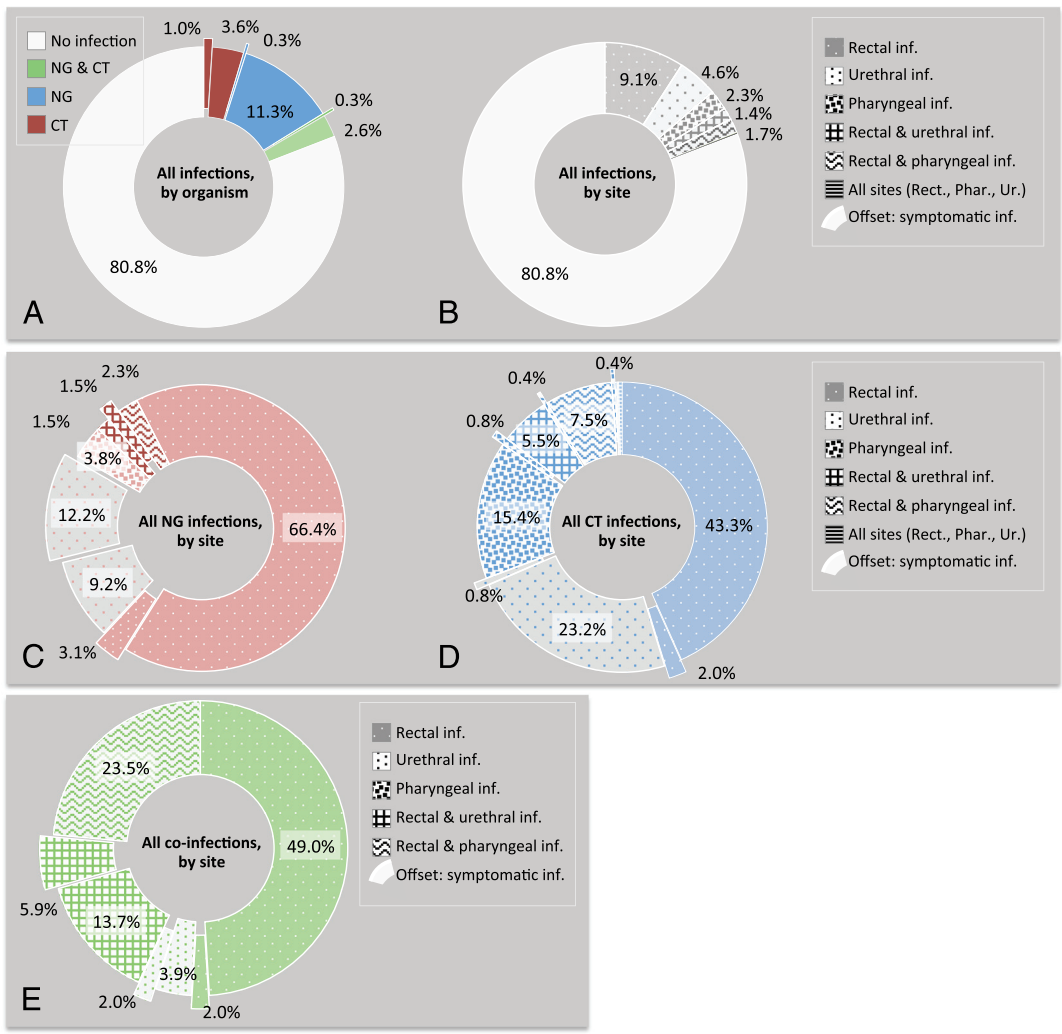

Figure 1. Distribution of infection by organism, anatomic site, and presence or absence of symptoms among 1743 MSM participating in the BMCS, Thailand. A, Infections by organism, all sites. B, Infections by anatomic site, all organisms. C, *N. gonorrhoeae* infections, by site. D, *C. trachomatis* infections, by site. E, *NG-CT* coinfections, by site.

and HSV-1 seropositivity, secondary or vocational education relative to university education, receptive anal intercourse, casual sex in own home, and receiving payment for sex in the multivariable model (Table 1). Pharyngeal *CT* infection was independently associated with concurrent *NG* infection at any site, HIV, HSV-1, and HSV-2 seropositivity, and casual sex at partner's home. Urethral *CT* infection was independently associated with prior STI diagnosis and having casual sex in more than 1 place, whereas reporting being the receptive/versatile partner was negatively associated with urethral *CT*. Hepatitis B immunological status (naive, immune, or actively infected) was not correlated with *CT* infection at any site (Table 1).

Correlates of *NG* Infection

Rectal *NG* infection was independently associated with HIV-1 seropositivity, concurrent *CT* infection at both same and any anatomic site, living alone or with a roommate (compared with living with family), and reporting no prior HIV testing in the multivariable model (Table 2). Urethral *NG* infection was independently associated with reporting no prior HIV testing and a history of STI diagnosis. No correlates of pharyngeal *NG* infection were identified in bivariate analysis. Hepatitis B immunological status was not correlated with *NG* infection at any site (Table 2).

Correlates of Multisite and Multipathogen Infections

Rectal *CT-NG* coinfection was independently associated with HIV seropositivity, having sex with casual partners at one's own home, receiving payment for sex, and reporting no prior HIV testing (Table 3). Urethral coinfection was marginally significantly associated with binge drinking in bivariate analysis (Table 3).

Number Needed to Screen

We present NNS values calculated based on the rate of detection of asymptomatic infection. The NNS values for all sites were 7 (*CT*), 16 (GC), and 5 for either infection at any site. Rectal screening represented the highest yield site, with an NNS of 8 when screening for both pathogens. In subgroup analyses, NNS values (both pathogens, any site) were particularly low for HIV-infected persons (NNS = 3), TP-reactive individuals (NNS = 4), those with a self-reported prior STI diagnosis (NNS = 4), and those receiving payment for sex (NNS = 3).

DISCUSSION

In this study, we present prevalence and correlates of *CT* and *NG* infection by anatomic site among 1744 urban Thai MSM. The principal findings of this analysis are high prevalence of asymptomatic infection, a predominance of rectal site infections, and a significant association between infection and several sociodemographic and behavioral factors defining high-risk subgroups. Both *CT* and *NG* infections were common among Thai urban MSM; prevalence in our cohort was 19%, somewhat lower than reports from some other settings, ranging from 23% to 36% in the United Kingdom, the United States, Indonesia, and the Netherlands.[1,7,10,29,30] In our cohort, urethral infection was less prevalent than in an earlier report,[26] possibly because recruitment in Sirivongrangson et al.[26] focused specifically on populations with HIV infection and those seeking treatment of symptoms of STI

The results presented here highlight the close linkage between *CT*, *NG*, and other STIs. Infections with *CT* and *NG* were each significantly correlated with the other and with past exposure or concurrent infection with another pathogen. HIV infection was independently associated with rectal *CT*, *NG*, and *CT-NG* coinfection and pharyngeal *CT* and was also associated with urethral *NG* infection in bivariate analysis. Seropositivities of HSV-1 and HSV-2 were linked to *CT* infection of the rectum and pharynx, respectively. These associations potentially reflect underlying common risk behavior because each of these pathogens is typically acquired through mucosal exposure during sexual contact. By contrast, serological immunity to HBV—a pathogen with a less clear predominant mode of transmission—was not a predictor of either *CT* or *NG* infection, although there was a modest trend toward a higher rate of *CT* and *NG* (any site) in those with active hepatitis B. Infections with *CT* and *NG* may also be linked to other STIs due to biological enhancement of susceptibility to a second infection, either through recruitment of target cells to mucosal tissue or through impairment of local host defenses.[8–10] The role of susceptibility enhancement is difficult to disentangle from behavioral factors assessed in observational studies.

A number of socioeconomic and behavioral predictors of either *CT* or *NG* infection were identified. Lack of prior HIV testing was independently associated with genitourinary and rectal *NG* infection, and lower educational status was associated with rectal *CT* infection. These associations may reflect lack of awareness, unconcern, or reluctance to consider the risks of unprotected sexual contact, and/or poor access to health care services, and suggest that there is still considerable potential for behavioral counseling and testing service outreach to impact sexual health in this population. In addition, rectal *CT* infection and *CT-NG* coinfection were independently associated with being paid for sex and having sex with casual partners in one's own home, whereas pharyngeal *CT* infection was associated with casual sex in a partner's home; both situations represent scenarios where condom use may be less likely or possible.

We present what is to our knowledge the largest study of STD epidemiology and correlates of infection that we are aware of among MSM in Southeast Asia. However, several limitations should also be considered when interpreting results. A modest number of participants declined rectal swabbing, and this may have resulted in lack of detection of some infections. Pharyngeal *NG* infection was diagnosed by swab culture methods due to NAAT cross-reactivity with commensal organisms, and some cases of *NG* infection of the pharynx may have been missed.[19,31] Behavioral data were collected by computer-assisted self-interview to minimize participant embarrassment or reluctance to provide information. However, self-reported sexual risk behaviors may still underestimate actual risk behavior. We observed a low number of urethral and pharyngeal infections, reducing our power to detect correlations with infection at these sites. A large number of covariables was considered in these analyses, requiring cautious interpretation of the effect estimates of primary and potentially confounding covariates.[32] The associations noted here may be due to chance in some cases and should be confirmed in future studies. Finally, convenience sampling was used to recruit participants, limiting the ability to generalize findings to all MSM in Bangkok.

Both *CT* and *NG* infections are common among Bangkok MSM participating in the BMCS, involve multiple mucosal sites, and frequently remain undetected due to lack of symptoms. The findings presented here and in other studies reinforce the need for regular screening in sexually active MSM, including asymptomatic men. Of note, 15 individuals reporting only insertive practices had rectal infection (data not shown), highlighting the need for screening even in the absence of self-reported risk factors. The NNS values obtained here suggest that high-frequency screening should focus on persons with HIV infection, serological evidence of prior exposure to TP, and/or those with a history of other STIs. In our setting, this approach would be expected to

TABLE 1. Sociodemographic, Behavioral, and Biological Traits and Factors Associated With *CT* Infection by Rectal, Pharyngeal, and Urethral Sites Among 1743 MSM Participating in the BMCS

Variable	All Participants	Rectal Infection			Pharyngeal Infection			Urethral Infection		
n infected/total (%)	n = 1734	n infected = 151 (9.5%), n sampled = 1596			n infected = 63 (3.6%), n sampled = 1737			n infected = 78 (4.5%), n = sampled: 1743		
Covariates	n (%)	n (%)	OR (95% CI)	AOR (95% CI)	n (%)	OR (95% CI)	AOR (95% CI)	n (%)	OR (95% CI)	AOR (95% CI)
Biological Variables (prevalent)										
HIV-1 antibody	372/1744 (21.3)	56 (16.3)	2.4 (1.7–3.4)	1.6 (1.0–2.4)	27 (7.3)	2.9 (1.7 –4.8)	2.3 (1.4 –4.0)	18 (4.8)	1.1 (0.7 –1.9)	
HSV-1 antibody	983/1740 (56.5)	103 (11.3)	1.7 (1.2–2.4)	1.6 (1.1–2.4)	45 (4.6)	2.0 (1.1–3.4)	2.0 (1.0 –3.4)	43 (4.4)	0.9 (0.6 –1.5)	
HSV-2 antibody	371/1740 (21.3)	35 (10.1)	1.1 (0.7–1.6)		22 (6.0)	2.0 (1.2–3.5)	1.9 (1.1 –3.4)	20 (5.4)	1.3 (0.8 –2.2)	
HBV core antibody	781/1739 (44.9)	76 (10.5)	1.2 (0.9–1.7)		32 (4.1)	1.3 (0.8–2.1)		37 (4.7)	1.1 (0.7 –1.8)	
HAV antibody	468/1734 (27.0)	37 (8.6)	0.9 (0.6–1.3)		11 (2.4)	0.6 (0.3–1.1)	0.4 (0.2–0.9)	16 (3.4)	0.7 (0.4 –1.2)	
HCV antibody	14/1740 (0.80)	2 (14.3)	1.6 (0.4–7.2)		0	—		4 (12.5)	3.2 (1.1 –9.2)	
Syphilis	82/1743 (4.7)	13 (16.9)	2.0 (1.1–3.8)		5 (6.1)	1.8 (0.7–4.6)		3 (3.7)	0.8 (0.3 –2.6)	
NG (same site)		36 (36.7)	7.0 (4.4–11.0)	5.4 (3.4–8.7)	0	—				
NG (any site)		38 (29.7)	5.1 (3.3–7.7)					10 (7.6)	2.4 (1.2 –4.9)	
Sociodemographic variables										
Age, y										
18–21 y	314/1743 (18.0)	39 (13.7)	2.6 (1.6–4.4)		12 (3.9)	1.8 (0.8–4.0)		17 (5.4)	1.4 (0.7 –2.8)	
22–29 y	934/1743 (53.6)	86 (10.1)	1.9 (1.2–2.9)		40 (4.3)	2.0 (1.0–3.9)		42 (4.5)	1.2 (0.7 –2.1)	
≥30 y	495/1743 (28.4)	26 (5.7)	Reference		11 (2.2)	Reference		19 (3.8)	Reference	
Education										
Less than secondary	58/1743 (3.3)	6 (10.7)	2.2 (0.9–5.4)	1.4 (0.5–3.7)	3 (5.2)	1.8 (0.5–6.3)		5 (8.6)	2.9 (1.1–7.9)	
Secondary/Vocational	926/1743 (53.1)	108 (12.9)	2.7 (1.8–3.9)	2.1 (1.4–3.1)	38 (4.1)	1.4 (0.8–2.5)		49 (5.3)	1.7 (1.0–2.8)	
University or higher	759/1743 (43.5)	37 (5.3)	Reference	Reference	22 (2.9)	Reference		24 (3.2)	Reference	
Living situation										
Live with family	672/1743 (38.6)	41 (6.7)	Reference		17 (2.5)	Reference		31 (4.6)	Reference	
Live alone/with roommate	810/1743 (46.5)	82 (11.1)	1.8 (1.2–2.6)		36 (4.5)	1.8 (1.0–3.2)		32 (4.0)	0.9 (0.5–1.4)	
Live with partner	261/1743 (15.0)	28 (11.4)	1.8 (1.1–3.0)		10 (3.8)	1.5 (0.7–3.4)		15 (5.8)	1.3 (0.7–2.4)	
Employment										
Student	630/1743 (36.1)	58 (10.3)	Reference		22 (3.5)	Reference		31 (4.9)	Reference	
Employed	1035/1743 (59.4)	84 (8.8)	0.8 (0.6–1.2)		37 (3.6)	1.0 (0.6–1.8)		44 (4.3)	0.9 (0.5–1.4)	
Unemployed	78/1743 (4.5)	9 (12.5)	1.3 (0.6–2.6)		4 (5.1)	1.5 (0.5–4.4)		3 (3.9)	0.8 (0.2–2.6)	
Behavioral variables (in last 4 mo, unless otherwise specified)										
Club drug use	299/1743 (17.2)	33 (12.1)	1.4 (0.9–2.1)		9 (3.0)	0.8 (0.4–1.6)		15 (5.0)	1.2 (0.7–2.1)	
Amyl nitrate use	191/1743 (11.0)	29 (16.3)	2.1 (1.3–3.2)		11 (5.8)	1.8 (0.9–3.4)		12 (6.3)	1.5 (0.8–2.9)	
Use drugs to enhance sex	300/1743 (17.2)	40 (14.2)	1.8 (1.2–2.6)		14 (4.7)	1.4 (0.8–2.6)		16 (5.3)	1.3 (0.7–2.2)	
Viagra use	202/1743 (11.6)	29 (15.1)	1.9 (1.2–2.9)		8 (4.0)	1.1 (0.5–2.4)		9 (4.5)	1.0 (0.5–2.0)	
Binge drinking	208/1743 (11.9)	29 (15.4)	1.9 (1.2–3.0)		6 (2.9)	0.8 (0.3–1.8)		14 (6.7)	1.7 (0.9–3.0)	
Usual sexual position (lifetime)										
Insertive	327/1717 (19.0)	9 (3.3)	Reference	Reference	5 (1.5)	Reference		24 (7.3)	Reference	Reference
Receptive/Versatile	1390/1717(81.0)	141 (10.9)	3.6 (1.8–7.2)	3.0 (1.5–6.1)	57 (4.1)	2.8 (1.1–7.0)		54 (3.9)	0.5 (0.3–0.8)	0.6 (0.3–0.9)
Have steady partner	1224/1743 (70.2)	105 (9.3)	0.9 (0.7–1.4)		46 (3.8)	1.2 (0.7–2.0)		64 (5.2)	2.0 (1.1–3.6)	
Have casual partner	1300/1743 (74.6)	120 (10.0)	1.3 (0.9–2.0)		51 (3.9)	1.5 (0.8–2.8)		64 (4.9)	1.6 (0.9–2.9)	
No. casual partners in last 4 mo										

0–1	642/1743 (36.8)	43 (7.5)	Reference		16 (2.5)	Reference		20 (3.1)	Reference	
2–4	562/1743 (32.2)	43 (8.4)	1.1 (0.7–1.8)		23 (4.1)	1.7 (0.9 –3.2)		30 (5.3)	1.8 (1.0–3.1)	
≥5	539/1743 (30.9)	65 (12.9)	1.8 (1.2–2.8)		24 (4.5)	1.8 (1.0 –3.5)		28 (5.2)	1.7 (1.0–3.1)	
Ever had group sex	620/1742 (35.6)	66 (11.5)	1.4 (1.0–2.0)		28 (4.5)	1.5 (0.9 –2.4)		30 (4.8)	1.1 (0.7– 1.8)	
Consistent condom use with any partner in the last 4 mo										
Consistent	683/1743 (39.2)	48 (7.7)	0.7 (0.3–1.3)		27 (4.0)	1.3 (0.4 –3.7)		28 (4.1)	5.4 (0.7– 40.2)	
Inconsistent	932/1743 (43.5)	91 (10.6)	0.9 (0.5–1.8)		32 (3.5)	1.1 (0.4 –3.2)		49 (5.3)	7.0 (1.0–51.4)	
No partner	128/1743 (7.3)	12 (11.1)	Reference		4 (3.1)	Reference		1 (0.8)	Reference	
Internet to meet partner(s)	637/1743 (36.5)	71 (12.1)	1.6 (1.1–2.2)		31 (4.9)	1.7 (1.0 –2.8)		34 (5.3)	1.4 (0.9–2.2)	
No. places for casual sex										
0–1	911/1743 (52.3)	58 (7.0)	Reference		25 (2.8)	Reference		29 (3.2)	Reference	Reference
≥ 2	832/1743 (47.7)	93 (12.1)	1.8 (1.3–2.6)		38 (4.6)	1.7 (1.0 –2.8)		49 (5.9)	1.9 (1.2–3.0)	1.8 (1.1–2.9)
Location of casual sexual encounters										
Sauna	610/1743 (35.0)	59 (10.4)	1.2 (0.8–1.7)		22 (3.6)	1.0 (0.6 –1.7)		32 (5.3)	1.3 (0.8–2.1)	
Hotel	401/1743 (23.0)	45 (12.0)	1.4 (1.0–2.1)		18 (4.5)	1.4 (0.8–2.4)		24 (6.0)	1.5 (0.9–2.5)	
Own home	651/1743 (37.3)	78 (13.1)	1.9 (1.4–2.7)	1.7 (1.2–2.4)	32 (4.9)	1.8 (1.1 –2.9)		37 (5.7)	1.6 (1.0–2.4)	
Partner's home	760/1743 (43.6)	85 (12.1)	1.7 (1.2–2.4)		37 (4.9)	1.9 (1.1 –3.2)	1.8 (1.1 –3.0)	41 (5.4)	1.5 (0.9–2.3)	
Pub/disco	92/1743 (5.3)	13 (15.5)	1.8 (1.0–3.4)		2 (2.2)	0.6 (0.1 –2.4)		4 (4.4)	1.0 (0.4–2.7)	
Department store toilet	142/1743 (8.1)	11 (8.2)	0.8 (0.4–1.5)		4 (2.8)	0.7 (0.2 –1.9)		10 (6.9)	1.5 (0.8– 3.0)	
Paying for sex	254/1743 (14.6)	21 (9.0)	0.9 (0.6–1.5)		5 (2.0)	0.5 (0.2 –1.2)		8 (3.2)	0.7 (0.3–1.4)	
Receiving money for sex	334/1743 (19.2)	56 (17.9)	2.7 (1.9–3.9)	1.9 (1.3–2.8)	18 (5.4)	1.7 (1.0 –3.0)		20 (6.0)	1.5 (0.9–2.5)	
Having a foreign partner	368/1742 (21.1)	44 (12.9)	1.6 (1.1–2.3)		17 (4.6)	1.4 (0.8 –2.5)		19 (5.2)	1.2 (0.7–2.1)	
No prior HIV test	868/1742 (49.8)	87 (10.9)	1.4 (1.0–2.0)		35 (4.0)	1.3 (0.8 –2.1)		39 (4.5)	1.0 (0.6–1.6)	
Never received HIV test result	822/1743 (47.2)	90 (10.7)	1.4 (1.0–1.9)		36 (3.9)	1.2 (0.7 –2.0)		43 (4.7)	1.1 (0.7–1.7)	
History STI diagnosis	444/1743 (25.5)	47 (11.4)	1.3 (0.9–1.9)		12 (2.7)	0.7 (0.4–1.3)		34 (7.7)	2.4 (1.5–3.8)	2.2 (1.4–3.4)

Table entries indicate the number of individuals with the given biological or behavioral factor (row) from among all participants (column 2), or from among participants sampled and infected at the relevant sites (columns 3, 6, 9), and corresponding odds ratios.

Variables included in the multivariable model used to calculate AORs, by anatomic site.

Rectal *CT* infection: HIV-1 serostatus, HSV-1 serostatus, syphilis infection, *NG* infection, age, education, club drug use, drugs to enhance sex, binge drinking, sexual role, number of casual partners, group sex, use of Internet to meet partner, number of sex locations, sex location, transactional sex, foreign partner, prior HIV test.

Pharyngeal *CT* infection: HIV-1 serostatus, HSV-1 serostatus, HSV-2 serostatus, HAV serostatus, *NG* infection, sexual role, Internet to meet partner, no. of sex locations, sex location, transactional sex.

Urethral *CT* infection: *NG* infection, binge drinking, sexual role, steady partner, condom use, number of sex locations, sex location, history of STI diagnosis.

Syphilis diagnostic algorithm: At clinical visits, participants were considered to have *T. pallidum* infection if either (*a*) a specimen collected at that visit had a measurable RPR titer and reactive TP-specific antibody test, or (*b*) the participant had a clinically confirmed diagnosis of syphilis from an earlier clinical encounter.

AOR indicates adjusted odds ratio; CI, confidence interval; n, number; OR = odds ratio.

TABLE 2. Sociodemographic, Behavioral, and Biological Traits and Factors Associated With *NG* Infection by Rectal, Pharyngeal, and Urethral Sites Among 1743 MSM Participating in the BMCS

Variable	Rectal Infection			Pharyngeal Infection			Urethral Infection		
n infected/total (%)	n infected = 98 (6.1%), n sampled = 1596			n infected: 8 (0.5%), n sampled = 1740			n infected: 32 (1.8%), n sampled = 1743		
Covariates	**n (%)**	**OR (95% CI)**	**AOR (95% CI)**	**n (%)**	**OR (95% CI)**	**AOR (95% CI)**	**n (%)**	**OR (95% CI)**	**AOR (95% CI)**
Biological variables (prevalent)									
HIV-1 antibody	39 (10.5)	2.6 (1.7–4.0)	2.0 (1.3–3.1)	1 (0.3)	0.5 (0.1–4.3)		12 (3.2)	2.3 (1.1–4.7)	
HSV-1 antibody	57 (5.8)	1.1 (0.7–1.7)		2 (0.2)	0.3 (0.1–1.3)		21 (2.1)	1.5 (0.7–3.1)	
HSV-2 antibody	30 (8.1)	1.7 (1.1–2.7)		0	—		8 (2.2)	1.3 (0.6–2.8)	
HBV core antibody	50 (6.4)	1.3 (0.9–2.0)		4 (0.5)	1.2 (0.3–4.9)		12 (1.5)	0.7 (0.4–1.5)	
HAV antibody	24 (5.1)	0.9 (0.6–1.4)		2 (0.4)	0.9 (0.2–4.5)		6 (1.3)	0.6 (0.3–1.5)	
HCV antibody	1 (7.1)	1.3 (0.2–10.1)		0	—		0	—	
Syphilis	7 (8.5)	1.6 (0.7–3.6)		0	—		4 (4.9)	3.0 (1.0–8.7)	
CT (same site)	36 (23.8)	9.7 (4.4–11.0)	2.4 (1.1–5.2)	0	—		4 (5.1)	3.2 (1.1–9.2)	
CT (any site)	46 (18.1)	6.1 (4.0–9.3)	2.8 (1.4–5.9)	2 (0.8)	2.0 (0.4–9.8)		7 (2.8)	1.7 (0.7–3.9)	
Sociodemographic variables									
Age, y									
18–21	39 (13.7)	2.6 (1.6–4.4)		12 (3.9)	1.8 (0.8–4.0)		17 (5.4)	1.4 (0.7 –2.8)	
22–29	86 (10.1)	1.9 (1.2–2.9)		40 (4.3)	2.0 (1.0–3.9)		42 (4.5)	1.2 (0.7 –2.1)	
≥30	26 (5.7)	Reference		11 (2.2)	Reference		19 (3.8)	Reference	
Education									
Less than secondary	22 (7.0)	1.9 (1.0–3.6)		3 (1.0)	2.4 (0.4–14.2)		7 (2.2)	1.9 (0.6–5.6)	
Secondary/Vocational	57 (6.1)	1.6 (1.0–2.8)		3 (0.3)	0.8 (0.1–4.7)		19 (2.0)	1.7 (0.7–4.3)	
University or higher	19 (4.2)	Reference		2 (0.4)	Reference		6 (1.2)	Reference	
Living situation									
Live with family	24 (3.6)	Reference		3 (0.5)	Reference		7 (1.0)	Reference	
Live alone/with roommate	63 (7.8)	2.3 (1.2– 3.7)	2.1 (1.3–3.4)	5 (0.6)	1.4 (0.3–5.8)		19 (2.4)	2.3 (1.0–5.5)	
Live with partner	11 (4.2)	1.2 (0.6–2.5)	1.0 (0.5–2.1)	0	—		6 (2.3)	2.3 (0.7–6.7)	
Employment									
Student	40 (6.3)	Reference		4 (0.6)	Reference		15 (2.4)	Reference	
Employed	51 (4.9)	0.8 (0.5–1.2)		3 (0.3)	0.5 (0.1–2.1)		15 (1.5)	0.6 (0.3–1.2)	
Unemployed	7 (9.0)	1.5 (0.6–3.4)		1 (1.3)	2.0 (0.2–18.4)		2 (2.6)	1.1 (0.2–4.8)	
Behavioral variables (in last 4 mo unless otherwise specified)									
Club drug use	21 (7.0)	1.3 (0.8–2.2)		1 (0.3)	0.7 (0.1–5.6)		7 (2.3)	1.4 (0.6–3.2)	
Amyl nitrate use	19 (9.9)	2.1 (1.2–3.5)		1 (0.5)	1.2 (0.1–9.5)		5 (2.6)	1.5 (0.6–4.0)	
Use drugs to enhance sex	26 (8.7)	1.8 (1.1–2.9)		0	—		7 (2.3)	1.4 (0.6–3.2)	
Viagra use	13 (6.4)	1.2 (0.6–2.2)		1 (0.5)	1.1 (0.1–8.9)		4 (2.0)	1.1 (0.4–3.2)	
Binge drinking	15 (7.2)	1.4 (0.8–2.4)		0	—		6 (2.9)	1.7 (0.7–4.3)	
Usual sexual position (lifetime)									
Insertive	8 (2.4)	Reference		0	Reference		7 (2.1)	Reference	
Receptive/Versatile	90 (6.5)	2.8 (1.3–5.8)		7 (0.5)	—		25 (1.8)	0.8 (0.4–2.0)	
Have steady partner	67 (5.5)	0.9 (0.6–1.4)		4 (0.3)	0.4 (0.1–1.7)		25 (2.0)	1.5 (0.7–3.6)	
Have casual partner	81 (6.2)	1.7 (1.0–2.8)		5 (0.4)	0.6 (0.1–2.4)		25 (1.9)	1.2 (0.5–2.8)	
No. casual partners in last 4 mo									
0–1	31 (4.8)	Reference		3 (0.5)	Reference		11 (1.7)	Reference	
2–4	26 (4.6)	1.0 (0.7–1.6)		0	—		9 (1.6)	0.9 (0.4–2.3)	
≥5	41 (7.6)	1.6 (1.0–2.6)		5 (0.9)	2.0 (0.5–8.4)		12 (2.2)	1.3 (0.6–3.0)	
Ever had group sex	37 (6.0)	1.1 (0.7–1.7)		2 (0.3)	0.6 (0.1–3.0)		10 (1.6)	0.8 (0.4–1.7)	

Consistent condom use with any partner in the last 4 mo									
Consistent	20 (4.3)	0.5 (0.2–1.1)		5 (0.7)	0.9 (0.1–8.1)		8 (1.2)	0.8 (0.2–3.6)	
Inconsistent	59 (6.3)	0.8 (0.4–1.6)		2 (0.2)	0.3 (0.03–3.0)		22 (2.4)	1.5 (0.4–6.6)	
No partner	10 (7.9)	Reference		1 (0.8)	Reference		2 (1.6)	Reference	
Internet to meet partner(s)	40 (6.3)	1.2 (0.8– 1.8)		5 (0.8)	2.9 (0.7–12.2)		11 (1.7)	0.9 (0.4–1.9)	
No. places for casual sex									
0–1	41 (4.5)	Reference		4 (0.4)	Reference		17 (1.9)	Reference	Reference
≥2	57 (6.8)	1.6 (1.0–2.4)		4 (0.5)	1.1 (0.3–4.4)		15 (1.8)	1.0 (0.5–2.0)	
Location of casual sexual encounters									
Sauna	36 (5.9)	1.1 (0.7–1.7)		1 (0.2)	0.3 (0.03–2.2)		10 (1.6)	0.8 (0.4–1.8)	
Hotel	29 (7.2)	1.4 (0.9–2.3)		1 (0.3)	0.5 (0.1–3.9)		7 (1.8)	0.9 (0.4–2.2)	
Own home	49 (7.5)	1.7 (1.2–2.6)		5 (0.8)	2.8 (0.8–11.8		15 (2.3)	1.5 (0.7–3.0)	
Partner's home	48 (6.3)	1.3 (0.8–1.9)		4 (0.5)	1.3 (0.3–5.2)		12 (1.6)	0.8 (0.4–1.6)	
Pub/disco	9 (9.8)	1.9 (0.9–3.9)		0	—		3 (3.3)	1.9 (0.6–6.3)	
Department store toilet	8 (5.5)	0.9 (0.4–1.8)		1 (0.7)	2.0 (0.2–18.1)		3 (2.1)	1.1 (0.3– 3.7)	
Paying for sex	10 (3.9)	0.7 (0.3–1.3)		0	—		1 (0.4)	0.2 (0.03–1.4)	
Receiving money for sex	31 (9.3)	2.1 (1.3–3.2)		2 (0.6)	1.4 (0.3–7.0)		7 (2.1)	1.2 (0.5–2.8)	
Having a foreign partner	28 (7.6)	1.5 (1.0–2.4)		1 (0.3)	0.5 (0.1–4.3)		5 (1.4)	0.7 (0.3–1.8)	
No prior HIV test	63 (7.9)	1.9 (1.3–3.0)	1.7 (1.1–2.6)	7 (0.8)	7.0 (0.9–57)		22 (2.5)	2.2 (1.0–4.7)	2.5 (1.2– 5.3)
Never received HIV test result	64 (7.6)	1.7 (1.2–2.7)		7 (0.8)	6.3 (0.8–51		23 (2.5)	2.3 (1.1–5.0)	
History STI diagnosis	24 (5.4)	0.9 (0.6–1.5)		3 (0.7)	1.8 (0.4–7.4)		17 (3.8)	3.4 (1.7– 6.9)	3.7 (1.8–7.5)

Table entries indicate the number of individuals with the given biological or behavioral factor (row) from among a from among participants sampled and infected at the relevant sites (columns 2, 5, 8), and corresponding odds ratios.

Variables included in the multivariable model used to calculate AORs, by anatomic site.

Rectal *NG* infection: HIV-1 serostatus, HSV-2 serostatus, *CT* infection, living situation, amyl nitrate use, drugs to enhance sex, sexual role, number of casual partners, condom use, number of sex locations, sex locations, transactional sex, prior HIV test, no received HIV test result.

Pharyngeal *NG* infection: HSV-1 serostatus, prior HIV test.

Urethral *NG* infection: HIV-1 serostatus, syphilis infection, *CT* infection, prior HIV test, history of STI diagnosis.

AOR indicates adjusted odds ratio; CI, confidence interval; n, number; OR, odds ratio.

TABLE 3. Sociodemographic, Behavioral, and Biological Factors Associated With Site-Specific *CT* and *NG* Coinfection by Rectal and Urethral Sites Among 1743 MSM Participating in the BMCS

	Rectal Infection			Urethral Infection		
Variable	**n (%)**	**OR (95% CI)**	**AOR (95% CI)**	**n (%)**	**OR (95% CI)**	**AOR (95% CI)**
Overall: infection/total (n/N)	36/1596 (2.3)			4/1743 (0.2)		
Biological variables (prevalent)						
HIV-1 antibody	16 (4.7)	3.0 (1.6–5.9)	2.4 (1.2–4.7)	0	—	
HSV-1 antibody	23 (2.5)	1.3 (0.7–2.6)		3 (0.3)	2.3 (0.2–22.3)	
HSV-2 antibody	11 (3.2)	1.6 (0.8–3.3)		1 (0.3)	1.2 (0.1–11.9)	
HBV core antibody	19 (2.6)	1.4 (0.7–2.6)		1 (0.1)	0.4 (0.04–3.9)	
HAV antibody	9 (2.1)	0.9 (0.4–1.9)		0	—	
HCV antibody	0	—		0	—	
Syphilis	5 (6.5)	3.3 (1.3–8.8)		0	—	
Sociodemographic variables						
Age, y						
18–21	11 (3.9)	9.1 (2.0–41.4)		3 (1.0)	—	
22–29	23 (2.7)	6.3 (1.5–26.7)		1 (0.1)	—	
≥30	2 (0.4)	Reference		0	Reference	
Education						
Less than secondary	2 (3.6)	3.7 (0.8–18.1)		0	—	
Secondary/Vocational	27 (3.2)	3.3 (1.4–7.6)		4 (0.4)	—	
University or higher	7 (1.0)	Reference		0	Reference	
Living situation						
Live with family	9 (1.5)	Reference		1 (0.2)	Reference	
Live alone/with roommate	22 (3.0)	2.1 (1.0–4.5)		3 (0.4)	2.5 (0.3–24.0)	
Live with partner	5 (2.0)	1.4 (0.5–4.2)		0	—	
Employment						
Student	17 (3.0)	Reference		4 (0.6)	Reference	
Employed	17 (1.8)	0.6 (0.3–1.2)		0	—	
Unemployed	2 (2.8)	0.9 (0.2–4.1)		0	—	
Behavioral variables (in last 4 mo, unless otherwise specified)						
Club drug use	6 (2.2)	1.0 (0.4–2.4)		0	—	
Amyl nitrate use	6 (3.4)	1.6 (0.7–3.9)		0	—	
Use drugs to enhance sex	9 (3.2)	1.6 (0.7–3.4)		0	—	
Viagra use	6 (3.1)	1.5 (0.6–3.6)		1 (0.5)	2.6 (0.3–24.6)	
Binge drinking	8 (4.3)	2.2 (1.0–4.9)		2 (1.0)	7.4 (1.0–53.1)	
Usual sexual position (lifetime)						
Insertive	2 (0.7)	Reference		2 (0.6)	Reference	
Receptive/Versatile	34 (2.6)	3.7 (0.9–15.5)		2 (0.1)	0.2 (0.03–1.7)	
Have steady partner	23 (2.0)	0.7 (0.4–1.5)		4 (0.3)	—	
Have casual partner	31 (2.6)	2.1 (0.8–5.4)		3 (0.2)	1.0 (0.1–9.9)	
No. casual partners in last 4 mo						
0–1	9 (1.6)	Reference		1 (0.2)	Reference	
2–4	8 (1.6)	1.0 (0.4–2.6)		1 (0.2)	1.1 (0.1–18.3)	
≥5	19 (3.8)	2.5 (1.1–5.5)		2 (0.4)	2.4 (0.2–26.4)	
Ever had group sex	19 (3.3)	2.0 (1.0–3.9)		2 (0.3)	1.8 (0.3–12.9)	
Consistent condom use with any partner in the last 4 mo						
Consistent	6 (1.0)	0.5 (0.1–2.6)		1 (0.2)	—	
Inconsistent	28 (3.3)	1.9 (0.4–7.6)		3 (0.3)	—	
No partner	2 (1.9)	Reference		0	Reference	
Internet to meet partner(s)	18 (3.1)	1.7 (0.9–3.4)		2 (0.3)	1.7 (0.2–12.4)	
No. places for casual sex						
0–1	14 (1.7)	Reference		3 (0.3)	Reference	
≥2	22 (2.9)	1.7 (0.9–3.4)		1 (0.1)	0.4 (0.04–3.5)	
Location of casual sexual encounters						
Sauna	10 (1.8)	0.7 (0.3–1.4)		0	—	
Hotel	10 (2.7)	1.3 (0.6–2.7)		1 (0.3)	1.1 (0.1–10.8)	
Own home	24 (4.0)	3.5 (1.7–7.0)	3.0 (1.5–6.1)	2 (0.3)	1.7 (0.2–12.0)	
Partner's home	20 (2.8)	1.6 (0.8–3.1)		2 (0.3)	1.3 (0.2–9.2)	
Pub/disco	4 (4.8)	2.3 (0.8–6.7)		0	—	
Department store toilet	1 (0.8)	0.3 (0.04–1.9)		0	—	
Paying for sex	6 (2.6)	1.2 (0.5–2.9)		0	—	
Receiving money for sex	17 (5.4)	3.8 (2.0–7.4)	3.1 (1.6–6.0)	0	—	

Continued next page

TABLE 3. *(Continued)*

Variable	Rectal Infection			Urethral Infection		
	n (%)	OR (95% CI)	AOR (95% CI)	n (%)	OR (95% CI)	AOR (95% CI)
Having a foreign partner	12 (3.5)	1.9 (0.9–3.8)		0	—	
No prior HIV test	27 (3.4)	3.1 (1.4–6.6)	2.8 (1.3–6.0)	2 (0.2)	1.0 (0.1–7.1)	
Never received HIV test result	27 (3.2)	2.8 (1.3–5.9)		2 (0.2)	0.9 (0.1–6.4)	
History STI diagnosis	10 (2.4)	1.1 (0.5–2.3)		0	—	

Variables included in the multivariable model used to calculate AORs, by anatomic site.

Rectal *CT-NG* coinfection: HIV-1 serostatus, syphilis infection, age, binge drinking, sexual role, number of casual partners, group sex, condom use, sex locations, transactional sex, prior HIV test.

No variables were independently associated with urethral *CT* and *NG* coinfection.

AOR indicates adjusted odds ratio; CI, confidence interval; n, number; OR, odds ratio.

capture 51% of all clinically silent infections. Targeted screening and presumptive treatment for high-risk subgroups continued outreach to expand awareness, and technological advances to reduce the cost of screening will all be necessary to address the high prevalence of unrecognized and asymptomatic *CT* and *NG* infection among sexually active MSM.

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