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Sexual Network Patterns and their Association with Genital and Anal Human Papillomavirus Infection in Adolescent and Young Men

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Abstract

Purpose: Determine individual- and partner-level factors associated with human papillomavirus (HPV) infection in vaccinated and unvaccinated men.

Methods: Men 13-26 years of age (N=747) completed a survey of sexual behaviors and were tested for genital and perianal/anal HPV (36 types). Sexual network variables included recent and lifetime concurrency (being in more than one sexual relationship at the same time) and recent sex partner discordance (by race, ethnicity, age, and number of sexual partners). We determined individual-level and sexual network variables associated with ≥1 HPV type and HPV16/18, stratified by vaccination status, using separate multivariable logistic regression models.

Results: Participants' mean age was 21.2 years; 64% were positive for ≥1 HPV type and 21% for HPV16/18. Factors associated with ≥1 HPV type in unvaccinated men included recruitment site

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Conflicts of Interest: Dr. Kahn served previously as Co-chair of studies of HPV vaccines in HIV-infected men and women; the studies were funded by NIH but Merck provided vaccine and serology testing.

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and lifetime concurrency. Factors associated with ≥1 HPV type among vaccinated men included recruitment site, Chlamydia history, main male partner, number of lifetime female partners, and no condom use with female partner. Factors associated with HPV16/18 in unvaccinated men included race and partner concurrency. Factors associated with HPV16/18 in vaccinated men included ethnicity, main male partner, and recent concurrency.

Conclusions: Sexual network variables associated with HPV infection were different based on vaccination status and HPV type, suggesting risk factors for HPV infection may change as the proportion of vaccinated men increases. In addition, participant report of concurrency and not knowing whether one had practiced concurrency were consistent risk factors; clinicians should consider including concurrency in the sexual history to determine risk of HPV.

Keywords

Papillomavirus infections; papillomavirus vaccines; sexual behaviors; sexual partners

Human papillomavirus (HPV) is the most common sexually transmitted infection (STI) in the United States [1], and HPV infection is an important cause of cancer in men. While HPV infections are often asymptomatic and clear spontaneously, persistent infections with high-risk types, such as HPV16 and HPV18, may progress to anogenital or oropharyngeal cancer [2]. In the United States, approximately 17,300 new cancers are diagnosed annually are attributable to HPV among men: 81% of these cancers are oropharyngeal, 12% anal, and 7% penile [2]. Rates of HPV-associated anal and oropharyngeal cancers have been steadily increasing among men [3-5].

The 9-valent vaccine is recommended for adolescents and is expected to prevent infections causing approximately 90% of HPV-related cancers [6]. However, HPV vaccine uptake rates have been suboptimal, especially among young men [7]. Low vaccination rates have likely contributed to persistently high prevalence rates of HPV in young men even after HPV vaccines were introduced. A recent study demonstrated 59% of 13- to 26-year-old male adolescents and young men were positive for at least one HPV type two to four years after HPV vaccine introduction [8].

While individual-level risk factors for HPV in men include sexual behaviors, such as number of female and male sexual partners and frequency of sexual intercourse [9-12], little is understood about partner-level risk factors, such as sexual network characteristics. Key sexual network characteristics associated with acquisition of other STIs include concurrency (being in more than one sexual relationship at the same time) and discordance (differences between sexual partners in terms of race, ethnicity, age, or other factors) [13-17]. However, few studies have addressed the associations between sexual network characteristics and HPV [18-20], and no studies have examined these associations in vaccinated and unvaccinated men. Identification of such risk factors for HPV infection in the post-vaccination era among vaccinated and unvaccinated men is necessary for the design of evidence-based public health interventions to prevent HPV among men.

Therefore, we designed a study with the following aims: (1) describe sexual network patterns in men 13-26 years of age; and (2) determine which individual-level and sexual

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network variables are associated with genital and anal HPV infection in these men (≥1 HPV type and HPV16 and/or HPV18) by vaccination status. The hypothesis was that individual and sexual network factors for HPV infection will be different for vaccinated and unvaccinated men as vaccinated and unvaccinated men may behave in different ways which have implications for HPV risk. In addition, the rationale for selecting HPV16 and/or HPV18 as an outcome was because of their association with cancer.

Methods

Sample

Young men 13-26 years old (N=747) were recruited from a hospital-based teen health center clinic (THC), the health department STI clinic (HD), and the community. Data for two surveillance studies were collected using identical methods from the same data collection sites in a Midwest metropolitan area at two time points, 2013–2014 (wave 1; n=400) and 2016–2017 (wave 2; n=347). To optimize generalizability and minimize selection bias, individuals representing a diverse population at an elevated risk for HPV exposure from sites where the population has been stable over time were recruited. Participants were recruited directly from the clinic setting, but other recruitment methods included advertising in print and digital media, mailing lists, and digital advertisements to hospital employees. Furthermore, selection bias and unmeasured confounding were reduced by recruiting sequential samples, ensuring continued high participation rates, measuring all demographic and behavioral factors associated with HPV prevalence, and using identical methods for recruitment.[21] Men who had engaged in sexual contact—defined as genital-oral or genital-genital contact with male or female partners—were eligible to participate in the study. Participants provided written informed consent, and the Institutional Review Boards of the hospital and the health department approved the study. All participants completed a paper-and-pencil, validated survey instrument, available in English or Spanish, assessing sociodemographic characteristics, HPV and HPV vaccine knowledge, vaccination history, substance use behaviors, sexual behaviors, and sexual network behaviors (including concurrency and discordance) [22-25].

Measures and statistical analyses

To assess the prevalence of genital and anal HPV, genital swabs (penile, including coronal sulcus, glans penis, and shaft of the penis as well as scrotal) and one perianal/anal swab were collected for HPV deoxyribonucleic acid (DNA) testing from each participant using previously described procedures [26]. Sterile saline was used to premoisten swabs, which were immediately placed into tubes containing 1 mL of Digene Specimen Transport Medium (STM; Qiagen, Germantown, MD) and stored at −80°C. The penile/scrotal swab samples were amalgamated to produce one genital DNA extract for each participant. The perianal/anal swab sample was analyzed separately. This method has been shown to increase HPV detection among men and result in reproducible genital HPV detection in men while attaining cost savings [26,27]. Samples were analyzed for HPV genotypes using the Roche Linear Array Assay (Roche Molecular Systems, Alameda, CA) [28], a polymerase chain reaction amplification technique using an L1 consensus primer system and reverse-line blot detection strip to identify 36 different HPV genotypes. The Roche Linear Array tests for 37

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high-risk and low-risk genotypes (6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51, 52, 53, 54, 55, 56, 58, 59, 61, 62, 64, 66, 67, 68, 69, 70, 71, 72, 73, 81, 82, 83, 84, IS39, and CP6108). IS39 has been reclassified as a subtype of HPV82; therefore, the test detects 36 distinct genotypes. For the purpose of these analyses, the HPV test results from genital (penile and scrotal) and perianal/anal swabs were combined.

The two primary outcome variables were (1) prevalence of ≥1 (of 36 tested) genital or anal HPV type and (2) prevalence of a cancer-associated, vaccine-type genital or anal HPV type (HPV16 and/or HPV18). Participant data from all recruitment sites were combined for univariable and multivariable analyses. Sociodemographic characteristics included age, race, ethnicity, insurance status, type of insurance, and recruitment site, and STI diagnosis was defined as history of Chlamydia or gonorrhea. Individual-level sexual behaviors included age of first vaginal sex, age of first anal sex, number of lifetime female and male sex partners, last time since vaginal or anal sex with female partner, last time since anal sex with male partner, number of female and male partners in the last three months and last 12 months, number of new female and male partners in the last three months and 12 months, sex of main sexual partner, frequency of oral sex in the last three months, frequency of condom use with female and male partners in the last three months, and condom use at last sexual intercourse with main female and main male partners.

Sexual network variables were created based on participant responses to survey items assessing information provided about the three most recent sexual partners in the last 12 months. To assess participant and partner discordance, we compared participant and partner (as reported by the participant) race, ethnicity, age, and number of sexual partners. Discordance by race and ethnicity was defined as a reported difference in race and ethnicity between the participant and the partner, discordance by age was defined as a greater than three-year difference in age between the participant and the partner, and discordance by number of sexual partners was defined as any difference in the number of reported sexual partners between the participant and partners in the past three months, with the number of sexual partners categorized as 0, 1, and 2 or more. Discordance with respect to race, ethnicity, and age was further defined in three ways: (1) discordance considering the three most recent partners in four categories (100% concordant, 100% discordant, mixed concordant and discordant, and do not know for any partner); (2) discordance considering the three most recent partners in three categories (100% concordant, discordant for any partner, and do not know for any partner); and (3) discordance considering only the most recent sexual partner in three categories (concordant, discordant, and don’t know). Discordant partnerships by the number of sexual partners for the past three months and 12 months were defined as follows: 100% concordant was defined as the participant and partner having identical numbers of partners (0-0, 1-1, or 2+−2+); discordant was defined as differing numbers of partners; and don’t know was defined as a participant responding “don’t know” for any partner.

To assess participant concurrency during the past 12 months, participants were asked whether they had sex with any other person between the first and last time they had sex with each of the last three partners. Concurrency was defined in two ways: (1) four categories (100% no concurrency with any partner, 100% concurrency with all partners, mixed

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concurrency and no concurrency, and do not know for any partner) and (2) three categories (100% no concurrency, concurrency with any partner, and do not know for any partner). We also assessed participant report of partner concurrency for each of the last three partners. Participants were asked if each of their three most recent partners had sex with any other person between the first and last time they had sex with the participant. Two composite variables were defined in the same way as for participant concurrency. In addition, we created a variable for partner concurrency considering only the most recent sexual partner using the following categories: concurrency, no concurrency, and do not know. To assess participant lifetime concurrency, participants were asked whether they had practiced concurrency with any partner in their lifetime: response options were “no,” “yes,” and “don’t remember.”

Due to missing values for variables measuring the number of female and male sexual partners in the last 12 months, 22 men were excluded from the analysis. Participants were classified as vaccinated if they had received ≥1 HPV vaccine dose and as unvaccinated if they had received no doses. Vaccination status was based on medical records (electronic medical record and the statewide vaccination registry; n=710) or on self-report when medical records were not available (n=15).

We used univariable logistic regression modeling to determine whether the following factors were associated with each of the two primary outcomes (prevalence of ≥1 HPV type and prevalence of HPV16 and/or HPV18): (1) participant characteristics and STI diagnosis, (2) individual-level sexual behaviors, and (3) partner-level (sexual network) variables. Independent variables associated with outcome variables at $p < .10$ in univariable analysis were eligible for inclusion in the multivariable logistic regression models. Collinearity was assessed between these independent variables, including individual-level variables and partner-level variables, prior to building the multivariable models. To measure collinearity, we examined associations between selected variables and derived a variance inflation factor to quantify how much the variance of an estimated coefficient was inflated due to multicollinearity, when possible. Highly correlated variables may impact parameter estimation in multivariable regression models; therefore, if variables were found to be highly correlated, we selected one of them, taking into account the degree of statistical significance of the variables and consistency in the variables chosen between multivariable models. A stepwise selection process was used for multivariable modeling. Models were stratified by vaccination status (vaccinated vs. unvaccinated) and were run separately for each of the two outcomes. Only variables associated with the outcome at $p < .05$ were retained in the final models.

Results

Participant characteristics, vaccination rates, and HPV prevalence

The mean age of participants was 21.2 years (range, 14-26 years; SD=3.08), 68% (n=493) were black, and 3.5% (n=25) were Hispanic (Table 1). A majority of participants were recruited from the HD clinic (n=419, 57.8%), followed by the THC (n=198, 27.3%) and the community (n=108, 14.9%). In addition, 68.1% (n=494) of participants reported having a current female main sexual partner. Thirty-four percent (n=246) of participants had received

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≥1 dose of the HPV vaccine, 64.4% (n=449 of 697) were positive for ≥ 1 HPV type, and 21.4% (n=148 of 692) were positive for HPV16 and/or HPV18. The mean age at vaccination was 15.3 years (SD=2.7), and the mean difference between first vaccine dose and study enrollment was 3.9 years (SD=1.74): 479 (66.5%) were not vaccinated, 56 (7.9%) received one dose, 38 (5.3%) received two doses, 140 (19.4%) received three doses, and 7 (1%) received four or more doses.

Sexual network variables

Most participants reported concordance with each of the previous three sexual partners by race (61.2%), ethnicity (85.0%), and age (62.9%; Table 1). Nearly half of participants (54.1%) reported they did not know whether at least one of their last three partners practiced concurrency, while 28.8% reported their partners did not practice concurrency. Approximately half of participants (46.5%) reported concurrency with at least one of the most recent three partners in the past 12 months, while 43.5% reported no concurrency with any of the three most recent partners. Forty-seven percent of participants reported engaging in concurrency with at least one lifetime partner.

Factors associated with being infected with ≥ 1 HPV type in unvaccinated men

The multivariable logistic regression model demonstrated the following factors were associated with infection with ≥1 HPV type (Table 2): recruitment site (HD vs. THC, adjusted odds ratio [AOR]=2.06; 95% CI=1.12–3.80) and participant concurrency (lifetime concurrency vs. no lifetime concurrency, AOR=2.34; 95% CI=1.54–3.54; don't remember vs. no lifetime concurrency, AOR=3.70; 95% CI=1.01–13.58).

Factors associated with being infected with HPV16 and/or HPV18 in unvaccinated men

In the multivariable logistic regression (Table 3), the following variables were associated with higher odds of infection with HPV16 and/or HPV18: race (multiracial vs. white, AOR=2.35; 95% CI=1.02–5.45) and partner concurrency (vs. no concurrency, AOR=3.05; 95% CI=1.53–6.07).

Factors associated with being infected with ≥1 HPV type in vaccinated men

In the multivariable logistic regression (Table 4), the following variables were associated with ≥ 1 HPV type in vaccinated men: recruitment site (HD vs. THC, AOR=2.85; 95% CI=1.43–5.66; community vs. THC, AOR=2.94; 95% CI=1.09–7.96); history of Chlamydia (AOR=2.20; 95% CI=1.06–4.57); having a main male sex partner (vs. female sex partner, AOR=19.61; 95% CI=2.16–166.67); having no main sex partner (vs. main female sex partner, AOR=4.29; 95% CI=1.10–16.67); and reporting between two and 10 lifetime female sex partners (vs. one partner, AOR=4.31; 95% CI=1.53–12.20). Participants were less likely to have ≥ 1 HPV type if they reported not having a main female partner (vs. never or rarely using a condom during the last three months with a main female partner, AOR=0.22; 95% CI=0.06–0.83).

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Factors associated with being infected with HPV16 and/or HPV18 in vaccinated men

In the multivariable logistic regression (Table 5), the following variables were associated with higher odds of HPV16 and/or HPV18 infection: ethnicity (Hispanic vs. non-Hispanic, AOR=14.90; 95% CI=2.68–82.77); having a main male sex partner (vs. female sex partner, AOR=6.67; 95% CI=2.31–19.23); and did not know if they (the participant) practiced concurrency (vs. did not practice concurrency with at least one of the three most recent sex partners, AOR=3.16; 95% CI=1.22–8.15).

Discussion

Participants' report that they or a partner engaged in concurrency emerged as a consistent variable associated with HPV prevalence in both unvaccinated and vaccinated men. In addition, participants' reports that they didn't know or didn't remember whether they practiced concurrency were a risk factor for HPV. Previous studies have demonstrated an association between concurrency and Chlamydia [29], gonorrhea [30], and HIV transmission [31] as well as high-risk HPV in women [19]. Not knowing one's own or a partner's concurrency status was associated with STIs in one previous study [32]. The current findings are novel in that they demonstrate an association between the practice of concurrency (as well as not knowing whether they engaged in concurrency) and HPV infection among men in the post-vaccination era both in unvaccinated and vaccinated adolescents and young men. These findings suggest clinicians should inquire about concurrency when assessing patients' sexual history given its association with HPV and other STIs. Even if a patient does not know whether concurrency occurred, the patient could be at higher risk of HPV and other STIs. Additional research is warranted to further examine the association between concurrency and HPV outcomes as well as to examine complete sexual network data to better understand risks for HPV transmission in the post-vaccination era.

While individual-level and sexual network variables were associated with HPV, we also found risk factors for HPV differed in analyses stratified by vaccination status and HPV type (≥1 HPV type vs. vaccine-type HPV). Among vaccinated men, individual-level behavioral risk factors traditionally associated with HPV infection, including history of Chlamydia, sex of main partner, and number of sexual partners, were the independent risk factors for ≥1 HPV type. This result is an expected finding given that riskier sexual behaviors, such as increased number of sex partners [9-12] and lack of condom use [33], are established risk factors for HPV, and vaccination does not protect against all HPV types. Among vaccinated men, risk factors for vaccine-type HPV16 and/or HPV18 included Hispanic ethnicity, having a male sex partner, and not knowing whether they (the participant) had practiced concurrency. Given that HPV vaccines are highly effective in preventing HPV16 and HPV18 if given prior to exposure, these findings imply men may have acquired HPV through sexual activity prior to vaccination. Regardless, the findings suggest a subgroup of vaccinated men are still at risk for vaccine-type HPV—likely due to exposure prior to vaccination—and that it may be possible to identify subgroups of vaccinated men who are at higher risk for anal cancers and who may benefit from more intensive cancer screening. In addition, the findings provide further support for the recommendation to vaccinate boys at 11-12 years of age to decrease risk before exposure to HPV [34,35] and for public health education campaigns to

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increase parents' acceptance of vaccinating boys at this age as well as promoting clinical interventions that reduce missed clinical opportunities to vaccinate [36].

Among unvaccinated men, recruitment site (other sites vs. THC) was associated with ≥1 HPV type. One explanation for this finding is that the HD participants were older than those recruited from the THC and were less likely to have insurance, both of which could be a proxy for decreased access to primary care and sexual health care. Among unvaccinated men, having practiced lifetime concurrency and not remembering whether one had practiced lifetime concurrency was associated with ≥1 HPV type. In addition, report of partner concurrency was associated with HPV16 and/or HPV18 in unvaccinated men. These findings align with previous studies demonstrating concurrency as a risk factor for STIs [19,29-31]. However, ours is the first study to demonstrate that concurrency, as well as not knowing whether concurrency had occurred, are risk factors for unvaccinated men in the post-vaccination era. While individual sexual behaviors, such as number of sexual partners and frequency of sexual intercourse, have been well documented as risk factors for HPV in men [9-12], these factors did not emerge as risk factors for unvaccinated men in our study. One explanation for this finding is our study includes a sample of younger men than those who traditionally participate in studies of HPV in men and identifies factors associated with early exposures. The context of sexual networks may be different for younger men, particularly those men who have sex with men (MSM), as they may have less dense networks than heterosexual young men and older MSM. In addition, temporal challenges exist in identifying current sexual behaviors with an HPV infection may have been acquired during a time when the behaviors practiced were different. While we did not examine differences in vaccinated and unvaccinated men's individual-level sexual behaviors, future research should explore these potential differences to better understand the discrepancies between unvaccinated and vaccinated men and to develop tailored public health interventions to prevent and screen for HPV infection.

Limitations

There were several limitations to this study should be considered when interpreting our results. First, data were cross-sectional, and causal inferences cannot be drawn from the results. Second, behaviors were self-reported; participant report of socially desirable responses and recall bias may limit the validity of the data. Third, report of partner characteristics and concurrency were based on participants' assessment and was not validated by any data collected from the partner, which may limit data accuracy [32,37]. Fourth, the number of observations was small within some variable categories, possibly limiting power to detect differences between the independent and outcome variables. Finally, although we used established and reliable methods for anogenital sampling and HPV DNA testing, there is a possibility of false-positive or false-negative results.

Findings from the current study suggest risk factors for HPV infection are changing over time as the proportion of vaccinated men increases and due to differences between vaccinated and unvaccinated men in behaviors may be associated with HPV, underscoring the importance of addressing both individual- and partner-level factors in HPV prevention efforts. In addition, concurrency and not knowing whether one had practiced concurrency

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were consistent risk factors across models, implying clinicians should consider including concurrency in the sexual history to determine HPV risk. Finally, future research should utilize interpersonal theoretical frameworks assessing expansive sexual network factors to better understand the complexities of HPV infection in the post-vaccination era.

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Acronyms

AOR	adjusted odds ratio
CI	confidence interval
DNA	deoxyribonucleic acid
HD	health department STI disease clinic
HPV	human papillomavirus
MSM	men who have sex with men
STI	sexually transmitted infection
THC	teen health center clinic

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Implications and Contributions

This study examined associations between sexual network factors and HPV infection in men during the post-vaccination era. Findings demonstrated sexual network variables associated with HPV infection were different based on vaccination status and HPV type, suggesting risk factors for HPV may change over time as the proportion of vaccinated men increases.

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Table 1.

Participant characteristics and behaviors (n = 725)

Characteristic	N (%)[a]
Prevalence of ≥1 HPV type[b]	
No HPV	248 (35.6)
≥1 HPV type	449 (64.4)
Prevalence of HPV16 and/or HPV18	
No HPV16 and/or HPV18	544 (78.6)
HPV16 and/or HPV18	148 (21.4)
Recruitment site	
Teen health clinic	198 (27.3)
Health department sexually transmitted disease clinic	419 (57.8)
Community health center	108 (14.9)
Demographic characteristics	
Age (years)	
13-17	98 (13.5)
18-21	278 (38.3)
22-26	349 (48.1)
Race	
White, Asian, and Pacific Islander[c]	182 (25.1)
Black, Native American, and Alaskan Native[d]	495 (68.3)
Multiracial and other	48 (6.6)
Ethnicity	
Non-Hispanic/Latino	700 (96.6)
Hispanic/Latino	25 (3.5)
Insurance plan	
Private	200 (27.6)
Medicaid/public	245 (33.8)
No insurance/do not know	280 (38.6)
Health history	
Sexually transmitted infections, lifetime	
Chlamydia	241 (33.2)
Gonorrhea	143 (19.7)
HPV vaccination	
Received ≥1 HPV Vaccination	
Yes	246 (33.9)
No	479 (66.1)
Sexual behaviors	
Sexual orientation	
Heterosexual	634 (87.8)

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Characteristic	N (%)[a]
Homosexual, bisexual, or other	88 (12.2)
Age of first sexual intercourse (vaginal), years	
Never had sex with a women	55 (7.6)
≤ 14	241 (33.2)
15-17	309 (42.6)
≥ 18	120 (16.6)
Age of first sexual intercourse (anal), years	
≤ 17	47 (6.5)
≥ 18	45 (6.2)
Did not have sex with a man	633 (87.3)
Number of female sex partners, lifetime	
0	55 (7.6)
1	53 (7.3)
2-10	340 (47.1)
11+	274 (38.0)
Number of male sex partners, lifetime	
0-10	59 (8.2)
11+	32 (4.4)
Did not have sex with a man	633 (87.4)
Sex with female partner, last time	
Within 24 hours	68 (9.4)
More than 24 hours	602 (83.0)
Did not have sex with a female partner	55 (7.6)
Sex with male partner, last time	
Within 24 hours	12 (1.7)
More than 24 hours	80 (11.0)
Did not have sex with a male partner	633 (87.3)
Number of female partners, past 3 months	
0	65 (9.0)
1	292 (40.3)
2+	312 (43.1)
Never	55 (7.6)
Number of male partners, past 3 months	
0-1	48 (6.6)
2+	44 (6.1)
Never	633 (87.3)
Number of new female partners, past 3 months	
0	324 (44.7)
1	201 (27.7)
2+	145 (20.0)
Never	55 (7.6)
Number of new male partners, past 3 months	

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Characteristic	N (%)[a]
0 + 1	64 (8.8)
2+	28 (3.9)
Never	633 (87.3)
Number of female partners, past 12 months	
0	20 (2.8)
1	199 (27.5)
2+	451 (62.2)
Never	55 (7.6)
Number of male partners, past 12 months	
0 + 1	28 (3.9)
2+	64 (8.8)
Never	633 (87.3)
Number of new female partners, past 12 months	
0	180 (24.8)
1	194 (26.8)
2+	296 (40.8)
Never	55 (7.6)
Number of new male partners, past 12 months	
0 + 1	41 (5.7)
2+	51 (7.0)
Never	633 (87.3)
Ever had sex with a woman, anal or vaginal	667 (92.0)
Ever had sex with a man, anal	92 (12.7)
Main sexual partner	
Female	494 (68.1)
Male	51 (7.0)
Do not have main sexual partner	180 (24.8)
Oral sex, past 3 months	
Received	609 (84.0)
Gave	471 (65.0)
Number of times had oral sex, past 3 months	
0	96 (13.2)
1	65 (9.0)
2-5	252 (34.8)
> 5	312 (43.0)
Condom use	
Frequency of condom use, past 3 months with main female partner	
Never + Every once in a while	303 (41.9)
Most + Every single time	156 (21.6)
No main partner + Main partner is male	265 (36.6)
Frequency of condom use for anal sex, past 3 months with main female partner	

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Characteristic	N (%)[a]
Never + Every once in a while	71 (9.8)
Most + Every single time	27 (3.7)
No main partner + Main partner is male	627 (86.5)
Frequency of condom use for insertive anal sex,[e] past 3 months with main male partner	
Never + Every once in a while	26 (3.6)
Most + Every single time	18 (2.5)
No main partner + Main partner is female	681 (93.9)
Frequency of condom use for receptive anal sex,[f] past 3 months with main male partner	
Never + Every once in a while	25 (3.5)
Most + Every single time	15 (2.1)
No main partner + Main partner is female	685 (94.5)
Used condom at last sexual intercourse with main female partner, vaginal	
No	315 (43.5)
Yes	170 (23.5)
No main partner + Main partner is male + No anal	240 (33.1)
Used condom at last sexual intercourse with main female partner, anal	
No	73 (10.1)
Yes	29 (4.0)
No main partner + Main partner is male + No anal	623 (85.9)
Used condom at last sexual intercourse (insertive) with main male partner[e]	
No	30 (4.1)
Yes	19 (2.6)
No main partner + Main partner is female	676 (93.2)
Used condom at last sexual intercourse (receptive) with main male partner[f]	
No	29 (4.0)
Yes	15 (2.1)
No main partner + Main partner is female	681 (93.9)
Sexual networking	
Discordant by race[g]	
100% Concordant	444 (61.2)
Any discordant	265 (36.6)
Do not know for ≥ 1 of the 3 most recent partners	16 (2.2)
Discordant by ethnicity[g]	
100% Concordant	616 (85.0)
Any discordant	64 (8.8)
Do not know for ≥ 1 of the 3 most recent partners	45 (6.2)

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Characteristic	N (%)[a]
Discordant by age[h]	
100% Concordant	456 (62.9)
Any discordant	185 (25.5)
Do not know for ≥ 1 of the 3 most recent partners	84 (11.6)
Discordant by sexual partnerships, 3 months[i]	
100% Concordant	159 (21.9)
Any discordant	115 (15.9)
Do not know for ≥ 1 of the 3 most recent partners	451 (62.2)
Participant's 3 most recent partners' concurrency practice[j]	
100% No concurrency	209 (28.8)
Any concurrency	124 (17.1)
Do not know for ≥ 1 of the 3 most recent partners	392 (54.1)
Participant concurrency practice, past 12 months with any of the 3 most recent partners[j]	
100% No concurrency	315 (43.5)
Any concurrency	337 (46.5)
Do not know for ≥ 1 of the 3 most recent partners	73 (10.1)
Participant lifetime concurrency[j]	
No	354 (48.8)
Yes	341 (47.0)
Don't remember	30 (4.1)

[a]Some percentages do not add up to 100% because of missing values.

[b]≥1 HPV genotype tested using the Roche Linear Array Assay to identify 36 distinct genotypes including 6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51, 52, 53, 54, 55, 56, 58, 59, 61, 62, 64, 66, 67, 68, 69, 70, 71, 72, 73, 81, 82, 83, 84, IS39, and CP6108.

[c]Categories were combined due to the small sample size of Asian or Pacific Islander participants (n = 4), and these participants had other characteristics similar to white participants.

[d]Categories were combined due to the small sample size of Native American or Alaskan Native participants (n = 2), and these participants had other characteristics similar to black participants.

[e]Insertive anal sex was defined as the participant inserting his penis into the rectum of his male partner.

[f]Receptive anal sex was defined as the participant's male partner inserting his penis into the participant's rectum.

[g]Discordance by race and ethnicity was defined as a reported difference in race or ethnicity between the participant and the partner and categorized as 100% concordant (participant and partner(s) were same race or ethnicity), any discordance (participant and ≥1 partner was a different race or ethnicity), and did not know for ≥ 1 of the 3 most recent partners.

[h]Discordance by age was defined as a greater-than-three-year difference in age between the participant and the partner and categorized as 100% concordant (participant and partner(s) were within a three-year difference in age), any discordance (participant and ≥1 partner's age difference was greater than three years), and did not know for ≥ 1 of the 3 most recent partners.

[i]Discordance by number of sexual partners was defined as any difference in the number of reported sexual partners between the participant and partners in the past three months, with the number of sexual partners categorized as 0, 1, and 2 or more and categorized as 100% concordant (participant and partner(s) had the same number of partners), any discordance (participant and ≥1 partner had a different number of partners), and did not know for ≥ 1 of the 3 most recent partners.

[J] Concurrency was defined as being involved in more than one sexual partnership during the same time period.

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Table 2.

Independent variables associated with ≥1 HPV-type infection in unvaccinated men: results of an adjusted logistic regression model (n = 464)

Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
Age		
13-17	1.00	
18-21	**2.77 (1.23 – 6.25)**	
22-26	**2.77 (1.30 – 5.94)**	
Race		
White, Asian, and Pacific Islander	1.00	
Black, Native American, and Alaskan Native	1.48 (0.98 – 2.26)	
Multiracial and other	2.34 (0.94 – 5.81)	
Insurance status		
Private	1.00	
Medicaid/public	**1.84 (1.07 – 3.15)**	
No insurance/do not know	1.45 (0.94 – 2.24)	
Recruitment site		
Teen health center	1.00	1.00
Health department sexually transmitted disease clinic	**2.36 (1.30 – 4.29)**	**2.06 (1.12 – 3.80)**
Community	0.70 (0.35 – 1.41)	0.71 (0.35 – 1.46)
Chlamydia infection, lifetime		
No	1.00	
Yes	1.51 (0.99 – 2.28)	
Number of female sex partners, lifetime		
0	1.00	
1	0.35 (0.11 – 1.06)	
2-10	0.94 (0.45 – 1.96)	
11+	1.59 (0.75 – 3.36)	
Participant concurrency, lifetime[b]		
No	1.00	1.00
Yes	**2.70 (1.80 – 4.04)**	**2.34 (1.54 – 3.54)**
Don’t remember	**3.95 (1.11 – 14.21)**	**3.70 (1.01 – 13.58)**
Partner concurrency		
No concurrency	1.00	
Any concurrency	**2.94 (1.62 – 5.34)**	
Do not know	**2.26 (1.43 – 3.55)**	
Partner 1 number of sex partners, 3 months		
Do not know	1.00	
0	2.61 (0.31 – 22.14)	
1	**0.49 (0.30 – 0.78)**	
2+	1.13 (0.70 – 1.81)	

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Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
Number of three most recent sexual partners, past 12 months		
1 Partner	1.00	
2 Partners	1.12 (0.66 – 1.89)	
3 Partners	**2.04 (1.29 – 3.24)**	

Bold indicates $p < .05$.

[a] CI = confidence interval.

[b] Concurrency defined as being involved in more than one sexual partnership during the same time period.

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Table 3.

Independent variables associated with HPV16 and/or HPV18 infection in unvaccinated men: results of an adjusted logistic regression model (n = 461)

Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
Race		
White	1.00	1.00
Black	0.88 (0.54 – 1.45)	0.79 (0.47 – 1.33)
Multiracial	**2.94 (1.30 – 6.64)**	**2.35 (1.02 – 5.45)**
Insurance status		
No/not sure/missing	1.00	
Yes	0.67 (0.43 – 1.04)	
Partner concurrency[b]		
No concurrency	1.00	1.00
Concurrency	**3.13 (1.60 – 6.10)**	**3.05 (1.53 – 6.07)**
Do not know	1.42 (0.78 – 2.58)	1.51 (0.81 – 2.81)

Bold indicates $p < .05$.

[a] CI = confidence interval.

[b] Concurrency defined as being involved in more than one sexual partnership during the same time period; partner concurrency defined as at least one of the most recent three partners practiced concurrency.

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Table 4.

Independent variables associated with ≥1 HPV-type infection in vaccinated men: results of adjusted logistic regression model (n = 232)

Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
Age		
13-17	1.00	
18-21	**2.18 (1.19 – 4.01)**	
22-26	**3.37 (1.36 – 8.39)**	
Recruitment site		
Teen health center	1.00	1.00
Health department sexually transmitted infection clinic	**2.96 (1.59 – 5.51)**	**2.85 (1.43 – 5.66)**
Community	1.94 (0.77 – 4.84)	**2.94 (1.09 – 7.96)**
Chlamydia infection, lifetime		
No	1.00	1.00
Yes	**2.00 (1.59 – 5.51)**	**2.20 (1.06 – 4.57)**
Gender of main sexual partner		
Female		1.00
Male		**19.61 (2.16 – 166.67)**
No main partner		**4.29 (1.10 – 16.67)**
Number of female partners, lifetime		
1	1.00	1.00
0	**5.10 (1.34 – 19.61)**	1.89 (0.31 – 11.49)
2-10	**3.80 (1.52 – 9.52)**	**4.31 (1.53 – 12.20)**
11+	**3.46 (1.32 – 9.09)**	2.02 (0.64 – 6.37)
Number of male partners, past 12 months		
0 or never had sex with a man	1.00	
1	0.42 (0.10 – 1.80)	
≥ 2	**3.93 (1.12 – 13.84)**	
Gave oral sex, past 3 months		
No	1.00	
Yes	**2.14 (1.25 – 3.66)**	
Condom use, past 3 months with main female partner		
Never/rarely	1.00	1.00
Always/most of the time	**0.41 (0.20 – 0.85)**	0.46 (0.21 – 1.03)
No main female partner[b]	0.87 (0.48 – 1.59)	**0.22 (0.06 – 0.83)**
Partner concurrency		
No concurrency	1.00	
Concurrency	**3.89 (1.33 – 11.38)**	
Do not know	**1.86 (1.06 – 3.27)**	
Partner 1 number of sexual partners, past 12 months		
Do not know	1.00	

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Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
1	**0.38 (0.20 – 0.74)**	
≥ 2	1.21 (0.64 – 2.30)	
Number of 3 most recent sexual partners, 12 months		
1 Partner	1.00	
2 Partners	2.05 (0.95 – 4.44)	
3 Partners	**2.11 (1.15 – 3.88)**	
Discordant by number of sexual partners of 3 most recent sexual partners, past 3 months		
100% Concordant	1.00	
Any discordant	**4.32 (1.59 – 11.70)**	
Do not know for any partner	**1.98 (1.05 – 3.75)**	

Bold indicates $p < .05$.

[a]CI = confidence interval.

[b]Includes those with male sex partners only.

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Table 5.

Independent variables associated with HPV16 and/or HPV18 infection in vaccinated men: results of adjusted logistic regression model (n = 231)

Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
Hispanic ethnicity		
No	1.00	1.00
Yes	**11.16 (2.09 – 59.53)**	**14.90 (2.68 – 82.77)**
Sexual orientation		
Heterosexual	1.00	
Homosexual, bisexual, or other	**2.58 (1.10 – 6.05)**	
Gender of main sexual partner		
Female	1.00	1.00
Male	**5.92 (2.13 – 16.39)**	**6.67 (2.31 – 19.23)**
No main partner	**2.37 (1.15 – 4.88)**	2.14 (0.99 – 4.63)
Age of first sexual intercourse with male (anal), years		
≤ 17	1.00	
≥ 18	0.46 (0.10 – 2.13)	
Did not have sex with a man	**0.24 (0.08 – 0.70)**	
Number of male anal sex partners, lifetime		
1-10	1.00	
11+	0.78 (0.12 – 5.16)	
Did not have sex with a man	**0.33 (0.13 – 0.81)**	
Vaginal sex, last time		
Within 24 hours	1.00	
More than 24 hours	5.35 (0.70 – 41.03)	
Did not have sex with female partner	**11.45 (1.22 – 107.49)**	
Condom use, past 3 months for insertive anal sex[b] with male partner		
Never/rarely	1.00	
Always/most of the time	1.00 (0.13 – 7.57)	
No main male partner[c]	0.22 (0.04 – 1.11)	
Condom use, past 3 months for receptive anal sex[d] with male partner		
Never/rarely	1.00	
Always/most of the time	0.19 (0.02 – 2.50)	
No main male partner[c]	**0.07 (0.01 – 0.73)**	
Condom use, past 3 months with main female partner		
Never/rarely	1.00	
Always/most of the time	1.71 (0.61 – 4.78)	
No main female partner[e]	**3.40 (1.51 – 7.70)**	
Participant concurrency[f]		

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Variable	Unadjusted odds ratio (95% CI)[a]	Adjusted odds ratio (95% CI)[a]
No concurrency	1.00	1.00
Concurrency	1.01 (0.49 – 2.10)	0.87 (0.40 – 1.93)
Do not know	**2.92 (1.19 – 7.19)**	**3.16 (1.22 – 8.15)**
Partner 1 number of sex partners, 3 months		
Do not know	1.00	
0	0.001 (0.001 – 999.99)	
1	**0.31 (0.14 – 0.72)**	
2+	0.47 (0.21 – 1.05)	
Partner 1 discordant by number of sexual partners, past 3 months		
Discordant	1.00	
Concordant	0.84 (0.31 – 2.29)	
Do not know	2.45 (0.98 – 6.15)	
Discordant by ethnicity of 3 most recent sexual partners		
100% Concordant	1.00	
100% Discordant	**7.75 (1.77 – 33.97)**	
Mixed with concordant and discordant	0.67 (0.14 – 3.06)	
Do not know for any partner	2.32 (0.75 – 7.23)	

Bold indicates $p < .05$.

[a] CI = confidence interval.

[b] Insertive anal sex was defined as the participant inserting his penis into the rectum of his male partner.

[c] Includes those with female sex partners only.

[d] Receptive anal sex was defined as the participant's male partner inserting his penis into the participant's rectum.

[e] Includes those with male sex partners only.

[f] Concurrency defined as being involved in more than one sexual partnership during the same time period; participant concurrency defined as concurrency with at least one of the most recent three partners.