Title

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Journal

The Journal of Infectious Diseases, 214(5)

ISSN

0022-1899

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Publication Date

2016-09-01

DOI

10.1093/infdis/jiw232

Peer reviewed

HHS Public Access

Author manuscript

J Infect Dis. Author manuscript; available in PMC 2017 September 01.

Published in final edited form as:

J Infect Dis. 2016 September 1; 214(5): 689–696. doi:10.1093/infdis/jiw232.

Monitoring for Human Papillomavirus Vaccine Impact Among Gay, Bisexual, and Other Men Who Have Sex With Men—United States, 2012–2014

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Abstract

Background—Gay, bisexual, and other men who have sex with men (MSM) are at high risk for human papillomavirus (HPV) infection; vaccination is recommended for US males, including MSM through age 26 years. We assessed evidence of HPV among vaccine-eligible MSM and transgender women to monitor vaccine impact.

Methods—During 2012–2014, MSM aged 18–26 years at select clinics completed a computer-assisted self-interview regarding sexual behavior, human immunodeficiency virus (HIV) status, and vaccinations. Self-collected anal swab and oral rinse specimens were tested for HPV DNA (37 types) by L1 consensus polymerase chain reaction; serum was tested for HPV antibodies (4 types)

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Presented in part: 30th International Papillomavirus Conference, Lisbon, Portugal, September 2015. Abstract HPV15-0175.

Supplementary Data

Supplementary materials are available at http://jid.oxfordjournals.org. Consisting of data provided by the author to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the author, so questions or comments should be addressed to the author.

Disclaimer. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

Potential conflicts of interest. All authors: No reported conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

by a multiplexed virus-like particle–based immunoglobulin G direct enzyme-linked immunosorbent assay.

Results—Among 922 vaccine-eligible participants, the mean age was 23 years, and the mean number of lifetime sex partners was 37. Among 834 without HIV infection, any anal HPV was detected in 69.4% and any oral HPV in 8.4%, yet only 8.5% had evidence of exposure to all quadrivalent vaccine types. In multivariate analysis, HPV prevalence varied significantly ($P < .05$) by HIV status, sexual orientation, and lifetime number of sex partners, but not by race/ethnicity.

Discussions—Most young MSM lacked evidence of current or past infection with all vaccine-type HPV types, suggesting that they could benefit from vaccination. The impact of vaccination among MSM may be assessed by monitoring HPV prevalence, including in self-collected specimens.

Keywords

epidemiological monitoring; homosexuality, male; papillomavirus infections; papillomavirus vaccines

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Human papillomavirus (HPV) infection is the most common sexually transmitted infection worldwide [1]. Gay, bisexual, and other men who have sex with men (MSM) have high rates of infection with HPV [2, 3]. In 2 recent studies, the incidence of any anal HPV per 100 person-years was 57.1 cases among 200 MSM aged 16–20 years and 46.2 cases among 94 MSM aged 19–23 years [4, 5]. Commonly reported risk factors include high numbers of lifetime sex partners and concomitant human immunodeficiency virus (HIV) infection [6–9].

Diseases associated with persistent HPV infections include anogenital warts and various types of cancers, including >90% of anal cancers in the United States [10]. In a meta-analysis of data from 9 studies, the pooled incidence rate of anal cancer among MSM was 5.1 cases per 100 000 person-years among HIV-negative MSM and 45.9 cases per 100 000 person-years among MSM infected with HIV [11, 12]. These rates are higher than that for all US males, which is estimated to be 1.6 cases per 100 000 persons [13]. In addition, the incidence of HPV-associated oropharyngeal cancer is rising in the United States, although the relative risk among MSM is not well established [14]. HPV type 16 is responsible for the majority of HPV-associated cancers in men [10].

In the United States, 2 prophylactic HPV vaccines are licensed for use in males. Quadrivalent HPV vaccine (4vHPV; Gardasil; Merck) protects against 4 HPV types (6, 11, 16, and 18) and was licensed in 2009 for use for males aged 9–26 years [15]. HPV vaccination was already routinely recommended for girls; the Advisory Committee on Immunization Practices (ACIP) stated that boys could be vaccinated but did not include HPV vaccination in the routine immunization schedule for boys at the time [16]. In 2011, the ACIP recommended routine vaccination for all males at ages 11–12 years, through age 21 years for men not previously fully vaccinated, and through age 26 years for MSM and immunocompromised men, including those infected with HIV [16].

The pivotal 4vHPV efficacy trial in males included heterosexual men and MSM who had 1–5 lifetime sex partners [17, 18]. The per-protocol efficacy was determined among those

naive to the respective vaccine type; the efficacy against external genital lesions was 92.4% among heterosexual men and 79.0% among MSM but was lower in the intent-to-treat population [17]. Among MSM aged 16–26 years, the efficacy for prevention of HPV vaccine type-related anal precancerous lesions was 77.5% in the per-protocol population and 50.3% in the intent-to-treat population [18]. The intent-to-treat efficacy in the vaccine trials and the effectiveness in vaccine programs depends on the length of follow-up, as well as the prevalence of previous exposure to HPV, since those already infected may not benefit from prophylactic vaccination.

Nonavalent HPV vaccine (9vHPV; Gardasil 9; Merck) protects against 9 HPV types, including all 4vHPV types and 5 additional types (31, 33, 45, 52, and 58). 9vHPV was licensed in late 2014, and in 2015 the ACIP added this vaccine as one of two that can be used for routine vaccination of males [19].

Although many countries already recommend vaccinating girls, only a few have implemented routine male HPV vaccination as part of their immunization programs [20]. Evaluating vaccine impact is important for improving public health programs, but identifying direct and indirect impacts among males presents a challenge. As MSM are less likely to benefit indirectly from increasing coverage among females, this remains an important risk group to monitor. A sentinel surveillance model involving consistent recruitment, sampling, and detection methods among MSM within the target age range for vaccination would allow detection of changes in circulating HPV types [21]. We assessed evidence of current and past exposure to HPV among young MSM and demonstrate a method for assessing anal and oral HPV DNA prevalence among a sentinel population to provide a baseline for monitoring HPV vaccine impact.

METHODS

Study Design and Procedures

The cross-sectional Young Men’s HPV study (YMHPV study) enrolled consenting gay, bisexual, and other MSM, including transgender women, aged 18–26 years. Enrollment occurred at 3 clinical facilities focused on providing sexual health services to lesbian, gay, bisexual, and transgender populations in 2 US cities (Chicago, Illinois, and Los Angeles, California) during July 2012–August 2014. These cities were selected from among 12 included in the US National HIV/AIDS Strategy operational plan, and sites were identified on the basis of available technical capacity and potential study population size [22]. The study protocol was reviewed and approved by institutional review boards at the participating institutions.

Participants were eligible if they provided written informed consent and met the following criteria at the time of enrollment: (1) age 18–26 years, to allow for consent requirements and vaccine eligibility; (2) assigned male sex at birth; and (3) eligible for HPV vaccine, based on sexual orientation (ie, identification as gay, homosexual, or bisexual, regardless of past sexual behavior) and/or sexual behavior (ie, ever having engaged in oral or anal sex with a male partner). Each received a gift card incentive of nominal value. Most were enrolled and

completed all study elements on the day of a clinic visit, without interruption of their scheduled appointment. Vaccine was not provided as part of the study.

Each participant completed a confidential 30-minute standardized computer-assisted interview in English regarding demographic characteristics, sexual orientation and behavior, past medical history (including HIV status, history of sexually transmitted infections, and self-reported vaccine history), and knowledge, attitudes, and practices regarding HPV infection, HPV-associated diseases, and HPV vaccines. Each participant was assigned a unique study ID code, and no personally identifying information was collected.

Specimen Collection

Each participant provided 3 types of biologic specimens: anal swab, oral rinse, and blood. Self-collected anal and oral specimens have been used elsewhere to evaluate HPV [23, 24]. Venipuncture was performed by a phlebotomist.

Illustrated schematic instructions were provided to aid in self-collection of anal and oral specimens (Supplementary Appendix). Anal specimens were self-collected using Digene swab specimen collection kits (Qiagen, Valencia, California). In a private room and using appropriate infection control technique (ie, hand hygiene), each participant inserted a sterile swab 1 inch into the anus, rotated the swab 360 degrees at least twice, and gently removed and placed the swab into a labeled Digene Specimen Transport Medium (STM) container for storage at −20°C. Oral specimens were self-collected by swishing and gargling 10 mL of sterile saline for 30 seconds, deposited in a labeled sterile container, and stored at −20°C. At least 5 mL of blood was collected in a red-topped (without additives) Vacutainer tube (Becton, Dickinson, and Company). Serum was separated, aliquoted into labeled cryovials, and stored at −20°C until shipment.

All specimens were shipped on dry ice for batch processing at the HPV laboratory at the Centers for Disease Control and Prevention. Long-term storage was at −80°C.

Laboratory Testing and Results

DNA extraction was performed with a MagNA Pure LC system and the MagNA Pure LC DNA Isolation Kit III for Bacteria and Fungi (Roche Diagnostics, Indianapolis, Indiana). From anal specimens, a 150-μL aliquot of cells in STM was mixed with 85 μL of lysis buffer and 15 μL of Proteinase K. From oral specimens, cells from 1.5 mL of medium were pelleted by centrifugation; the resulting pellet was resuspended in 130 μL of lysis buffer and 20 μL of Proteinase K. Both lysis mixtures were incubated for 1 hour at 65°C and subsequently processed with the MagNA Pure LC instrument; a100-μL DNA extract was eluted. A 10-μL aliquot of each DNA extract was added for each 100-μL polymerase chain reaction assay, using the Research Use Only Linear Array HPV Genotyping Assay (Roche Diagnostics), following the manufacturer's protocol modified to accommodate sample volume and automated hybridization and detection with Beeblot instrument (Bee Robotics, Caernarfon, United Kingdom). This assay distinguishes 37 HPV types: 6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51, 52 (XR), 53, 54, 55, 56, 58, 59, 61, 62, 64, 66, 67, 68, 69, 70, 71, 72, 73, 81, 82, 83, 84, 89, or IS39. However, the XR probe cross-reacts with HPV 33, 35, and 58. When these cross-reacting types were also detected in an XR-positive specimen, the

presence of HPV 52 was confirmed by a quantitative type-specific assay, as described elsewhere [25]. Specimen adequacy was assessed in every test by coamplification and detection of the human β-globin gene; any sample negative for HPV (all 37 types) and negative for the β-globin gene was considered inadequate. Of all specimens submitted, 95.9% of anal specimens and 98.9% of oral specimens were adequate for analysis.

Serum specimens were tested for antibody levels to 4vHPV types, using a multiplexed virus-like particle–based immunoglobulin G direct enzyme-linked immunosorbent assay (M4ELISA) on a Meso Scale Discovery electrochemiluminescent platform as described elsewhere; cutoffs were set at ≥99% relative light units, based on a Johnson-Su distribution [26].

Data Analysis

Behavioral questionnaire results were collected in Qualtrics (Qualtrics, Provo, Utah). For this analysis, all vaccine-eligible participants were included, regardless of current gender identity or expression; transgender women were included. Participants were considered vaccine eligible if they reported never receiving any doses of HPV vaccine. Participants were excluded from this analysis if they did not complete the questionnaire or if any of their biologic specimens were inadequate for analysis. Participants were considered naive to an HPV type if they had no anal, oral, or serologic evidence of infection (current or past) with that HPV type. The following 14 HPV types were considered high-risk for being oncogenic as they are included in clinical tests: 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, or 68. Descriptive statistics were calculated, and binomial regression analysis (using the log link function) was conducted to calculate prevalence ratios and their 95% confidence intervals to assess risk factors for current infections (≥1 type of anal or oral HPV DNA) with any HPV type or any high-risk type of HPV. We also performed multivariate binomial regression analysis, including in the model as independent variables those significantly associated with prevalent HPV in univariate analysis. Variables with a P value of $< .05$ were considered significant. Type-specific prevalence of HPV infection by site, including serology results, was stratified based on self-reported HIV status. All calculations were performed using SAS, version 9.3 (SAS Institute, Cary, North Carolina).

Upon request, participants received their high-risk HPV DNA test results confidentially, along with telephone counseling about the interpretation of such results.

RESULTS

Of 1033 participants aged 18–26 years who completed the questionnaire and provided adequate specimens, 111 who reported receiving any HPV vaccine were excluded from this analysis, and the remaining 922 were considered vaccine eligible. Mean and median age was 23 years. Participants represented a variety of races and ethnicities (Table 1). Most identified as male gender (853 [92.5%]), with a sexual orientation of homosexual or gay (643 [69.7%]). Mean age at first sex with any partner was 16 years, and mean number of lifetime sex partners was 37 (median, 15 lifetime sex partners). There were 88 (9.5%) who self-reported their most recent HIV test result as positive. Other results included HIV-negative

for 712 (77.2%) and indeterminate for 11 (1.2%); 26 (2.8%) did not get or did not remember their result, and 85 (9.2%) provided no response.

Any type of HPV at the oral site or anal site was detected in 678 participants (73.5%): 661 (71.7%) had any anal HPV, and 87 (9.4%) had any oral HPV, while 70 (7.6%) had any HPV at both sites. Overall, 534 (57.9%) had any high-risk HPV detected in anal or oral specimens. In univariate analysis, prevalence of any HPV and high-risk HPV among vaccine-eligible participants varied significantly ($P < .05$) by HIV status, sexual orientation, gender identity, and lifetime sex partners but not by race/ethnicity (Table 2). In multivariate analysis, variables associated with any HPV were sexual orientation ($P = .0009$), HIV status ($P = .001$), and lifetime number of sex partners ($P < .01$); for high-risk HPV, associated variables were HIV status ($P < .0001$) and sexual orientation ($P = .006$; each analysis was adjusted for city, age group, race/ethnicity, sexual orientation, lifetime number of sex partners, and HIV test result).

The prevalence of oral and anal HPV DNA and seropositivity by HPV type were analyzed according to self-reported HIV status (Table 3). Among 834 participants with negative or unknown HIV status, any HPV was detected in 579 anal specimens (69.4%), including 422 (50.6%) with multiple types. Any HPV was detected in 70 oral specimens (8.4%) from this group. In anal and oral specimens, respectively, high-risk HPV was detected in 438 (52.5%) and 41 (4.9%), HPV 16 was detected in 104 (12.5%) and 9 (1.1%), and at least 1 additional 9vHPV type was detected in 202 (24.2%) and 10 (1.2%). Seropositivity to 4vHPV types was 39.8% for HPV 6, 26.3% for HPV 11, 22.8% for HPV 16, and 19.9% for HPV 18. Combining HPV DNA and serologic results, 525 (62.9%) had evidence of past or current infection with at least 1 4vHPV type, and 255 (30.6%) had evidence of HPV 16; yet only 71 (8.5%) had evidence of all 4vHPV types (Figure 1).

Among 88 HIV-positive participants, any HPV was detected in 82 anal specimens (93.2%), including 80 (90.9%) with multiple types. Any HPV was detected in 17 oral specimens (19.3%) from this group. In anal and oral specimens, respectively, high-risk HPV was detected in 78 (88.6%) and 10 (11.4%), HPV 16 was detected in 32 (36.4%) and 2 (2.3%), and at least 1 additional 9vHPV type was detected in 55 (62.5%) and 3 (3.4%). Seropositivity to 4vHPV types was 64.8% for HPV 6, 50.0% for HPV 11, 51.1% for HPV 16, and 44.3% for HPV 18. Combining HPV DNA and serologic results, 80 (90.9%) had evidence of past or current infection with at least 1 4vHPV type, and 59 (67.1%) had evidence of HPV 16; 26 (29.6%) had evidence of all 4vHPV types (Figure 1).

None of the 922 vaccine-eligible participants had evidence of current anal or oral infection with all 9 of the 9vHPV types or with all 5 additional 9vHPV vaccine types (Table 3).

DISCUSSION

HPV prevalence was high in this population of young MSM and transgender women. However, despite high numbers of sex partners and other risk factors for HPV infections, most participants in this large study, even those with HIV infection, lacked evidence of current infection or past exposure to all 4vHPV types. Less than one third of those without

HIV infection and about two thirds of those with HIV infection had any evidence of past or current infection with HPV 16 alone. In addition, none of the 922 participants had evidence of current infection with all 9vHPV types. Although HPV vaccination is most effective when given before first sexual activity, our findings suggest that many sexually active MSM who are 18–26 years old could benefit from HPV vaccination.

Anal HPV DNA prevalence results from this study are consistent with those of previously published studies conducted among MSM of various ages [2, 11]. In anal specimens, we detected any HPV in 69.4% of specimens from participants without HIV infection and in 93.2% of those with HIV infection. A meta-analysis of HPV prevalence among MSM estimated that the pooled prevalence of any anal HPV was 64.9% among those without HIV infection and 92.6% among those with HIV infection [11]. For high-risk HPV types, pooled prevalence in anal specimens was 37.2% among those without HIV infection and 73.5% among those with HIV infection [11]. Given high baseline prevalence of anal HPV, especially among HIV-positive MSM, HPV vaccine impact among young MSM might be detected earliest among anal specimens as vaccine uptake among eligible young men increases over time.

In oral specimens, we detected any HPV in 8.4% of specimens from participants without HIV infection and in 19.3% of those with HIV infection. These results are in line with previously published data for men and older MSM. A nationally representative study found that the prevalence of oral HPV detection among US men aged 14–69 years was 10.1% [27]. A study of HIV-negative MSM aged 16–40 years found that the oral HPV prevalence was 13.7% for any HPV type, and in a study of HIV-positive MSM, the oral prevalence of any HPV type was initially 17.3% [28, 29]. A larger study of MSM aged ≥18 years (median age, 40 years) found oral prevalences of 8.8% among HIV-negative MSM and 24.8% among HIV-positive MSM for any of 25 HPV types [30]. Although no clinical trial has been conducted specifically evaluating oral HPV-associated disease end points, vaccine efficacy against oral vaccine-type HPV in women was suggested in a post hoc analysis [31]. Postlicensure impact and vaccine effectiveness against oral HPV in men should be explored.

We evaluated seroprevalence as a marker of past HPV exposure and also as a way to assess potential benefit from HPV vaccination. Studies of MSM have consistently reported higher seroprevalences than national studies of US men in general [32], possibly because of higher numbers of sex partners or different routes of exposure as compared to men who have had sex exclusively with women. However, direct comparison of seroprevalence between studies is impeded by the use of different assay formats to measure antibody response to HPV [33]. In this study, about half of participants without HIV infection and three-quarters of those with HIV infection had antibodies to at least 1 4vHPV type. Seroprevalence was highest for HPV 6 followed by HPV 16, similar to the pattern among males in the general population [32]. Antibody positivity to HPV 16 was 51.1% and 22.8% among participants with and without HIV infection, respectively. In the 4vHPV efficacy trial, among MSM with a mean age of 22 years and <5 lifetime sex partners (2.0% with previously undiagnosed HIV infection), seroprevalence at enrollment, determined using a competitive Luminex assay (cLIA), was lower at 22.8% for any 4vHPV types and 7.1% for HPV 16 [6]. However, among MSM enrolled from a sexually transmitted disease clinic with a median age of 40.1

years and a median of 200 lifetime sex partners, the seroprevalence of HPV 16, determined using a fluorescent bead–based ELISA, was 37.1% among HIV-negative MSM and 62.7% among HIV-positive MSM [8, 9]. Since seroconversion after natural infection may be less common in men than women, seropositivity in men might be a less accurate marker of past exposure to HPV [34]. Nevertheless, seroprevalence was high in our study population. Some studies have suggested that antibodies induced by natural infection may not be protective against subsequent HPV [35, 36]; if men with detectable antibody who cleared a previous natural infection are not protected from repeat infections with that type, we might be underestimating the percentage of MSM standing to benefit from vaccination.

Factors associated with HPV infection in our study included lifetime number of sex partners, sexual orientation, and HIV status, consistent with other studies [3, 6–9]. Our study did not identify significant differences in HPV prevalence by race/ethnicity. One analysis of racial differences in HPV incidence and clearance found that Asian/Pacific Islander men had a lower incidence of HPV than white or black men [37]. Additional data are needed on racial disparities in anal HPV and anal cancer prevalence among MSM [38].

Monitoring using self-collected specimens may be a feasible way to assess early vaccine impact in MSM and could also reduce the burden on clinics and clinical staff. The vast majority of self-collected anal swab and oral rinse specimens were adequate for analysis (95.9% and 98.9%, respectively). Methods used in this study may be used to assess HPV prevalence and potential vaccine impact in the future, as more men are vaccinated against HPV. Since HPV vaccine was routinely recommended for US males in late 2011, uptake has risen among males, although remaining low overall: in several large surveys of US MSM aged 18–26 years, self-reported HPV vaccine uptake was 4.9% during 2011 [39], 6.8% at the end of 2011 [40], and 13% by 2013 [41]. Increasing vaccination rates suggest that the vaccine impact in this population could be monitored using baseline data from this study.

Data in this report are subject to several limitations. First, enrollment from clinics serving MSM resulted in a convenience sample that may not be broadly representative of MSM. Also, the 45 transgender women included in this analysis might have unique risk factors worthy of additional investigation; little is known about HPV in this population, and evidence-based clinical recommendations for transgender women are needed. Second, HPV vaccine history and HIV status were self-reported, and medical record review was not conducted to confirm vaccine eligibility, allowing the possibility of misclassification, reporting, or recall bias. Third, since external genital surfaces were not tested, it is possible that some additional current infections might have been missed; however, genital without concurrent anal HPV infection is uncommon among MSM [34].

The United States was one of the first countries to recommend routine HPV vaccination for males. Various countries around the world are considering whether to expand HPV vaccination programs to all boys or to attempt to target young MSM and transgender women despite programmatic difficulties [42–45]. The early impact of HPV vaccination programs, including significant reductions in HPV 16 prevalence and cases of anogenital warts, have been identified in populations where HPV vaccine uptake is <50% and only among females, and cross-protection and herd immunity effects have been detected in populations with

higher vaccine uptake among females [46]. Cost-effectiveness modeling suggests that when uptake among girls is low, increasing uptake among girls is still a more cost-effective approach to preventing HPV-associated disease than vaccinating men; however, this strategy would be of limited benefit for MSM [47–50]. Even as more MSM and transgender women are vaccinated, HPV vaccine impact might be challenging to detect if they also have more risk factors for HPV and a higher burden of disease. For these reasons, baseline data on HPV prevalence and seroprevalence among young, vaccine-eligible MSM and transgender women should be useful for planning policy and prevention programs, as well as for monitoring HPV vaccine impact in these at-risk populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank all Young Men's Human Papillomavirus study participants, Robert Bolan, William Lonergan, Michael Maloney, Danielle Miller, Ira Rajbhandari, Michael Zimmerman, and staff at participating clinics.

Financial support. This work was supported by the CDC.

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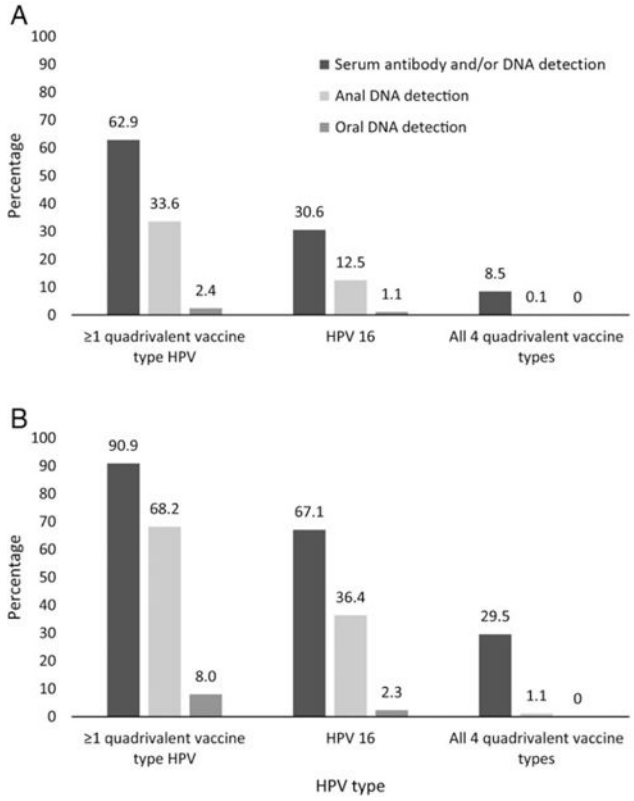

Figure 1.

Evidence of past or current infection with quadrivalent vaccine-type human papillomavirus (HPV) among vaccine-eligible young transgender women and gay, bisexual, and other men who have sex with men, by negative or unknown human immunodeficiency virus (HIV) status (n = 834; *A*) and HIV-positive status (n = 88; *B*).

Table 1

Characteristics of Participating Transgender Women and Gay, Bisexual, and Other Men Who Have Sex With Men

Characteristic	Subjects, No. (%)
Total	922 (100)
City	
Los Angeles	639 (69.3)
Chicago	283 (30.7)
Age, y	
18–21	245 (26.6)
22–26	677 (73.4)
Gender identity	
Male	853 (92.5)
Female/Transgender female	45 (4.9)
Other/unknown[a]	24 (2.6)
Race/ethnicity	
Non-Hispanic white	221 (24.0)
Non-Hispanic black	175 (19.0)
Non-Hispanic Asian/Pacific Islander	76 (8.2)
Hispanic/Latino (any race)	352 (38.2)
Other/unknown	98 (10.6)
Sexual orientation	
Gay/homosexual	643 (69.7)
Bisexual	199 (21.6)
Straight/heterosexual	26 (2.8)
Other/unknown	54 (5.9)
Lifetime no. of sex partners	
≤5	178 (19.3)
6–10	125 (13.6)
11–20	165 (17.9)
>20	283 (30.7)
Other/unknown	171 (18.6)
Most recent HIV test result, self-reported	
Negative or unknown	834 (90.5)
Positive	88 (9.5)

Abbreviation: HIV, human immunodeficiency virus.

[a]Includes participants reporting gender identity as genderqueer, queer, intersex, and write-in responses.

Table 2

Characteristics Associated With Prevalence of Any Human Papillomavirus (HPV) and High-Risk HPV Among 922 Vaccine-Eligible Young Transgender Women and Gay, Bisexual, and Other Men Who Have Sex With Men

	Any HPV[a]			High-Risk HPV[b]		
		Prevalence Ratio (95% CI)			Prevalence Ratio (95% CI)	
Characteristic	**No. (%)**	**Unadjusted**	**Adjusted**	**No. (%)**	**Unadjusted**	**Adjusted**
Total	678 (73.5)	NA	NA	534 (57.9)	NA	NA
City						
Los Angeles	467 (73.1)	Reference	Reference	355 (55.6)	Reference	Reference
Chicago	211 (74.6)	1.02 (.94–1.11)	0.99 (.90–1.09)	179 (63.3)	1.14 (1.02–1.27)	1.10 (.97–1.25)
Age, y						
18–21	180 (73.5)	Reference	Reference	129 (52.7)	Reference	Reference
22–26	498 (73.6)	1.00 (92–1.09)	0.98 (.89–1.08)	405 (59.8)	1.14 (.99–1.30)	1.12 (.98–1.29)
Race/ethnicity						
Non-Hispanic white	154 (69.7)	Reference	Reference	123 (55.7)	Reference	Reference
Non-Hispanic black	127 (72.6)	1.04 (.92–1.18)	0.96 (.84–1.10)	104 (59.4)	1.07 (.90–1.27)	0.89 (.74–1.09)
Non-Hispanic Asian/Pacific Islander	55 (72.4)	1.04 (.88–1.22)	1.03 (.87–1.21)	38 (50.0)	0.90 (.70–1.16)	0.90 (.69–1.18)
Hispanic/Latino (any race)	259 (73.6)	1.06 (.95–1.18)	1.03 (0.93–1.14)	207 (58.8)	1.06 (.91–1.22)	1.04 (.89–1.21)
Other/unknown	83 (84.7)	1.22 (1.08–1.37)	1.06 (.90–1.25)	62 (63.3)	1.14 (.94–1.38)	0.93 (.74–1.18)
Sexual orientation						
Gay/homosexual	503 (78.2)	Reference	Reference	399 (62.1)	Reference	Reference
Bisexual	122 (61.3)	0.78 (.70–.88)	0.79 (.70–.90)	87 (43.7)	0.71 (.60–.83)	0.74 (.61–.89)
Straight/heterosexual	13 (50.0)	0.64 (.43–.94)	0.58 (.36–.93)	13 (50.0)	0.81 (.55–1.19)	0.76 (.47–1.21)
Other/unknown[c]	40 (74.1)	0.95 (.80–1.12)	0.96 (.81–1.16)	35 (64.8)	1.05 (.85–1.28)	1.12 (.87–1.43)
Lifetime number of sex partners						
≤5	113 (63.5)	Reference	Reference	85 (47.8)	Reference	Reference
6–10	85 (68.0)	1.07 (.91–1.26)	1.04 (.89–1.22)	62 (49.6)	1.04 (.82–1.31)	0.95 (.75–1.19)
11–20	115 (69.7)	1.10 (.95–1.28)	1.03 (.88–1.19)	88 (53.3)	1.12 (.91–1.38)	1.03 (.83–1.28)
>20	225 (79.5)	1.25 (1.11–1.42)	1.16 (1.02–1.32)	184 (65.0)	1.36 (1.14–1.62)	1.17 (.98–1.41)

Characteristic	Any HPV[a]			High-Risk HPV[b]		
		Prevalence Ratio (95% CI)			Prevalence Ratio (95% CI)	
	No. (%)	Unadjusted	Adjusted	No. (%)	Unadjusted	Adjusted
Other/unknown	140 (81.9)	1.29 (1.13–1.47)	1.23 (1.07–1.42)	115 (67.3)	1.41 (1.17–1.70)	1.17 (.95–1.43)
Most recent HIV test result						
HIV-negative or unknown	595 (71.3)	Reference	Reference	456 (54.7)	Reference	Reference
HIV-positive	83 (94.3)	1.32 (1.24–1.41)	1.24 (1.09–1.40)	78 (88.6)	1.62 (1.47–1.79)	1.57 (1.34–1.84)

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; NA, not applicable.

[a]Defined as ≥1 type of anal and/or oral HPV DNA and includes 37 HPV types detected by Linear Array: 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, 89, or IS39.

[b]Defined as ≥1 type of anal and/or oral high-risk HPV DNA and includes 14 HPV types: 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, or 68.

[c]Includes participants reporting gender identity as genderqueer, queer, intersex, and write-in responses.

Table 3

Prevalence of Type-Specific Human Papillomavirus (HPV) DNA at Oral and Anal Sites and Serum Antibody Among Vaccine-Eligible Young Transgender Women and Gay, Bisexual, and Other Men Who Have Sex With Men, by Human Immunodeficiency Virus (HIV) Status

	HIV-Negative or Unknown Status (n = 834)				HIV-Positive Status (n = 88)			
HPV Type	**Anal HPV DNA**	**Oral HPV DNA**	**Serum HPV Antibody**	**HPV DNA and/or Antibody**	**Anal HPV DNA**	**Oral HPV DNA**	**Serum HPV Antibody**	**HPV DNA and/or Antibody**
Any HPV type[a]								
(≥1)	579 (69.4)	70 (8.4)	NA	NA	82 (93.2)	17 (19.3)	NA	NA
High-risk HPV type[b]								
(≥1)	438 (52.5)	41 (4.9)	NA	NA	78 (88.6)	10 (11.4)	NA	NA
All 14	0 (0.0)	0 (0.0)	NA	NA	0 (0.0)	0 (0.0)	NA	NA
4vHPV types								
HPV 6	128 (15.4)	7 (0.8)	332 (39.8)	366 (43.9)	29 (32.9)	3 (3.4)	57 (64.8)	67 (76.1)
HPV 11	62 (7.43)	0 (0.0)	219 (26.3)	244 (29.26)	16 (18.2)	1 (1.1)	44 (50.0)	50 (56.8)
HPV 6 or 11	181 (21.7)	7 (0.8)	390 (46.8)	441 (52.9)	38 (43.2)	4 (4.6)	62 (70.5)	71 (80.7)
HPV 6 and 11	9 (1.1)	0 (0.0)	161 (19.3)	0 (0.0)	7 (8.0)	0 (0.0)	39 (44.3)	0 (0.0)
HPV 16	104 (12.5)	9 (1.1)	190 (22.8)	255 (30.6)	32 (36.4)	2 (2.3)	45 (51.1)	59 (67.1)
HPV 18	61 (7.3)	4 (0.5)	166 (19.9)	197 (23.6)	29 (32.9)	3 (3.4)	39 (44.3)	53 (60.2)
HPV 16 or 18	145 (17.4)	13 (1.6)	259 (31.1)	333 (39.9)	47 (53.4)	4 (4.6)	52 (59.1)	69 (78.4)
HPV 16 and 18	20 (2.4)	0 (0.0)	97 (11.6)	0 (0.0)	14 (15.9)	1 (1.1)	32 (36.4)	0 (0.0)
4vHPV type(s)[c]								
≥1	280 (33.6)	20 (2.4)	455 (54.6)	525 (62.9)	60 (68.2)	7 (8.0)	67 (76.1)	80 (90.9)
All 4	1 (0.1)	0 (0.0)	66 (7.9)	71 (8.5)	1 (1.1)	0 (0.0)	23 (26.1)	26 (29.5)
Additional 9vHPV type(s)[d]								
≥1	202 (24.2)	10 (1.2)	NA	NA	55 (62.5)	3 (3.4)	NA	NA
All 5	0 (0.0)	0 (0.0)	NA	NA	0 (0.0)	0 (0.0)	NA	NA
9vHPV type(s)[e]								
≥1	381 (45.7)	28 (3.4)	NA	NA	73 (83.0)	9 (10.2)	NA	NA
All 9	0 (0.0)	0 (0.0)	NA	NA	0 (0.0)	0 (0.0)	NA	NA

Abbreviations: 4vHPV, quadrivalent HPV vaccine; 9vHPV, nonavalent HPV vaccine; NA, not applicable.

[a] Includes 37 HPV types detected by Linear Array: 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, 89, or IS39.

[b] Includes 14 HPV types: 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, or 68.

[c] Comprises types 6, 11, 16, or 18.

[d] Comprises the additional 9vHPV types not included in 4vHPV: 31, 33, 45, 52, or 58.

[e] Comprises types 6, 11, 16, 18, 31, 33, 45, 52, or 58.