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## Effectiveness of Human Papillomavirus (HPV) Vaccination Against Penile HPV Infection in Men Who Have Sex With Men and Transgender Women

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### Abstract

**Background.**—In the United States, human papillomavirus (HPV) vaccination has been recommended since 2011 for boys aged 11–12 years, with catch-up vaccination recommended through age 26 years for previously unvaccinated men who have sex with men (MSM).

**Methods.**—During 2016–2018, a cross-sectional study enrolled MSM and transgender women aged 18–26 years in Seattle, Washington. Participants submitted self-collected penile swab specimens for HPV genotyping. HPV vaccination history was self-reported. We compared HPV prevalence among vaccinated participants with that in participants with no or unknown vaccination history, using log-binomial regression to estimate adjusted prevalence ratios and confidence intervals.

**Results.**—Among 687 participants, 348 (50.7%) self-reported ever receiving 1 HPV vaccine dose; the median age at first HPV vaccination was 21 years, and the median age at first sex, 17 years. Overall, the prevalence of penile quadrivalent HPV vaccine (4vHPV)–type HPV was similar

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in vaccinated participants (12.1%) and participants with no or unknown vaccination (15.6%) (adjusted prevalence ratio, 0.69 [95% confidence interval, .47–1.01]). However, the prevalence was significantly lower in participants vaccinated at age 18 years than in those with no or unknown vaccination (0.15 [.04–.62]), corresponding to a vaccine effectiveness of 85% against 4vHPV-type HPV.

**Conclusions.**—Results suggest that HPV vaccination is effective in preventing penile HPV infections in young MSM when administered at age 18 years.

### Keywords

papillomavirus infections; papillomavirus vaccines; sexual and gender minorities; vaccination

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Human papillomavirus (HPV) infections in males are etiologically linked to anogenital warts and cancers of the penis, anus, and oropharynx [1]. Compared with men who have sex with women (MSW), men who have sex with men (MSM) are at increased risk for anal HPV infections and anal cancer [2–4], and at similar risk for anogenital warts and penile HPV infections [5–7].

A clinical trial of 16–26-year-old males demonstrated quadrivalent HPV vaccine (4vHPV) efficacy against HPV type 6, 11, 16, or 18 anogenital infections (detected in the penis, scrotum, or perineal/perianal regions) and anogenital lesions (inclusive of external anogenital warts and penile, perineal, and perianal neoplasias or cancers) [8]. Furthermore, substudy analyses of MSM participants demonstrated 94.4% (95% confidence interval [CI], 64.4%–99.9%) efficacy against 6-month persistent HPV type 6, 11, 16, or 18 anogenital infections in the per-protocol population, and 43.6% (19.5%–60.8%) efficacy in the intention-to-treat population [9]. Trial participation, however, was restricted to males reporting a lifetime number of 5 sex partners, and results may not translate to the broader population of MSM or transgender women.

Prophylactic HPV vaccines have been approved by the US Food and Drug Administration for the prevention of anogenital warts and cervical, vulvar, vaginal, anal, and oropharyngeal cancers [10]. (There is no Food and Drug Administration indication for the prevention of penile cancers; the HPV vaccine efficacy trial [9] that included penile outcomes was not powered for efficacy against penile intraepithelial neoplasias.)

Since 2011, the US Advisory Committee on Immunization Practices has recommended routine HPV vaccination for boys at age 11 or 12 years, with catch-up vaccination recommended through age 21 years for most men, and through age 26 years for MSM, transgender people [11], and women [12]. The 2011 Advisory Committee on Immunization Practices recommendations were made when only 4vHPV was licensed for use in males; recommendations were updated in 2015 to include nonavalent HPV vaccine (9vHPV) after that vaccine was licensed [11].

Uptake of these vaccines in males, and MSM in particular, is suboptimal but has increased over time. The proportion of males aged 13–17 years who received 1 dose of HPV vaccine increased from 8.3% in 2011 to 69.8% in 2019, based on National Immunization Survey–

Teen data [13]. Among 18–26-year old MSM, 1-dose coverage increased from 1.2% in 2011 to 32.8% in 2017, based on National HIV Behavioral Surveillance data [14]. The increasing HPV vaccine coverage in MSM has enhanced feasibility to evaluate HPV vaccine effectiveness outside clinical trials.

To generate real-world data on HPV vaccine effectiveness in MSM, we conducted the Vaccine Impact in Men (VIM) study in young adult MSM and transgender women. Our group previously evaluated vaccine effectiveness against anal or oral 4vHPV-type HPV among MSM in 3 US cities [15]. In the current report, we present results on vaccine effectiveness against penile HPV detection among MSM who participated in the VIM study in Seattle, Washington. The ability to prevent penile HPV infections in MSM and transgender women has implications for reducing the incidence of anogenital warts and penile cancers in these populations, as well as for decreasing HPV transmission.

## METHODS

### Study Population

During 2016–2018, 18–26-year-old gay, bisexual, and other MSM, and transgender women were enrolled in Seattle as part of the multicenter, cross-sectional VIM study [15]. Persons seeking counseling, testing, or treatment for sexually transmitted diseases (STDs) or human immunodeficiency virus (HIV) were approached by clinicians or STD testers at the Public Health–Seattle & King County Sexual Health Clinic and Gay City Health Project, a community HIV/STD testing site. People were eligible to enroll if they (1) were assigned male sex at birth, (2) were 18–26 years of age, and (3) reported a history of anal or oral sex with a male partner, identified as gay/homosexual or bisexual, and/or intended to have sex with a male partner in the future. Eligible people were excluded if they required language translation services for clinical services or if they did not provide written informed consent. The research study protocol was reviewed and approved by the University of Washington Institutional Review Board, authorized as the reviewing institutional review board by the Centers for Disease Control and Prevention.

### Data Collection

All study procedures were completed on the same day as enrollment, either before or after non-study-related counseling, testing, or treatment services. Self-reported information on age, race and ethnicity, gender identity, sexual orientation, circumcision status, lifetime number of sex partners, age at first sex, history of preexposure prophylaxis (PrEP) to prevent HIV infection, HIV status, and HPV vaccination history were collected from clinic computer-assisted self-interview data and a study-specific self-completed paper questionnaire. HPV vaccination history questions asked whether participants had ever received any HPV vaccine, how many doses were received, age at first dose, and date of first dose. Participants were not asked to recall whether they had received 4vHPV or 9vHPV.

Participants in Seattle self-collected a penile swab specimen in addition to the 3 biologic specimens obtained at all VIM study sites (self-collected anal swab sample, self-collected oral rinse sample, and serum sample, described elsewhere [15]). A clinician or STD tester

provided each participant with illustrated instructions and reviewed the procedure for self-collecting a penile swab specimen [16]. After washing or sanitizing their hands, participants used a Dacron swab (Puritan Medical Products) to rub all external surfaces of the penis for a total of 10 seconds. Uncircumcised participants were instructed to pull the foreskin back before swabbing. Participants placed the swab into a specimen collection vial containing 1 mL of Digene Specimen Transport Medium (Qiagen).

Specimens were stored at  $-20^{\circ}$  C and shipped on dry ice to the Centers for Disease Control and Prevention laboratory for HPV testing. Extracted DNA was tested for HPV using the L1-consensus polymerase chain reaction–based Roche Linear Array HPV genotyping assay (Roche Diagnostics) for 37 types (HPV types 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, and IS39), using methods described elsewhere [17]. Specimens were considered inadequate if results were negative for  $\beta$ -globin and negative for all 37 HPV types. Results from research-use only tests were not provided to participants.

### Statistical Analysis

We dichotomized self-reported HPV vaccination history as “yes” versus “no” or “don’t know” based on the response to the question “Have you ever received any vaccine against human papillomavirus (HPV)?” We also categorized age at first vaccine dose (< 18 years, >18 years, or unknown), timing of age at first vaccine dose relative to age at first sex with any partner (younger than age at first sex, at or older than age at first sex, or unknown), and number of doses received (1, 2, 3, or unknown).

We used  $\chi^2$ , Wilcoxon rank-sum, or Fisher exact tests to compare characteristics of participants by self-reported vaccination history (yes vs no or don’t know). We also used  $\chi^2$  or Fisher exact tests to identify characteristics associated with penile HPV detection (< 1 of any HPV type, < 1 4vHPV type [types 6, 11, 16, and/or 18], or < 1 non-4vHPV type). We calculated penile HPV prevalence (< 1 of any HPV type, < 1 4vHPV type, < 1 9vHPV type [types 6, 11, 16, 18, 31, 33, 45, 52, and/or 58], < 1 additional 9vHPV type not targeted by 4vHPV [types 31, 33, 45, 52, and/or 58], < 1 non-4vHPV type, < 1 non-9vHPV type, and individual HPV vaccine types) and 95% CIs by self-reported HPV vaccination history.

We also used log-binomial regression to calculate crude prevalence ratios and adjusted prevalence ratios (aPRs) and 95% CIs for associations between self-reported HPV vaccination history and penile HPV detection (< 1 4vHPV or < 1 non-4vHPV type). In addition to dichotomous HPV vaccination history, we evaluated age at first dose in a separate model. Variables significantly associated with HPV vaccination history in bivariate analyses ( $P < .10$ ) were included in the adjusted models. Vaccine effectiveness against penile HPV was calculated as  $(1 - \text{aPR}) \times 100$ . All analyses were performed using Stata version 15 software (StataCorp).

## RESULTS

A total of 751 participants were enrolled in Seattle. One participant who did not submit a penile swab specimen, 49 with inadequate penile swab specimens (6.5% of tested

specimens), and 14 with missing HPV vaccination history data were excluded, leaving 687 participants in the analysis. Among these participants, the mean age (standard deviation) was 23.0 (2.2) years. Just over half of participants (50.9%) self-identified as non-Hispanic white, 19.7% as Hispanic, 17.3% as Asian or Pacific Islander, and 6.3% as non-Hispanic black; 5.8% reported another race or >1 race or did not respond (Table 1). Most participants reported their gender identity as male (96.8%), with a small number (0.9%) identifying as female or transgender female. Most (85.3%) identified as gay or homosexual, <1% identified as straight or heterosexual, and 14.1% identified as other sexual orientation or did not respond. Almost two-thirds (64.3%) were circumcised. In total, 21.8% of participants self-reported ever taking PrEP, and 2.2% self-reported being HIV positive. The median age at first sex with any partner was 17 years, and most participants (87.8%) reported >5 sex partners in their lifetime.

About half of participants (n = 348 [50.7%]) self-reported ever having received an HPV vaccine, and the other half reported either that they had not been vaccinated (n = 180 [26.2%]) or that they did not know whether they had been vaccinated (n = 159 [23.1%]) (Table 1). Among vaccinated participants, the median age at first HPV vaccine dose was 21 years, and only 10.6% reported that their age at first vaccine dose was younger than that at first sex. More than half (51.4%) of vaccinated participants reported receiving 3 doses, 33.0% reported 1 or 2 doses, and 15.5% did not know how many doses they had received.

Age, PrEP history, HIV positivity, and lifetime number of sex partners differed significantly by HPV vaccination history (Table 1). Vaccinated participants were more likely than those with no or unknown vaccination history to be 18–21 years of age (29.0% vs 22.7%), report ever taking PrEP (28.2% vs 15.3%), or report being HIV positive (3.7% vs 0.6%). The median lifetime number of sex partners was 29.5 in vaccinated participants versus 23 in those with no or unknown vaccination history. Other characteristics did not differ significantly by vaccination history.

Penile HPV DNA was detected in 333 participants (48.5%), with 95 (13.8%) positive for 1 4vHPV type and 133 (19.4%) positive for 1 9vHPV type (Figure 1). The prevalence of each individual HPV vaccine type was 6.3% for HPV-6, 5.2% for HPV-16, 3.9% for HPV-45, 2.2% for HPV-18, and <2% for HPV-11 and each of the additional 9vHPV types. The prevalence of any penile HPV was significantly higher in participants who were aged 22–26 years, reported ever taking PrEP, or reported more sex partners in their lifetime (Table 2). Similar associations were observed for the prevalence of 1 4vHPV type or 1 non-4vHPV type, although associations with older age were not statistically significant. Observed differences in prevalence for other characteristics (race/ethnicity, gender identity, sexual orientation, and HIV status) were not statistically significant.

The prevalence of 1 non-4vHPV-type HPV was similar in vaccinated participants (42.5%) and participants with no or unknown vaccination history (45.7%) (Figure 1) (aPR 0.89 [95% CI, .76–1.05]) (Table 3). The prevalence of 1 4vHPV type was also similar in vaccinated (12.1%) versus unvaccinated participants or those with unknown vaccination history (15.6%) (aPR, 0.69 [95% CI, .47–1.01]).

However, compared with participants with no or unknown vaccination history, 4vHPV-type HPV prevalence was significantly lower in participants who were first vaccinated at 18 years of age (aPR 0.15 [95% CI, .04–.62]). The effectiveness of 1 HPV vaccine dose at 18 years of age was 85% against 4vHPV-type HPV. Among vaccinated participants, 4vHPV-type penile HPV prevalence was 0% (0 of 37) when age at first HPV vaccine dose was younger than age at first sex, 12.9% (34 of 263) when at or older than age at first sex, and 16.7% (8/48) when age at first sex was unknown.

## DISCUSSION

Results from the current study suggest that vaccinating MSM and transgender women at age 18 years is effective in preventing penile HPV infections. Among our study population of 18–26-year-old MSM and transgender women seeking STD/HIV services, the effectiveness of 1 HPV vaccine dose received at age 18 years was 85% against 4vHPV types. Furthermore, no 4vHPV-type HPV was detected in participants who reported that their age at first HPV vaccine dose was younger than their age at first sex. Effectiveness against penile HPV was not observed in participants who reported receiving their first dose of HPV vaccine at age >18 years. This observed lack of effectiveness with older age at vaccine administration is likely due to exposure to HPV before vaccination, as the reported median age at first HPV vaccine dose (21 years) was older than the median age at first sex with a partner (17 years) in this study. Furthermore, most participants reported >5 sex partners, and more than half reported >20 sex partners in their lifetime. In contrast, the 4vHPV clinical trial that demonstrated efficacy against 6-month persistent anogenital (penile, scrotal, perineal, or perianal) infections in MSM was restricted to participants with 5 sex partners in their lifetime [9].

In our study, we adjusted for variables that could have affected vaccine effectiveness, including age, lifetime number of sex partners, history of taking PrEP, and HIV status. Prevalence of non-4vHPV types can also provide information on sexual risk and differences by vaccination history. The prevalence of 1 non-4vHPV-type penile HPV was somewhat lower in vaccinated participants than in participants with no or unknown vaccination history, but this difference was not statistically significant. The difference in non-4vHPV type prevalence was greater when comparing participants vaccinated at age 18 years to those who had no or unknown vaccination history, but this was not statistically significant in the adjusted analysis. The difference in non-4vHPV type prevalence by vaccination status was not attributable to differences in prevalence of HPV types targeted by 9vHPV only. Although some participants in this study could have received 9vHPV rather than 4vHPV (9vHPV has been the only vaccine distributed in the United States since late 2016 [11]), the prevalence of any of the additional 5 types targeted by 9vHPV was similar regardless of vaccination status.

Only one HPV vaccine efficacy trial has evaluated penile outcomes [9]. To our knowledge, ours is the first study in MSM to report on HPV vaccine effectiveness against penile HPV infections outside the initial clinical efficacy trial. In the general US population, an analysis of 304 men aged 18–24 years participating in the 2013–2014 National Health and Nutrition Examination Survey showed that self-reporting a history of HPV vaccination

was associated with a 30% reduction in 4vHPV-type penile HPV, but the effect was not statistically significant [18].

In another study of 400 males aged 13–26 years recruited from a teen health clinic and an STD clinic in 2013–2015, 4vHPV-type HPV detection did not differ significantly between those who did (20.4%) and did not (27.9%) self-report prior HPV vaccination [19]. Penile and anal HPV test results were combined owing to insufficient study power, and no subanalysis restricted to MSM participants (representing only 10% of the study population) was reported. In addition, power was limited by a relatively small sample size and low proportions of vaccinated participants (17%–26%) in both of these studies. In Australia, a repeated cross-sectional study of MSM aged 16–20 years showed a decrease in penile 4vHPV-type HPV prevalence from 2011–2012 (12%) to 2017–2018 (6%), before and after implementation of a nationwide gender-neutral HPV vaccination program; most (75%) of the 200 participants in the postimplementation cohort self-reported a history of HPV vaccination, and no contemporaneous analysis of vaccine effectiveness was performed [20].

Data used in this analysis were collected as part of a larger study on HPV vaccine effectiveness in young MSM and transgender women. In the full VIM study population—combining data from participants aged 18–26 years in Seattle as well as Chicago, Illinois, and Los Angeles, California—we observed 29% vaccine effectiveness for 1 self-reported dose against anal or oral 4vHPV-type HPV [15]. Similar to the current analysis of penile HPV, the effectiveness against anal or oral HPV was greater when the first vaccine dose was administered at age 18 years (59% effectiveness), although a modest degree of protection was still observed among individuals vaccinated after 18 years of age (18% effectiveness). These observed differences in vaccine effectiveness against anal/oral versus penile HPV in those vaccinated after age 18 years may be due in part to study site differences in sexual behavior or median age at vaccination, with Seattle participants self-reporting a higher lifetime number of sex partners (median, 25 partners) and older age at first dose (median, 21 years) compared with Chicago and Los Angeles participants (median, 21 sex partners and 18 years at first dose).

Penile HPV prevalence (48.5% for any type) was at the upper end of the range of penile HPV estimates reported in other studies of MSM, and closer to those observed in HIV-positive versus HIV-negative MSM, despite the very low proportion of HIV-infected participants in our study. In a meta-analysis conducted among 7169 MSM from 13 countries, penile HPV prevalence was 36.2% overall, and 45.4% versus 28.6%, respectively, in HIV-positive versus HIV-negative participants [21]. Among 18–59-year-old male participants in the 2013–2014 National Health and Nutrition Examination Survey (using identical self-collection methods and the same HPV detection assay as in our study), the prevalence of any penile HPV was 42.2% [16]. Whereas anal HPV prevalence is consistently higher in MSM than in MSW [2, 3], penile HPV prevalence estimates tend to be more comparable [5, 7].

Compared with participants with no or unknown HPV vaccination history, HPV-vaccinated participants in our study were more likely to report having used PrEP, being HIV positive, and a higher lifetime number of sex partners, characteristics associated with increased HPV

infection risk [16, 19, 21–24]. Similarly, data from the 2017 National HIV Behavioral Surveillance showed that HPV vaccine coverage in MSM was positively associated with HIV positivity and higher numbers of recent sex partners [14]. Studies of MSM in Australia and Canada have also demonstrated positive associations between use of PrEP and HPV vaccination [25, 26]. As observed in other studies of MSM [22] and MSW [16, 19, 23], we also found that the lifetime number of sex partners was associated with penile HPV detection; compared with participants reporting 10 partners, prevalence was higher in those reporting 11–20 or >20 partners. Penile HPV detection was also higher in participants who did than in those who did not report a history of PrEP. Two small studies in France demonstrated high HPV prevalence among MSM using PrEP [24, 27].

Strengths of our study include the relatively large sample size, relatively high (50%) 1 dose HPV vaccine coverage, and a sufficient number of penile 4vHPV-type HPV outcomes to detect differences in prevalence by HPV vaccination history. Several limitations should also be noted. First, we relied on self-report for capturing HPV vaccination history, which may have limited validity. Second, the cross-sectional nature of the study did not allow for an evaluation of HPV vaccination effectiveness against penile HPV acquisition. Third, few participants were HIV positive, thus precluding an analysis of HPV vaccine effectiveness stratified by HIV status. Finally, participants were recruited from a sexual health clinic and community HIV/STD testing site in a single US city, and few transgender women were enrolled. Therefore, results may not be generalizable to the broader population of MSM or transgender women.

In conclusion, our findings contribute real-world data on HPV vaccine effectiveness in MSM and transgender women. When initiated at 18 years of age, HPV vaccination was protective against penile 4vHPV-type HPV, and no penile 4vHPV-type HPV was detected in participants who were vaccinated before sexual debut. No protective effect was observed with HPV vaccine initiation after 18 years of age, likely attributable to HPV exposure before vaccination in this highly sexually active population. Results highlight the importance of routine HPV vaccination in early adolescence and the need for continued public health efforts to increase adolescent HPV vaccine coverage.

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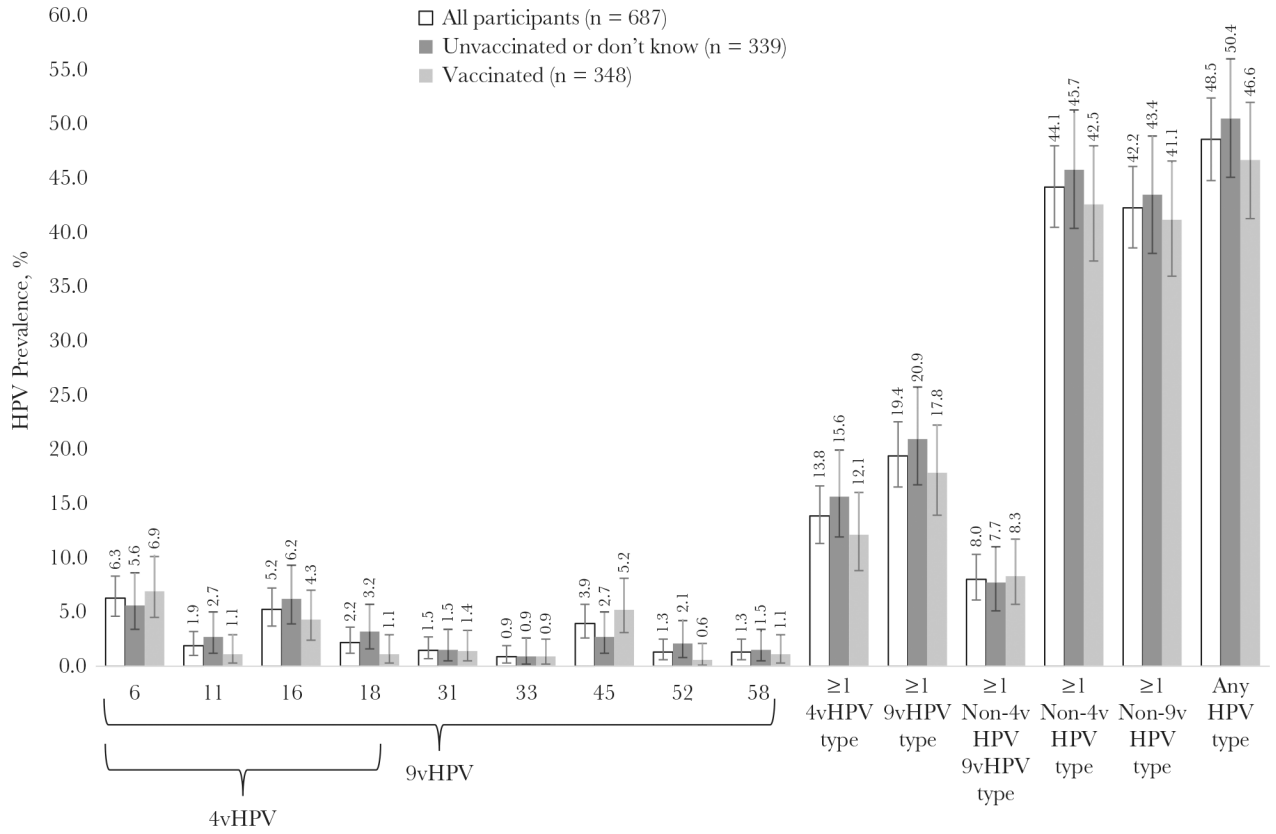
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**Figure 1.** Human papillomavirus (HPV) prevalence in penile swab specimens from 18–26-year-old transgender women and men who have sex with men, overall and by self-reported HPV vaccination history (Seattle, Washington, 2016–2018). Error bars show 95% confidence intervals. Abbreviations: 4vHPV, quadrivalent HPV vaccine; 9vHPV, nonavalent HPV vaccine.

Characteristics of Participating Transgender Women and Men Who Have Sex With Men, by Self-Reported Human Papillomavirus Vaccination History—Seattle, Washington, 2016–2018

Table 1.

Characteristic	Total	Participants, No. (%) <sup>d</sup>		P Value
		No or Don't Know <sup>b</sup>	Yes	
Total	687 (100)	339 (100)	348 (100)	...
Age, y				
18–21	178 (25.9)	77 (22.7)	101 (29.0)	.06 <sup>c</sup>
22–26	509 (74.1)	262 (77.3)	247 (71.0)	
Gender identity				
Male	665 (96.8)	326 (96.2)	339 (97.4)	.59 <sup>c</sup>
Female/transgender female	6 (0.9)	4 (1.2)	2 (0.6)	
Other/unknown	16 (2.3)	9 (2.7)	7 (2.0)	
Sexual orientation				
Gay/homosexual	586 (85.3)	296 (87.3)	290 (83.3)	.26 <sup>c</sup>
Straight/heterosexual	4 (0.6)	1 (0.3)	3 (0.9)	
Other/unknown	97 (14.1)	42 (12.4)	55 (15.8)	
Race and/or ethnicity				
Non-Hispanic white	350 (50.9)	172 (50.7)	178 (51.1)	.80 <sup>c</sup>
Non-Hispanic black	43 (6.3)	24 (7.1)	19 (5.5)	
Asian/Pacific Islander	119 (17.3)	58 (17.1)	61 (17.5)	
Hispanic	135 (19.7)	63 (18.6)	72 (20.7)	
Other/unknown <sup>d</sup>	40 (5.8)	22 (6.5)	18 (5.2)	
Circumcised				
Yes	444 (64.6)	213 (62.8)	231 (66.4)	.52 <sup>c</sup>
No	235 (34.2)	121 (35.7)	114 (32.8)	
Unknown	8 (1.2)	5 (1.5)	3 (0.9)	

History of PrEP for HIV prevention

Characteristic	Participants, No. (%) <sup>a</sup>			P Value
	Total	History of 1 HPV Vaccine Dose		
		No or Don't Know <sup>b</sup>	Yes	
Yes	150 (21.8)	52 (15.3)	98 (28.2)	<.01 <sup>c</sup>
No or unknown	537 (78.2)	287 (84.7)	250 (71.8)	
Most recent HIV test result				
Negative or unknown	672 (97.8)	337 (99.4)	335 (96.3)	.007 <sup>e</sup>
Positive	15 (2.2)	2 (0.6)	13 (3.7)	
Lifetime no. of sex partners of any sex				
5	47 (6.8)	21 (6.2)	26 (7.5)	.03 <sup>c</sup>
6–10	83 (12.1)	37 (10.9)	46 (13.2)	
11–20	149 (21.7)	86 (25.4)	63 (18.1)	
>20	371 (54.0)	171 (50.4)	200 (57.5)	
Other/unknown	37 (5.4)	24 (7.1)	13 (3.7)	
Lifetime no. of sex partners of any sex, <sup>f</sup> mean/median (IQR)	45.3/25 (12–50)	37.2/23 (13–41)	52.8/29.5 (12–55)	.06 <sup>g</sup>
Age at first sex with any partner, <sup>h</sup> mean/median (IQR), y	16.8/17 (15–18)	16.8/17 (15–18)	16.8/17 (15–18)	.96 <sup>g</sup>
Age at first HPV vaccination				
18 y	...	...	83 (23.9)	...
>18 y	...	...	217 (62.4)	...
Unknown	...	...	48 (13.8)	...
Age at first HPV vaccination, mean/median (IQR), y <sup>i</sup>	...	...	20.4/21 (18–23)	...
First HPV vaccination relative to age at first sex				
Before first sex	...	...	37 (10.6)	...
At or after first sex	...	...	263 (75.6)	...
Don't know	...	...	48 (13.8)	...
No. of HPV vaccine doses received (by self-report)				
1	...	...	50 (14.4)	...
2	...	...	65 (18.7)	...
3	...	...	179 (51.4)	...
Don't know	...	...	54 (15.5)	...

Abbreviations: HIV, human immunodeficiency virus; HPV, human papillomavirus; IQR, interquartile range; PrEP, preexposure prophylaxis.

<sup>a</sup>Data represent no. (%) of participants unless otherwise specified.

<sup>b</sup>Includes 180 participants who reported “no” and 159 who reported “don’t know.”

<sup>c</sup>Based on Pearson  $\chi^2$  test.

<sup>d</sup>Includes American Indian, Alaska Native, other race, >1 race, or unknown.

<sup>e</sup>Based on Fisher exact test.

<sup>f</sup>Includes 650 participants (315 in the “no or don’t know” group and 335 in the “yes” group).

<sup>g</sup>Based on Wilcoxon rank-sum test.

<sup>h</sup>Includes 685 participants (338 in the “no or don’t know” group and 347 in the “yes” group).

<sup>i</sup>Includes 300 participants.

**Table 2.**

Prevalence of Any Human Papillomavirus (HPV), Quadrivalent HPV Vaccine (4vHPV)-Type HPV or Non-4vHPV-Type HPV in Penile Swab Specimens, by Characteristics of Participating Transgender Women and Men Who Have Sex With Men—Seattle, Washington, 2016–2018

Characteristic	Total Participants, No.	Participants by HPV Type					
		Any HPV Type		1 4vHPV Type <sup>a</sup>		1 Non-4vHPV Type <sup>b</sup>	
		No. (%)	P Value	No. (%)	P Value	No. (%)	P Value
Total	687	333 (48.5)	...	95 (13.8)	...	303 (44.1)	...
Age, y							
18–21	178	74 (41.6)	.03 <sup>c</sup>	21 (11.8)	.36 <sup>c</sup>	69 (38.8)	.10 <sup>c</sup>
22–26	509	259 (50.9)		74 (14.5)		234 (46.0)	
Gender identity							
Male	665	323 (48.6)	.24 <sup>c</sup>	93 (14.0)	.61 <sup>c</sup>	294 (44.2)	.36 <sup>c</sup>
Female/transgender female	6	1 (16.7)		0 (0.0)		1 (16.7)	
Other/unknown	16	9 (56.3)		2 (12.5)		8 (50.0)	
Race and/or ethnicity							
Non-Hispanic white	350	164 (46.9)	.16 <sup>c</sup>	52 (14.9)	.26 <sup>c</sup>	147 (42.0)	.10 <sup>c</sup>
Non-Hispanic black	43	28 (65.1)		8 (18.6)		25 (58.1)	
Asian/Pacific Islander	119	53 (44.5)		15 (12.6)		46 (38.7)	
Hispanic	135	66 (48.9)		12 (8.9)		22 (55.0)	
Other/unknown <sup>d</sup>	40	22 (55.0)		8 (20.0)		63 (46.7)	
Sexual orientation							
Gay/homosexual	586	280 (47.8)	.34 <sup>f</sup>	76 (13.0)	.19 <sup>f</sup>	255 (43.5)	.54 <sup>f</sup>
Straight/heterosexual	4	1 (25.0)		0 (0.0)		1 (25.0)	
Other/unknown	97	52 (53.6)		19 (19.6)		47 (48.5)	
Circumcised <sup>e</sup>							
Yes	444	208 (46.8)	.30 <sup>c</sup>	69 (15.5)	.08 <sup>c</sup>	185 (41.7)	.11 <sup>c</sup>
No	235	120 (51.1)		25 (10.6)		113 (48.1)	
Lifetime no. of sex partners of any sex							
5	47	16 (34.0)	<.001 <sup>c</sup>	2 (4.3)	<.01 <sup>c</sup>	16 (34.0)	<.01 <sup>c</sup>

Characteristic	Total Participants, No.	Participants by HPV Type					
		Any HPV Type		1 4vHPV Type <sup>a</sup>		1 Non-4vHPV Type <sup>b</sup>	
		No. (%)	P Value	No. (%)	P Value	No. (%)	P Value
6-10	83	26 (31.3)		3 (3.6)		25 (30.1)	
11-20	149	66 (44.3)		18 (12.1)		60 (40.3)	
>20	371	198 (53.4)		64 (17.3)		179 (48.2)	
Other/unknown	37	27 (73.0)		8 (21.6)		23 (62.2)	
History of ever taking PrEP for HIV prevention							
No or unknown	537	247 (46.0)	.01 <sup>c</sup>	65 (12.1)	.01 <sup>c</sup>	224 (41.7)	.02 <sup>c</sup>
Yes	150	86 (57.3)		30 (20.0)		79 (52.7)	
Most recent HIV test result							
Negative or unknown	672	323 (48.1)	.19 <sup>f</sup>	91 (13.5)	.14 <sup>f</sup>	293 (43.6)	.11 <sup>f</sup>
Positive	15	10 (66.7)		4 (26.7)		10 (66.7)	

Abbreviations: 4vHPV, quadrivalent HPV vaccine; HIV, human immunodeficiency virus; HPV, human papillomavirus; PrEP, preexposure prophylaxis.

<sup>a</sup>4vHPV types include types 6, 11, 16, and 18.

<sup>b</sup>Non-4vHPV types include types 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, and IS39.

<sup>c</sup>Based on Pearson  $\chi^2$  test.

<sup>d</sup>Including American Indian, Alaska Native, other race, >1 race, or unknown.

<sup>e</sup>Excludes 8 participants with unknown circumcision status.

<sup>f</sup>Based on Fisher exact test.



Prevalence of Quadrivalent Human Papillomavirus (HPV) Vaccine (4vHPV)-Type HPV and Non-4vHPV-Type HPV Detected in Penile Swab Specimens, by HPV Vaccination History, Among 18–26-Year-Old Transgender Women and Men Who Have Sex with Men—Seattle, Washington, 2016–2018

Table 3.

Variable	Total Participants, No.	Participants With 1 4vHPV Type <sup>a</sup>			Participants With 1 Non-4vHPV Type <sup>b</sup>		
		No. (%)	PR (95% CI)	aPR <sup>c</sup> (95% CI)	No. (%)	PR (95% CI)	aPR <sup>c</sup> (95% CI)
HPV vaccination history, self-reported <sup>d</sup>							
No/don't know	339	53 (15.6)	Reference	Reference	155 (45.7)	Reference	Reference
Yes	348	42 (12.1)	0.77 (.53–1.12)	0.69 (.47–1.01)	148 (42.5)	0.93 (.79–1.10)	0.89 (.76–1.05)
Age at first HPV vaccination							
18 y	83	2 (2.4)	0.15 (.04–.62)	0.15 (.04–.62)	27 (32.5)	0.71 (.51–.99)	0.75 (.54–1.05)
>18 y	217	32 (14.7)	0.94 (.63–1.41)	0.80 (.52–1.22)	101 (46.5)	1.02 (.85–1.22)	0.93 (.77–1.12)
Unknown	48	8 (16.7)	1.07 (.54–2.10)	1.00 (.51–1.96)	20 (41.7)	0.91 (.64–1.30)	0.94 (.67–1.31)
Age, y							
18–21	178	21 (11.8)	Reference	Reference	69 (38.8)	Reference	Reference
22–26	509	74 (14.5)	1.23 (.78–1.94)	1.05 (.67–1.64)	234 (46.0)	1.19 (.96–1.46)	1.11 (.91–1.36)
History of ever taking PrEP for HIV prevention							
No or unknown	537	65 (12.1)	Reference	Reference	224 (41.7)	Reference	Reference
Yes	150	30 (20.0)	1.65 (1.12–2.45)	1.56 (1.04–2.35)	79 (52.7)	1.26 (1.05–1.51)	1.22 (1.01–1.47)
Most recent HIV test result							
Negative or unknown	672	91 (13.5)	Reference	Reference	293 (43.6)	Reference	Reference
Positive	15	4 (26.7)	1.97 (.83–4.66)	2.16 (.91–5.12)	10 (66.7)	1.53 (1.06–2.21)	1.62 (1.30–2.02)
Lifetime no. of sex partners of any sex							
5	47	2 (4.3)	Reference	Reference	16 (34.0)	Reference	Reference
6–10	83	3 (3.6)	0.85 (.15–4.90)	0.81 (.14–4.62)	25 (30.1)	0.88 (.53–1.48)	0.85 (.51–1.43)
11–20	149	18 (12.1)	2.84 (.68–11.79)	2.56 (.63–10.48)	60 (40.3)	1.18 (.76–1.84)	1.13 (.72–1.75)
>20	371	64 (17.3)	4.05 (1.03–16.02)	3.33 (.85–13.11)	179 (48.2)	1.42 (.94–2.14)	1.27 (.84–1.92)
Other/unknown	37	8 (21.6)	5.08 (1.15–22.51)	4.05 (.92–17.83)	23 (62.2)	1.83 (1.14–2.92)	1.68 (1.06–2.66)

Abbreviations: 4vHPV, quadrivalent HPV vaccine; aPR, adjusted prevalence ratio; CI, confidence interval; HIV, human immunodeficiency virus; HPV, human papillomavirus; PR, prevalence ratio; PrEP, preexposure prophylaxis.

<sup>a</sup> 4vHPV types include types 6, 11, 16, and 18.

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<sup>b</sup>Non-4vHPV types include types 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, and IS39.

<sup>c</sup>Analyses were adjusted for age, history of ever taking PrEP for HIV prevention, HIV status, and lifetime number of sex partners. The aPRs presented for age, HIV status, and lifetime number of sex partners are from models that considered HPV vaccination history as a dichotomous variable.

<sup>d</sup>Separate models were constructed considering HPV vaccination history as either a dichotomous (yes vs no/don't know) or 4-level variable (yes with first dose at age >18 years, yes with first dose at age 18 years, yes with first dose at age <18 years, yes with unknown age at first dose, or no/don't know).