Validity of Self-reported HPV Vaccination History in 18-26 Year Old Men Who Have Sex with Men, 2016-2018

Terra Forward

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Public Health

University of Washington

2020

Committee:

Rachel Winer

Jim Hughes

Paul Faestel

Program Authorized to Offer Degree:

Epidemiology

©Copyright 2020

Terra Forward

University of Washington

Abstract

Validity of Self-reported HPV Vaccination History in 18-26 Year Old Men Who Have Sex with Men, 2016-2018

Terra Forward

Chair of the Supervisory Committee:
Rachel Winer
Department of Epidemiology

Background

Since 2011, human papillomavirus (HPV) vaccination has been recommended for men who have sex with men (MSM) through age 26 to prevent infection with the HPV types most commonly associated with cancer. Accurate estimates of HPV vaccine coverage are needed to monitor coverage and impact of HPV vaccine over time. We assessed the validity of self-report as a measure of HPV vaccination status among young MSM in the Seattle, Washington area.

Methods

During 2016-2018, 18-26-year-old MSM and transgender women (TGW) were enrolled at the Public Health-Seattle & King County STD Clinic and Gay City Health Project. HPV vaccination data were collected via a self-administered survey, clinic electronic medical records (EMR), and the Washington State Immunization Information System (WAIIS) vaccine registry. Serum samples were assessed for seropositivity to 4 types of HPV included in the quadrivalent HPV vaccine. We assessed the sensitivity of self-report compared to verified HPV vaccine status

(documented in either the EMR or the WAIIS). We did not evaluate specificity due to known incompleteness of verified HPV vaccine status. We also assessed the positive predictive value (PPV) of self-report using seropositivity to all 4 HPV quadrivalent vaccine types as the gold standard. Additional subanalyses were conducted to assess self-report validity by age, number of doses recalled, and time since vaccination.

Results

There were 751 participants in this study. Most participants were aged 22-26 years (74.4%) and reported their gender identity as male (96.9%); 57.4% self-identified as white. Of the 290 participants with a verified record of HPV vaccine, 241 self-reported having received the HPV vaccine (sensitivity=83.1%, 95% CI: 78.3% to 87.2%). The likelihood of correct self-report was lower, but not statistically different, for those aged 18-21 years compared to those aged 22-26 years (OR=0.7, 95% CI: 0.4 to 1.3). In addition, compared to participants who received their first dose less than a year ago, the likelihood of correct self-report was similar for those with 1-2 years since first dose (OR=0.9, 95% CI: 0.4 to 2.1), but lower for those with more than three years since first dose (OR=0.4, 95% CI: 0.2 to 0.9). Of 369 participants who self-reported a history of HPV vaccination and had an adequate serum sample for HPV serology testing, 314 were seropositive to all 4 vaccine types (PPV=85.1%, 95% CI: 81.0% to 88.6%). PPV was highest among those with 3 or more doses (94.1%, 95% CI: 89.8% to 97.0%).

Conclusions

Our results suggest that self-report of HPV vaccination is a valid way of assessing HPV vaccine status among young MSM when neither vaccine registry nor medical record data are available. Our results indicating reduced recall in participants with three or more years since first vaccine dose suggest that the validity of self-report in young adult MSM may decline over time as adolescent vaccination coverage increases.

Background

HPV is the most common sexually transmitted infection in the United States with an estimated 79 million Americans infected.[1] Many HPV infections appear to be transient and do not cause apparent adverse clinical outcomes; however, infection with certain types of HPV may cause genital warts, anogenital cancers, and oropharyngeal cancers.[1] From 2008 to 2012 there were an average of 38,793 HPV-associated cancers (11.7 per 100,000 persons) diagnosed annually, including 23,000 (13.5 per 100,000) among females and 15,793 (9.7 per 100,000) among males.[2] From 2004 to 2008 the estimated average number of annual HPV-associated cancers was 33,369 (10.8 per 100,000 population).[3] This is an overall rate increase of 0.9 per 100,000 persons with rate increases seen in both male (1.6) and female (0.3) populations. Common HPV-related cancers among males include oropharyngeal and anal cancers, with men who have sex with men (MSM) being at particularly high risk for these cancers.[4,5]

Since 2009, the Advisory Committee on Immunization Practices (ACIP) issued guidance that males aged 9 through 26 years may receive the HPV vaccine series.[6] In 2011, the ACIP updated its guidance to formally recommend routine HPV vaccination of all males aged 11 to 12 years with catch up vaccination up to age 21 or 26 for MSM.[7] Most recent updated ACIP guidelines in 2019 expanded recommendations to include routine HPV vaccination for all males up to age 26.[8] These updated guidelines also recognized adults aged 27 to 45 may benefit from catch up vaccination if at increased risk of new HPV infection; however, routine vaccination beyond age 26 is not recommended.[8]

National Immunization Survey–Teen (NIS-Teen) data from 2018 showed that 48.7% of adolescent males aged 13-17 years had completed the HPV vaccination series (2 or 3 doses, depending on age) and that 66.3% had received at least one dose.[9] Looking at the same NIS-Teen data for Washington State, only 47.0% of adolescent males aged 13 to 17 completed the

series and 68.2% reported at least one dose.[10] National HIV Behavioral Surveillance data from 2014 found the proportion of those self-reporting at least one HPV vaccine dose was only 17.2% among young adult MSM aged 18-26 years.[11]

Accurate capture of HPV vaccine history is needed for individual clinical decision making, monitoring of population-level vaccine coverage, and assessing population-level impacts of HPV vaccination to aid in HPV policy and research efforts. Of the various sources for capturing HPV vaccination history (including self-report, electronic medical records [EMR], vaccine registry, paper records, and HPV serology), EMR and registry documentation is considered to be the gold standard. However, there are several limitations to using EMR and registry records to verify HPV vaccine receipt. Not all EMR data is shared between health systems, leaving patients to keep track of their vaccine history either through paper copies or release of information agreements. State vaccine registries are not always updated by the reporting provider or the patient may have received vaccinations out of state, again placing the burden on the patient to maintain accurate vaccine reports. Self-reported vaccination status is necessary in the absence of accurate EMR or registry data. However, self-report of vaccine history is subject to recall bias and paper records are often misplaced or lost.

There have been a few cross-sectional questionnaire-based studies looking at the accuracy of self-reported HPV vaccine history compared to electronic medical record (EMR) and state registry data. Most of these studies have focused on female populations with only one study, to our knowledge, that focused on males. One study reported the sensitivity of self-report of HPV vaccine compared to medical records to be 54% among adolescent females aged 14-17 years[12], while other studies reported a higher sensitivity of self-reported HPV vaccination at 85.2% among females aged 20-22 years, 91.6% among females aged 14-26 years, and 96% among females aged 18-39 years with high-grade cervical lesions reported to a statewide

surveillance system.[13–15] When looking at the validity of self-reported vaccine history for 8 different adult vaccines compared to EMR data, one study showed among males and females aged 18-49 the sensitivity of self-reported vaccine history was 90% for all vaccines combined, and 91% for HPV vaccine among females only (HPV vaccination in males was not evaluated); however, vaccines typically given in early childhood had lower sensitivity estimates.[16] In males aged 13-26 years, 73% accurately reported their HPV vaccine history (i.e., having received or not received at least one dose).[17] A number of international studies also showed wide variations in the validity of self-reported vaccine history for a number of vaccines, however none of these studies included HPV vaccine.[18–20] Two of these studies looked at health care workers' and young military recruits' self-reported vaccine status compared to serology data and reported positive predictive value (PPV) estimates ranging from 15% to 100% for various childhood or occupational vaccines.[18,19] The other study looked at the sensitivity of self-report compared to vaccine records in healthcare students and found estimates ranging from 12% to 98%.[20]

To our knowledge, no study has reported the validity of self-reported HPV vaccine status among MSM. We evaluated the sensitivity and PPV of self-reported HPV vaccine status and further analyzed the effect of age, number of vaccine doses, and time since vaccination on validity of self-report.

METHODS

Study Design and Procedures

This study used Seattle-based data collected as part of the large U.S. multi-centered Centers for Disease Control and Prevention (CDC)-funded Vaccine Impact in Men (VIM) study. Gay, bisexual, other MSM, and TGW seeking STD testing or counseling services from February 2016 to September 2018 were recruited and enrolled at the Public Health – Seattle & King County

Sexually Transmitted Disease (PHSKC STD) Clinic and Gay City Health Project (GCHP). The study protocol was reviewed and approved by the CDC, Washington State, and University of Washington institutional review boards.

Participants were considered eligible if 1) they were assigned male sex at birth, 2) they were between 18-26 years old, and 3) they reported one or more male sex partners in the past 12 months. Study participants were excluded from the study if 1) they required language translation services for clinical service, or 2) they were unable to provide written informed consent. Nominal compensation was given to each eligible participant in the study. Questionnaires and specimen collection were completed for eligible participants during their visit for usual clinic and testing services. HPV vaccination was not provided as part of the study.

Clinicians or STD testers handed out paper questionnaires for eligible participants to complete which included questions on demographics, sexual behaviors, and HPV vaccine history. HPV vaccine history questions asked whether participants had ever received the vaccination, how many doses were received, and the date of first dose. Data were also collected from clinic EMRs for key demographic, health, sexual behavior data, and HPV vaccination history data, including vaccination dates and number of vaccine doses. Additional vaccine history records were obtained via participant signed release of information from the Washington State Immunization Information System (WAIIS) vaccine registry, including vaccination dates and number of doses.

Specimen Collection

Each participant submitted a 5 mL blood specimen collected by a trained and licensed phlebotomist via venipuncture into one 10 mL red top vacutainer tube without coagulant. Samples were refrigerated within 30 minutes of collection at 2-8 degrees C. Within 24 hours of

collection, serum samples were transported on ice to the University of Washington Harborview Medical Center for centrifugation and aliquoting. Specimens were batched shipped on dry ice to the CDC's HPV laboratory for processing.

Laboratory Testing

The CDC HPV laboratory tested serum specimens for antibody levels to 4 vaccine HPV types using a multiplexed virus-like particle–based immunoglobulin G direct enzyme-linked immunosorbent assay (M4ELISA) on a Meso Scale Discovery electrochemiluminescent platform. Cutoffs were set at ≥99% relative light units, based on a Johnson-Su distribution.[21]

Data Analysis

This study includes all Seattle participants who completed the survey questionnaire. Those who self-reported at least one HPV vaccine dose were considered to have a self-reported history of HPV vaccination. Verified vaccine history was defined as a clinic EMR or WAIIS record of at least one dose of HPV vaccine. We also captured both self-reported and EMR/WAIIS data on time since first dose (less than 1 year, 1-2 years, or 3 or more years) and number of doses (1, 2, or ≥3). Although the 2016 ACIP guidelines changed the recommended number of doses from 3 to 2 for individuals aged 9-14 years, none of the participants in our study would have been young enough at the time of the enrollment period to qualify for the 2-dose recommendation.

We conducted a descriptive analysis on participant characteristics including proportions of key demographics and mean, median and interquartile ranges for lifetime number of partners, age at first sexual encounter, age at first HPV vaccination, and time since first vaccination. Self-reported number of lifetime partners and age at first sexual encounter was with any partner, male, female or other.

Among those with a verified record of HPV vaccination, we calculated sensitivity, with 95% confidence intervals, of self-reported HPV vaccination. We also conducted sensitivity analyses stratified by age group (18-21 years versus 22-26 years), time since first verified vaccine dose, and restricting to participants with verified 3 or more HPV vaccine doses. We also performed univariate and multivariate logistic regression to estimate odds ratios of associations between age group and vaccine timing and likelihood of correct HPV vaccine self-report. The multivariate model included both age group and time since first verified HPV vaccine as independent variables and verified vaccine record as the dependent variable. Variables with a p-value of $< .05$ were considered significant. We did not calculate specificity of self-reported vaccination status due to known incompleteness of the EMR and WAIIS. For example, EMR data may not include all vaccinations received at other clinic locations, and state registry data may not include vaccinations that were received out of state, or by clinics that inconsistently report vaccination data to the registry.

PPVs with 95% confidence intervals were determined for those who self-reported HPV vaccination using seropositivity for all 4 HPV vaccine types as the gold standard. These PPVs were also stratified by age group and time since first self-reported HPV vaccine. We also looked at the characteristics of those who reported at least one HPV vaccine dose, but who were not seropositive for all 4 HPV vaccine types.

All calculations were performed using STATA version 13 (StataCorp, LLC, College Station, TX).

RESULTS

Descriptive statistics

A total of 751 participants, including 594 from the PHSKC STD clinic and 157 from GCHP, were consented and enrolled in this study. Of these, 375 (49.9%) self-reported receiving at least one dose of HPV vaccine prior to study enrollment and 290 (38.6%) had at least one verified recorded HPV vaccine dose in either the EMR or WAIIS registry (Table 1). Approximately one quarter of participants were aged 18-21 years (25.6%) with all others being aged 22-26 years. Most reported their gender identity as male (96.9%) with others reporting female (0.8%) or other (2.2%). The majority of participants identified their race as white (57.4%). Most of the participants identified their ethnicity as non-Hispanic (78.7%). Most participants (69.5%) identified as gay or homosexual. The mean/median lifetime number of partners was 43.2/23.5 and the mean/median age at first sexual encounter with any partner was 16.8/17 years. The descriptive statistics of participants by verified HPV record and self-reported HPV status are also recorded in Table 1.

Among those who self-reported HPV vaccination, 50.9% reported 3 or more doses, whereas 39.3% with verified vaccination had 3 or more recorded doses (Table 1). Notably, 14.9% of those who self-reported vaccination did not report or did not recall how many doses they received. The mean/median age at first verified dose was 20/20 years compared to 20.4/21 years for those who self-reported vaccination. Mean/median time since first dose was 2.2/2 years for those with verified vaccination and 2.6/2 years for those who self-reported.

Sensitivity of self-report

Among the 290 participants with ≥1 verified dose of HPV vaccine, 241 self-reported ≥1 vaccine dose, corresponding to a sensitivity of 83.1% (95% CI: 78.3% to 87.2%) (Table 2). When restricting to 114 participants with 3 or more verified doses, 80 participants self-reported 3 or more doses (sensitivity=70.2%, 95%CI: 60.9% to 78.4%).

The sensitivity of self-report was lower, but not statistically significantly so, in participants who were aged 18-21 years (79.1%, 95% CI: 69.3% to 86.9%) versus 22-26 years (84.9%, 95% CI: 79.2% to 89.6%) (Table 2). The corresponding OR for correct self-report was 0.7 (95% CI: 0.4 to 1.3) for participants aged 18-21 versus 22-26 years (Table 3). The sensitivity of self-report was similar in participants with verified documented first vaccine dose less than a year ago (88.5%, 95% CI: 79.9% to 94.3%) and those who had their first dose 1-2 years ago (87.2%, 95% CI: 78.8% to 93.2%). Sensitivity of self-report was significantly lower in those who had their first dose 3 or more years ago (75.2%, 95% CI: 66.0% to 83.0%) (Table 2). The corresponding ORs for correct self-report was 0.9 (95% CI: 0.4 to 2.1) for participants with verified first vaccine 1-2 years ago, and 0.4 (95% CI: 0.2 to 0.9) for participants with verified first vaccine 3 or more years ago, versus those with first vaccine less than a year ago (Table 3). The ORs did not change after adjusting for either age group or time since first vaccine dose.

PPV of self-report

Of the 751 participants, 747 (99.5%) submitted serum samples, and of those, 743 (99.5%) had adequate serum specimens for analysis. Among those who self-reported HPV vaccination, the PPV of self-report using seropositivity to all 4 quadrivalent HPV vaccine types as the gold standard was 85.1% (95% CI: 81.0% to 88.6%) (Table 4). When stratifying by self-reported number of doses, the PPV among those reporting 1 dose was 64.8% (95% CI: 50.6% to 77.3%), 91.7% (95% CI: 82.7% to 96.9%) among those reporting 2 doses, and 94.1% (95% CI: 89.8% to 97.0%) among those reporting 3 or more doses. When looking at time since first self-reported HPV vaccine dose, the PPV was 88.5% (95% CI: 79.9% to 94.3%) for first dose received less than a year ago, 81.8% (95% CI: 73.3% to 88.5%) for first dose received 1-2 years ago, and 89.1% (95% CI: 82.5% to 93.9%) for first dose received 3 or more years ago.

Among the 55 participants (15.0%) who self-reported at least one dose of HPV vaccine and were not seropositive for all 4 quadrivalent vaccine types, almost half (47.3%) were seropositive to 3 out of 4 HPV types and only 20% reported 3 or more vaccine doses (Table 5). About one-fifth of these participants reported first vaccination 3 or more years ago with the remainder reporting first vaccination within 3 years. Among 10 participants who reported their first vaccine dose less than a year ago, the mean/median time since first vaccination was 92.7/56.5 days with a range of 3-360 days.

DISCUSSION

There are very few studies reporting on the accuracy of self-reported HPV vaccination status compared to verified medical records, especially among male populations. In our study the sensitivity of self-report in 18-26-year-old MSM (83%) was higher than previously reported in a small study of female adolescents (54%), but lower than in studies of adult females (85-96%) and adolescent to adult females combined (92%).[12–16] Thomas, et al. reported on the accuracy of self-reported HPV vaccine among 13-26 year old males (73% overall); however, a direct comparison with our results could not be made as they did not report on sensitivity among those with confirmed vaccination.[17] Our study is the first to our knowledge to report on the sensitivity of self-report in MSM with confirmed HPV vaccine.

Based on the limited data available, the sensitivity of self-report in comparably aged females is slightly higher than observed in our study, although comparisons are complicated by differences in ages and timing of vaccination across study populations. Greater efforts in educating females versus males about the risks of HPV infection and HPV vaccine may contribute to gender-based differences in HPV vaccine recall. Several studies suggest there is gender bias favoring females over males in provider communicated HPV vaccine recommendations.[22–24]

In our study, sensitivity increased with older age, but not significantly so, and shorter time since the first vaccination. Other comparable studies did not report sensitivity estimates stratified by time since vaccination or age, precluding comparisons with the stratified groups in our study. Thomas, et al. reported higher accuracy (not sensitivity) results for older male groups when stratified by age; however, this was likely due to males in these groups having less likely been vaccinated where accuracy included correctly reporting both having received and not having received HPV vaccine.[17]

None of the studies looked at time since vaccination and accuracy of self-report; however, one study found sensitivity of self-report was higher for vaccines more likely to be administered in adulthood rather than those more common in childhood.[16] This may suggest vaccination recall may be more difficult for those who received vaccines at an early age, especially if patients did not keep or have access to reliable vaccination records. ORs for associations of age and time since vaccination with self-report accuracy did not change between univariate and multivariate models, indicating age and time since vaccination are independent factors in accuracy of self-reported vaccine status.

Additionally, we found the PPV of self-report for HPV vaccination using serology as the gold standard to be 85%. Vaccine trials showed the seropositivity one month after the 3 dose HPV vaccine series in men and boys aged 9 to 26 to be greater than 97% for all 4 HPV vaccine types.[25] This is much higher than reported natural infection seroconversion of 7.7% for all 4 HPV vaccine types.[26] Single vaccine dose immunogenicity has been shown to produce a less robust immune response than a 2 or 3 dose vaccine series; however, the immunogenicity of a single vaccine dose is still greater than that of natural infection.[27] In this study, the PPV was lower for those who reported only one vaccine dose compared to 3 or more doses (64.8% versus 94.1%), suggesting some with one dose may have not seroconverted due to incomplete recommended

dosing or not enough time elapsed since first vaccination. There were no appreciable differences in PPV related to time since first dose, however, a few received their first dose just before participation in the study indicating that the time for seroconversion prior to serum collection may have been inadequate. For those who reported at least one HPV vaccine dose but were not seropositive for all 4 quadrivalent vaccine types, most were seropositive for 3 strains. One possible explanation for this finding is waning immunity, especially for HPV 18 where antibody levels have been reported to diminish to that of natural infection levels after a few years, or natural exposure to all 3 strains.[28]

Interestingly, of the 182 participants in our study who reported not having ever received an HPV vaccine and did not have a verified dose on record, 23.6% were seropositive to all 4 HPV vaccine types. One large multinational study in 2011 reported 0.5% seroprevalence for all 4 HPV quadrivalent vaccine types in their unvaccinated male study population with higher proportions among unvaccinated MSM (6.3%) than among men who have sex with women (0.2%).[4] Another study reported a seroprevalence of 8.5% in MSM for all 4 HPV vaccine types, and even higher proportions in HIV positive MSM at 29.5%.[29] Different routes of exposure or higher numbers of sex partners may be contributing to higher seroprevalence seen in MSM populations compared with men who have sex with women exclusively. Given that HPV seroprevalence is relatively high in the unvaccinated MSM population, the utilization of seropositivity for HPV vaccine types as a marker for vaccination status may be diminished compared to populations with lower vaccine-type seroprevalence. High seroprevalence in an unvaccinated population also prevents negative predictive value (NPV) analysis of self-reported HPV vaccine status compared to serology.

This study has several limitations. First, EMR and WAIIS data may not be complete. EMR data was only collected from the participating study clinics and not from EMRs owned by other

healthcare clinics that participants may have previously visited. WAIIS registry data captured some of the missing HPV vaccine data from other clinics in Washington State; however, this relies on the clinics to report to the state registry. It is also unclear how complete the WAIIS vaccine registry is for adults as studies are lacking for this population. Participants may have also received HPV vaccine out-of-state, and unless they produced paper vaccination histories or release of information authorizations to be transferred to the clinic EMR or state registry, the HPV vaccine history would not be available. These missing records resulted in our inability to calculate specificity, PPV or NPV of self-report. For serology data, it is difficult to compare with other studies as several different assays have been used to measure antibody response; however, most HPV serology studies have shown high seropositivity to the quadrivalent HPV vaccine types among those who have been previously vaccinated and low seropositivity in those who have not.[4,28,30–33] Due to our low HIV-positive population seen at our study clinics (<3%) we were not able to evaluate whether HIV status modifies the PPV of HPV vaccine history with HPV seroprevalence. HIV infection often reduces the immune response to vaccinations and could have presumably lowered the PPV in this group.[34–36]

In conclusion, the validity of self-report of HPV vaccine among young adult MSM may be a valid way of recording vaccine status until vaccine records can be easily accessed and integrated between EMRs and vaccine registries. Validity of self-report in young adult MSM populations may decrease in the future as more males are vaccinated earlier in their adolescent years in accordance with vaccine recommendations. Ideally, to ensure the most accurate information for vaccination surveillance and individual clinic decision making, accurate electronic medical records would be preferred. This can be accomplished by integrated electronic medical record systems, online platforms easily allowing patients to access medical records, and national immunization registries. Accurate information for vaccination surveillance is important for future vaccination policy and research.

Acknowledgements

I would like to thank the study's data manager, John Lin, for his excellent STATA skills and attention to detail, which made this thesis project possible.

REFERENCES

1. Centers for Disease Control and Prevention. STD Facts - HPV and Men. HPV and Men - Fact Sheet. Published September 23, 2019. Accessed November 4, 2019. https://www.cdc.gov/std/hpv/stdfact-hpv-and-men.htm

2. Viens LJ, Henley SJ, Watson M, et al. Human Papillomavirus–Associated Cancers — United States, 2008–2012. *MMWR Morb Mortal Wkly Rep*. 2016;65(26):6.

3. Wu X, Watson M, Wilson R, Saraiya M, Markowitz LE. Human Papillomavirus–Associated Cancers — United States, 2004–2008. *MMWR Morb Mortal Wkly Rep*. 2012;61(15):258-261.

4. Lu B, Viscidi RP, Lee J-H, et al. Human Papillomavirus (HPV) 6, 11, 16, and 18 Seroprevalence Is Associated with Sexual Practice and Age: Results from the Multinational HPV Infection in Men Study (HIM Study). *Cancer Epidemiol Prev Biomark*. 2011;20(5):990-1002. doi:10.1158/1055-9965.EPI-10-1160

5. Machalek D, Poynten M, Jin F, et al. Anal human papillomavirus infection and associated neoplastic lesions in men who have sex with men: a systematic review and meta-analysis - ScienceDirect. *The Lancet*. 2012;13(5):487-500. doi:10.1016/S1470-2045(12)70080-3

6. Centers for Disease Control. FDA Licensure of Quadrivalent Human Papillomavirus Vaccine (HPV4, Gardasil) for Use in Males and Guidance from the Advisory Committee on Immunization Practices (ACIP). *MMWR Morb Mortal Wkly Rep*. 2010;59(20):630-632.

7. Dunne E, Markowitz L, Chesson H, Curtis CR, Saraiya M, Unger E. Recommendations on the Use of Quadrivalent Human Papillomavirus Vaccine in Males — Advisory Committee on Immunization Practices (ACIP), 2011. *MMWR Morb Mortal Wkly Rep*. 2011;60(50):1705-1708.

8. Meites E, Szilagyi PG, Chesson H, Unger ER, Romero JR, Markowitz LE. Human Papillomavirus Vaccination for Adults: Updated Recommendations of the Advisory Committee on Immunization Practices. *MMWR Morb Mortal Wkly Rep*. 2019;68. doi:10.15585/mmwr.mm6832a3

9. Walker TY, Elam-Evans LD, Yankey D, et al. National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13–17 Years — United States, 2018. *MMWR Morb Mortal Wkly Rep*. 2019;68(33):718-723. doi:10.15585/mmwr.mm6833a2

10. National Center for Immunization and Respiratory Diseases. TeenVaxView | 2008-2018 Adolescent HPV Vaccination Coverage Trend Report | CDC. Published November 7, 2019. Accessed May 17, 2020. https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/data-reports/hpv/trend/index.html

11. Oliver SE, Hoots BE, Paz-Bailey G, Markowitz LE, Meites E. Increasing Human Papillomavirus Vaccine Coverage Among Men Who Have Sex With Men—National HIV Behavioral Surveillance, United States, 2014. *J Acquir Immune Defic Syndr 1999*. 2017;75(Suppl 3):S370-S374. doi:10.1097/QAI.0000000000001413

12. Stupiansky NW, Zimet GD, Cummings T, Fortenberry JD, Shew M. Accuracy of Self-Reported HPV Vaccine Receipt Among Adolescent Girls and Their Mothers. *J Adolesc Health Off Publ Soc Adolesc Med*. 2012;50(1):103-105. doi:10.1016/j.jadohealth.2011.04.010

13. Yamaguchi M, Sekine M, Kudo R, et al. Differential misclassification between self-reported status and official HPV vaccination records in Japan: Implications for evaluating vaccine safety and effectiveness. *Papillomavirus Res*. 2018;6:6-10. doi:10.1016/j.pvr.2018.05.002

14. Grimaldi-Bensouda L, Aubrun E, Leighton P, Benichou J, Rossignol M, Abenhaim L. Agreement between patients' self-report and medical records for vaccination: the PGRx database. *Pharmacoepidemiol Drug Saf*. 2013;22(3):278-285. doi:10.1002/pds.3401

15. Niccolai LM, McBride V, Julian PR. Sources of information for assessing human papillomavirus vaccination history among young women. *Vaccine*. 2014;32(25):2945-2947. doi:10.1016/j.vaccine.2014.03.059

16. Rolnick SJ, Parker ED, Nordin JD, et al. Self-report compared to electronic medical record across eight adult vaccines: Do results vary by demographic factors? *Vaccine*. 2013;31(37):3928-3935. doi:10.1016/j.vaccine.2013.06.041

17. Thomas R, Higgins L, Ding L, Widdice LE, Chandler E, Kahn JA. Factors Associated With HPV Vaccine Initiation, Vaccine Completion, and Accuracy of Self-Reported Vaccination Status Among 13- to 26-Year-Old Men. *Am J Mens Health*. 2018;12(4):819-827. doi:10.1177/1557988316645155

18. Arteaga A, Desviat PV, Jaqueti J, Santos J, Miguel AG de, Jiménez-García R. Self-reported history of vaccination and disease and immunity against hepatitis A, hepatitis B, tetanus, diphtheria and varicella among spanish military recruits. *Hum Vaccin*. 2010;6(2):198-201. doi:10.4161/hv.6.2.10398

19. Kumakura S, Onoda K, Hirose M. Self-reported histories of disease and vaccination against measles, mumps, rubella and varicella in health care personnel in Japan. *J Infect Chemother*. 2014;20(3):194-198. doi:10.1016/j.jiac.2013.10.006

20. Loulergue P, Pulcini C, Massin S, et al. Validity of self-reported vaccination status among French healthcare students. *Clin Microbiol Infect*. 2014;20(12):O1152-O1154. doi:10.1111/1469-0691.12759

21. Panicker G, Rajbhandari I, Gurbaxani BM, Querec TD, Unger ER. Development and evaluation of multiplexed immunoassay for detection of antibodies to HPV vaccine types. *J Immunol Methods*. 2015;417:107-114. doi:10.1016/j.jim.2014.12.013

22. Gerend MA, Shepherd MA, Lustria MLA, Shepherd JE. Predictors of provider recommendation for HPV vaccine among young adult men and women: findings from a cross-sectional survey. *Sex Transm Infect*. 2016;92(2):104-107. doi:10.1136/sextrans-2015-052088

23. Gilkey MB, McRee A-L. Provider communication about HPV vaccination: A systematic review. *Hum Vaccines Immunother*. 2016;12(6):1454-1468. doi:10.1080/21645515.2015.1129090

24. Gilkey MB, Calo WA, Moss JL, Shah PD, Marciniak MW, Brewer NT. Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine*. 2016;34(9):1187-1192. doi:10.1016/j.vaccine.2016.01.023

25. Merck & Co., Inc. Gardasil Package Insert. *FDA*. Published online October 24, 2019. Accessed May 17, 2020. https://www.fda.gov/vaccines-blood-biologics/vaccines/gardasil

26. Giuliano AR, Viscidi R, Torres BN, et al. Seroconversion following anal and genital HPV infection in men: The HIM study. *Papillomavirus Res*. 2015;1:109-115. doi:10.1016/j.pvr.2015.06.007

27. Garritty C, Stevens A, Hamel C. Effectiveness and immunogenicity of one dose of HPV vaccine compared with no vaccination, two doses, or three doses. Published online August 2019. Accessed May 17, 2020. https://www.who.int/immunization/sage/meetings/2019/october/4_._FINAL_One_dose_HPV_vaccine_report_v4.0_20190820.pdf

28. Pinto LA, Dillner J, Beddows S, Unger ER. Immunogenicity of HPV prophylactic vaccines: Serology assays and their use in HPV vaccine evaluation and development. *Vaccine*. 2018;36(32, Part A):4792-4799. doi:10.1016/j.vaccine.2017.11.089

29. Meites E, Gorbach PM, Gratzer B, et al. Monitoring for Human Papillomavirus Vaccine Impact Among Gay, Bisexual, and Other Men Who Have Sex With Men—United States, 2012–2014. *J Infect Dis*. 2016;214(5):689-696. doi:10.1093/infdis/jiw232

30. van Rijn VM, Mooij SH, Mollers M, et al. Anal, Penile, and Oral High-Risk HPV Infections and HPV Seropositivity in HIV-Positive and HIV-Negative Men Who Have Sex with Men. *PLoS ONE*. 2014;9(3). doi:10.1371/journal.pone.0092208

31. Huang T, Liu Y, Li Y, et al. Evaluation on the persistence of anti-HPV immune responses to the quadrivalent HPV vaccine in Chinese females and males: Up to 3.5 years of follow-up. *Vaccine*. 2018;36(11):1368-1374. doi:10.1016/j.vaccine.2018.02.006

32. Van Damme P, Olsson SE, Block S, et al. Immunogenicity and Safety of a 9-Valent HPV Vaccine. *Pediatrics*. 2015;136(1):e28-39. doi:10.1542/peds.2014-3745

33. Schiller JT, Lowy DR. Immunogenicity Testing in Human Papillomavirus Virus-Like-Particle Vaccine Trials. *J Infect Dis*. 2009;200(2):166-171. doi:10.1086/599988

34. Irungu E, Mugo N, Ngure K, et al. Immune Response to Hepatitis B Virus Vaccination Among HIV-1 Infected And Uninfected Adults in Kenya. *J Infect Dis*. 2013;207(3):402-410. doi:10.1093/infdis/jis695

35. Cohen C, von Mollendorf C, de Gouveia L, et al. Effectiveness of 7-Valent Pneumococcal Conjugate Vaccine Against Invasive Pneumococcal Disease in HIV-Infected and -Uninfected Children in South Africa: A Matched Case-Control Study. *Clin Infect Dis Off Publ Infect Dis Soc Am*. 2014;59(6):808-818. doi:10.1093/cid/ciu431

36. Moscicki A-B, Karalius B, Tassiopoulos K, et al. Human Papillomavirus Antibody Levels and Quadrivalent Vaccine Clinical Effectiveness in Perinatally Human Immunodeficiency

Virus–infected and Exposed, Uninfected Youth. *Clin Infect Dis Off Publ Infect Dis Soc Am*. 2019;69(7):1183-1191. doi:10.1093/cid/ciy1040

TABLES

Table 1: Characteristics of participating men who have sex with men and transgender women, overall and restricted by documented and self-reported HPV vaccination status, Seattle, Washington, 2016-2018

Characteristic	**Total**	**Verified HPV Vaccination***	**Self-reported HPV Vaccination****
	N (%)	n (%)	n (%)
Total	751 (100)	290 (100)	375 (100)
Recruitment site			
Gay City Health Project	157 (20.9)	34 (11.7)	64 (17.1)
Public Health Seattle & King County STD Clinic	594 (79.1)	256 (88.3)	311 (82.9)
Age, years			
18-21	192 (25.6)	91 (31.4)	107 (28.5)
22-26	559 (74.4)	199 (68.6)	268 (71.5)
Gender Identity			
Male	728 (96.9)	280 (96.6)	366 (97.6)
Female/Transgender female	6 (0.8)	3 (1.0)	2 (0.5)
Other/unknown	17 (2.3)	7 (2.4)	7 (1.9)
Race			
African-American or Black	51 (6.8)	18 (6.2)	21 (5.6)
White or Caucasian	431 (57.4)	167 (57.6)	217 (57.9)
Asian or Pacific Islander	133 (17.7)	61 (21.0)	70 (18.7)
American Indian or Alaska Native	9 (1.2)	4 (1.4)	6 (1.6)
Multiracial or Mixed	68 (9.1)	19 (6.6)	35 (9.3)
Other/unknown/no answer	59 (7.9)	21 (7.2)	26 (6.9)
Ethnicity			
Non-Hispanic	591 (78.7)	232 (80.0)	294 (78.4)
Hispanic	155 (20.6)	56 (19.3)	78 (20.8)
Don't know/unsure	5 (0.7)	2 (0.7)	3 (0.8)
Sexual orientation			
Gay or homosexual	522 (69.5)	201 (69.3)	270 (72.0)
Bisexual	77 (10.3)	29 (10.0)	35 (9.3)
Heterosexual or straight	4 (0.5)	3 (1.0)	3 (0.8)
Queer	43 (5.7)	6 (2.1)	9 (2.4)
Other/unknown/no answer	105 (14.0)	51 (17.6)	58 (15.5)
Lifetime number of partners*** (mean/median, IQR)	43.2/23.5 (11,50)	49.4/25 (10,53)	51.5/28 (11,55)
Age at first sexual encounter with any partner**** (mean/median, IQR)	16.8/17 (15,18)	16.6/17 (15,18)	16.8/17 (15,18)
HPV vaccine dose number			

1 dose	N/A	102 (35.2)	55 (14.7)
2 doses	N/A	74 (25.5)	73 (19.5)
3 or more doses	N/A	114 (39.3)	191 (50.9)
Unknown/no answer	N/A	N/A	56 (14.9)
Source of verified vaccination			
WAIIS and EMR	N/A	290 (100)	N/A
WAIIS only	N/A	256 (88.3)	N/A
EMR only	N/A	198 (68.3)	N/A
Age at first vaccine, years***** (mean/median, IQR)	N/A	20/20 (18,23)	20.4/21, (18,23)
Time since first vaccine, years***** (mean/median, IQR)	N/A	2.2/2 (0,4)	2.6/2 (1,4)

*Verified at least one HPV vaccine as documented in either the clinic electronic medical records (EMR) or The Washington State Immunization Information System (WAIIS) or both.

**Self-report of at least one HPV vaccine as reported in the participant questionnaire.

***For the total population 7 did not report number of lifetime partners, 1 did not for verified vaccination, and 1 did not for self-reported vaccination.

****For the total population 6 did not report age at first sex, for verified vaccination 2 did not report, for self-reported vaccination 1 did not report.

*****For self-reported vaccination age at first vaccine could not be calculated for 50 participants who did not report their age at first vaccine.

****** For self-reported vaccination, time since first vaccination could not be calculated for 43 participants who did not report their date of first vaccine dose.

Table 2: Sensitivity of self-report of HPV vaccine compared to verified vaccine record

Self-report response*		**yes**	**no**	**don't know/no answer**	**Sensitivity %**	**95% Confidence Interval**
	n (verified doses)**	**n (responses)**				
Overall	290	241	14	35	83.1	78.3-87.2
Age group						
18-21 years	91	72	7	12	79.1	69.3-86.9
22-26 years	199	169	7	23	84.9	79.2-89.6
Time since 1st verified HPV vaccine						
<1 year ago	87	77	3	7	88.5	79.9-94.3
1-2 years ago	94	82	2	10	87.2	78.8-93.2
3 or more years ago	109	82	9	18	75.2	66.0-83.0
Verified 3 or more HPV vaccine doses**	114	80	8	26	70.2***	60.9-78.4

*Answer to the survey question "Have you ever received any vaccine against human papillomavirus (HPV)?" as reported by the participant.
**≥1 verified HPV vaccine as documented in either the clinic electronic medical records (EMR) or The Washington State Immunization Information System (WAIIS) or both.
**Restricted to those with 3 or more verified vaccine record doses.
***Sensitivity for self-reporting at least 3 doses of HPV vaccine.

Table 3: Odds ratios for associations between age and time since vaccination on the sensitivity of self-report for capturing verified HPV vaccination (n=290)*

	Univariate OR	**95% confidence interval**	**P value**	**Multivariate OR***	**95% confidence interval**	**P value**
Age group						
22-26 years	1.0	N/A	N/A	1.0	N/A	N/A
18-21 years	0.7	0.4-1.3	0.22	0.7	0.4-1.3	0.32
Time since 1st verified HPV vaccine**						
<1 year ago	1.0	N/A	N/A	1.0	N/A	N/A
1-2 years ago	0.9	0.4-2.2	0.79	0.9	0.4-2.1	0.74
3 or more years ago	0.4	0.2-0.9	0.02	0.4	0.2-0.9	0.02

*Adjusted for either age or time since 1st verified HPV vaccine.

**Verified HPV vaccine as documented in either the clinic electronic medical records (EMR) or The Washington State Immunization Information System (WAIIS) or both.

Table 4: Positive predictive value of self-report of HPV vaccine compared with positive serology for all 4 quadrivalent HPV vaccine types as the gold standard

	n				
	Self-report yes**	**Seropositive all 4 types**	**Seropositive < 4 types**	**PPV %**	**95% Confidence Interval**
Overall	369	314	55	85.1	81.0-88.6
Self-reported number of vaccine dose(s)*					
1 dose	54	35	19	64.8	50.6-77.3
2 doses	72	66	6	91.7	82.7-96.9
3 or more doses	188	177	12	94.1	89.8-97.0
Don't know/no answer	55	36	18	65.5	51.4-77.8
Time since 1st self-reported HPV vaccine dose**					
<1 year ago	87	77	10	88.5	79.9-94.3
1-2 years ago	110	90	20	81.8	73.3-88.5
3 or more years ago	129	115	14	89.1	82.5-93.9
Don't know/no answer	43	32	11	74.4	58.8-86.5

* Answer to the survey question “How many doses (shots)?” as reported by the participant.

** Answer to the survey question “Date of 1st dose (shot)?” as reported by the participant.

**Restricted to participants who self-reported receiving at least one dose of HPV vaccine and had an adequate serum sample for HPV serology testing.

Table 5: Characteristics of self-reported vaccine time and dosage compared to serology for those who reported at least one dose of HPV vaccine and were seropositive for < 4 quadrivalent vaccine strains

	Self-report of HPV Vaccine*
	n (%)
Total	55 (100)
Serology	
HPV 6 positive	38 (69.1)
HPV 11 positive	29 (52.7)
HPV 16 positive	29 (52.7)
HPV 18 positive	6 (10.9)
Number of HPV stains positive via serology	
0 strains	12 (21.8)
1 strain	10 (18.2)
2 strains	7 (12.7)
3 strains	26 (47.3)
HPV vaccine dose number**	
1 dose	19 (34.6)
2 doses	6 (10.9)
3 or more doses	11 (20.0)
First dose reported, in year ranges***	
<1	13 (23.6)
1-2	8 (14.6)
3+	23 (20.0)
Time since first dose in days for those with self-reported first dose less than a year ago	n=10
<1 mean/median (range)	92.7/56.5 (3-360)

*Self-report of at least one HPV vaccine as reported in the participant questionnaire.
**19 of the 55 did not report vaccine dose number.
***11 of the 55 did not report time since vaccination.