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Factors related to human papillomavirus vaccine uptake and intentions among adults aged 18–26 and 27–45 years in the United States: A cross-sectional study

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AUTHOR CONTRIBUTIONS

Mariana Arevalo: Manuscript conceptualization and original draft. **Naomi C. Brownstein:** Project conceptualization, methodology, formal analysis, and critical review of all stages of the manuscript. **Junmin Whiting:** Statistical analysis and critical review of all stages of the manuscript. **Susan T. Vadaparampil:** Project conceptualization, methodology, and critical review of the final manuscript. **Katharine J. Head:** Project methodology and critical review of the final manuscript. **Cathy D. Meade:** Project conceptualization, methodology, and critical review of the final manuscript. **Jessica Y. Islam:** Conceptualization and critical review of the final manuscript. **Monica L. Kasting:** Project methodology and critical review of the final manuscript. **Clement K. Gwede:** Project conceptualization, methodology, and critical review of the final manuscript. **Veronica Barrios-Monroy:** Project management and coordination and critical review of the final manuscript. **Shannon M. Christy:** Project funding, project conceptualization, data curation, resources, supervision, and critical review of all stages of the manuscript. The final manuscript was reviewed and approved by all coauthors.

CONFLICT OF INTEREST

Outside of the present work, Katharine J. Head has received investigator-initiated research funding from Merck, administered through Indiana University, and serves as an unpaid advisory member to the Indiana Immunization Coalition. Outside of the present work, Monica L. Kasting has received investigator-initiated research funding from Merck, administered through Purdue University. Jessica Y. Islam received consulting fees from Flatiron Health Inc. Shannon M. Christy is an unpaid advisory member to HPV Cancers Alliance. The other authors declare no conflicts of interest.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Abstract

Background: The current study examined self-reported human papillomavirus (HPV) vaccination uptake and intentions, and associations with psychosocial constructs among United States adults aged 18 to 26 and 27 to 45 years.

Methods: Data were collected via an online survey from participants recruited from a research panel. Outcomes were HPV vaccination uptake and intentions. Multivariable binary and ordered logistic regression models were used to examine associations between HPV vaccination outcomes and psychosocial constructs, sociodemographics, and previous health behaviors.

Results: HPV vaccination uptake in both age cohorts (N = 2722) was associated with multiple variables, including but not limited to: provider recommendation (adjusted odds ratio [aOR], 11.63 [95% CI, 7.70–17.56] and aOR, 14.26 [95% CI, 9.52–21.38], for those aged 18 to 26 and 27 to 45 years, respectively) and positive HPV vaccine attitudes (aOR, 2.40 [95% CI, 1.70–3.40] and aOR, 1.46 [95% CI,1.06–2.02]). Among those who did not report or were unsure of prior HPV vaccination (N=1894), only 4.6% and 8.1% (aged 18–26 and 27–45 years, respectively) reported being very likely to receive the HPV vaccine in the next year. Increased intentions were associated with more positive vaccine attitudes (aOR, 2.45 [95% CI, 1.91–3.15] and aOR, 2.19 [95% CI, 1.72–2.78]) and provider recommendation (yes vs no; aOR, 1.97 [95% CI, 1.38–2.83] and aOR, 1.82 [95% CI, 1.31–2.52]; don't know/can't remember vs no; aOR, 1.38 [95% CI, 1.03–1.84] and aOR, 1.60 [95% CI, 1.17–2.18]). Sociodemographics and health behaviors associated with increased intentions differed for each age cohort.

Conclusions: Individual and interpersonal factors were associated with HPV vaccination uptake and intentions. Findings reveal the need for targeted interventions to improve HPV vaccination rates among these age groups.

Keywords

adults; cancer prevention; HPV vaccine; human papillomavirus; intentions; vaccination

Introduction

The human papillomavirus (HPV) vaccine can prevent up to 92% of HPV-related cancers.[1] In the United States, routine HPV vaccination is recommended for all children aged 11 to 12 years and can be received starting at age 9 years.[2] Catch-up vaccination is recommended for all individuals aged 13 to 26 years.[2] The incidence of common HPV types and genital warts among young adults has decreased since the introduction of the HPV vaccine, and cervical cancer rates are expected to decline among cohorts of vaccinated adults.[3,4]

A large proportion of age-eligible adults in the United States remain unvaccinated.[5] In 2017, only 51.5% of females and 21.1% of males aged 19 to 26 years and 15.8% of females and 3.2% of males aged 27 to 45 years had received at least 1 dose of the HPV vaccine.[6] In 2018, the US Food and Drug Administration extended HPV vaccine eligibility to individuals aged 27 to 45 years.[2,7] In 2019, the Advisory Committee on Immunization Practices recommended shared clinical decision-making for HPV vaccination among adults aged 27 to 45 years.[8] The HPV vaccine has been deemed safe for adults, effective among adults aged 18 to 26 years, and includes early evidence of effectiveness among adults aged 27 to 45 years.[9–13] HPV vaccination in adult populations shows some potential efficacy in reducing HPV-related morbidity and mortality and can be cost-effective.[14,15] Thus, it is important to understand factors related to vaccination uptake among adults up to age 45 years to better understand influencing behavioral factors among these age cohorts.

The Health Belief Model[16,17] and the Theory of Planned Behavior[16,18] have been used to study HPV vaccination-related behaviors. The Health Belief Model[19] and Theory of Planned Behavior[20] focus on factors that influence individuals' health behavior, with constructs assessing perceptions of risk, barriers to performing a behavior, and confidence in their ability to perform the behavior, among others.[21] Among adults aged 18 to 45 years, predictors of HPV vaccination include positive social norms, younger age, and provider recommendation.[22] Low HPV vaccine knowledge and lack of provider recommendation have been reported among reasons for young adults (aged 18–26 years) not receiving the vaccine.[23] Among unvaccinated individuals aged 18 to 45 years, intentions to receive HPV vaccination have been associated with social norms, perceived behavioral control, sex, and provider recommendation.[22] Previous studies were conducted with populations outside of the United States,[24] limited to a specific United States,[23] reported combined results for young and mid-age adults,[22] or assessed only intentions to be vaccinated.[25,26] Gaps in research are noted among adults of the specific age ranges that align with updated guidelines (i.e., aged 18–26 and 27–45 years). The purpose of this study was to examine associations between behavioral constructs, sociodemographics, health care covariates, and HPV vaccination uptake and intentions among a national sample of adults aged 18 to 26 and 27 to 45 years.

Materials and Methods

This cross-sectional study enrolled 4000 English-speaking adults to complete a 30-minute online survey between February 25, 2021, and March 24, 2021. The survey assessed self-reported HPV vaccination behaviors and intentions as well as sociodemographic, behavioral, and health-related factors. Participants were recruited through a research panel company using quota sampling based on sex at birth (50% female; 50% male) and age (50% aged 18–26 years; 50% aged 27–45 years). Eligible individuals were aged 18 to 45 years; able to speak, read, and understand English; living in the United States; had internet access; and were a research panelist directly through the research panel company or via verified partners. Although participants were recruited from all United States regions, we oversampled Florida residents to inform future research in the cancer center's catchment area. The panel company sent emails to eligible individuals inviting them to complete the survey. We recruited 4000 participants (3485 broadly and 515 in Florida). Our team used

a systematic strategy to review and clean all survey records.[27] We removed records with consecutive identical answers, contradictory responses, nonsensical open-ended responses, and those completed in a unrealistic amount of time, resulting in 2722 final records. Methodological details for data cleaning and other analyses from this study are included elsewhere.[27–29] For the current analyses, participants were asked about prior receipt of HPV vaccination (1 item), intentions to receive the vaccine in the next year (1 item), HPV vaccine knowledge (11 items),[30,31] perceived risk (6 items for females and 4 items for males),[16] perceived barriers (3 items),[32] self-efficacy (9 items),[33] attitudes about HPV vaccine (8 items),[34] descriptive norms (3 items),[35] health literacy (1 item),[36] previous health behaviors and other covariates (5 items), and sociodemographics (13 items). Details about measures are found in Table 1. Study procedures were reviewed and approved with exempt status by the Moffitt Cancer Center Scientific Review Committee and institutional review board of record (Advarra).

Statistical analysis

Variables were summarized using descriptive statistics. Outcomes included HPV vaccination receipt and, among individuals who did not report prior vaccination, intentions to obtain the HPV vaccine in the next year. HPV vaccination was treated as a binary variable, and intentions were treated as ordinal. Multivariable logistic regression models were used for HPV vaccination, and multivariable proportional odds models were used for HPV vaccination intentions. Models used a complete case analysis method for handling missing data. Final models were chosen using backward selection with a significance level of 10%. Each relevant parameter estimate included an associated 95% CI. Analyses were conducted in SAS (Version 9.4).[38]

RESULTS

After data cleaning,[27] the final analytic sample included 2722 individuals. Sociodemographic and health care variables by age cohort are displayed in Table 2. Among individuals aged 18 to 26 and 27 to 45 years, respectively, 492 (35.6%) and 336 (25.1%) reported ever receiving HPV vaccination; of those, 76.4% and 75.6% respectively reported receiving at least two vaccine doses. Among those who did not report prior vaccination, only 4.6% of those aged 18 to 26 years and 8.1% of those aged 27 to 45 years indicated being very likely to get the HPV vaccine in the next year.

Factors associated with receipt of HPV vaccine

Most notably, provider recommendation (or lack thereof) was associated with a substantial difference in HPV vaccination uptake. Among those aged 18 to 26 and 27 to 45 years, respectively, those who received a provider recommendation had 11.63 times and 14.26 times the adjusted odds of receiving HPV vaccination compared with those who did not (95% CI, 7.70–17.56 and 9.52–21.38, respectively; Table 3); even those who were unsure of whether they had a provider recommendation had higher adjusted odds than those who reported that their provider did not recommend HPV vaccination (adjusted odds ratio (aOR); 2.56 [95% CI, 1.63–4.01] and 1.59 [95% CI, 0.90–2.83]; Table 3).

Additional factors positively associated with having received the HPV vaccine in both age groups were more positive HPV vaccine attitudes (aOR, 2.40 [95% CI, 1.70–3.40]) for those aged 18 to 26 years and aOR, 1.46 (95% CI, 1.06–2.02) for those aged 27 to 45 years; higher HPV vaccine knowledge (aOR, 1.27 [95% CI, 1.19–1.36]) for those aged 18 to 26 years and aOR, 1.13 (95% CI, 1.05–1.21) for those aged 27 to 45 years; greater perceived HPV risk (aOR, 1.19 [95% CI, 1.03–1.37]) for those aged 18 to 26 and aOR, 1.16 (95% CI, 1.02–1.33) aged 27 to 45 years; greater descriptive norms (aOR, 1.03 [95% CI, 1.02–1.04]) for those aged 18 to 26 and aOR, 1.02 (95% CI, 1.02–1.03; Table 3) for those aged 27 to 45 years (Table 3). Individuals with a parent born outside of the United States had higher adjusted odds of having received HPV vaccination compared with those who did not (aOR, 1.65 [95% CI, 1.15–2.36] for those aged 18–26 and aOR, 1.77 [95% CI, 1.14–2.73] for those aged 27–45 years). Previous health behaviors associated with vaccination include, for those 18 to 26 and 27 to 45 years, respectively, receipt of the tetanus shot (aOR, 1.51 [95% CI, 1.03–2.21] and 1.58 [95% CI, 1.08–2.32]), and ever having a Papanicolaou test (aOR, 2.73 [95% CI, 1.73–4.31] and aOR, 3.19 [95% CI, 1.73–5.89]). HPV vaccination uptake was negatively associated with higher self-efficacy scores (aOR, 0.45 [95% CI, 0.35–0.58] for those 18–26 years and aOR, 0.48 [95% CI, 0.36–0.64] for those aged 27–45 years). Among those aged 18 to 26 years, lower adjusted odds of HPV vaccination were associated with higher perceived vaccine barriers (aOR: 0.62 [95% CI, 0.50–0.77]), and higher adjusted odds of HPV vaccination were associated with receipt of the flu shot (aOR, 1.42 [95% CI, 1.02–2.00]) and having heard about HPV vaccine from at least one information source (aOR, 1.48 [95% CI, 1.04–2.10]).

Among individuals aged 27 to 45 years, sociodemographics such as sexual orientation other than heterosexual/straight (aOR, 1.87 [95% CI, 1.12–3.11]) were positively associated with having received HPV vaccination, whereas lower income level, especially having an annual income of less than $19,999 (vs. $100,000 or more), was associated with lower adjusted odds of receiving the HPV vaccine (aOR, 0.24 [0.10–0.58]). Employment status was associated with vaccination; in particular, those who checked “other” employment status (i.e., homemaker, retired, disabled, military, or student) had lower adjusted odds of having received HPV vaccination than those who were employed (aOR, 0.47 [95% CI, 0.22–1.03]). Having health insurance was associated with vaccination (aOR, 1.82 [95% CI, 1.00–3.31]).

Factors associated with intentions to receive the HPV vaccine in the next year

Among those who had not reported prior vaccination, factors associated with higher intentions to receive the HPV vaccine in both cohorts (aged 18–26 and 27–45 years, respectively) were more positive HPV vaccine attitudes (aOR, 2.45 [95% CI, 1.91–3.15] and aOR, 2.19 [95% CI, 1.72–2.78]); higher perceived risk (aOR, 1.74 [95% CI, 1.56–1.94] and aOR, 1.40 [95% CI, 1.27–1.55]); higher descriptive norms (aOR, 1.01 [95% CI, 1.00–1.01] and aOR, 1.02 [95% CI, 1.01–1.03]); and receiving a provider recommendation for HPV vaccine (vs. not receiving a recommendation; aOR, 1.97 [95% CI, 1.38–2.83] and aOR, 1.82 [95% CI, 1.31–2.52]) or being unsure or unable to remember receiving a recommendation (vs. not receiving a recommendation; aOR, 1.38 [95% CI, 1.03–1.84] and aOR, 1.60 [95% CI, 1.17–2.18]). In both cohorts, lower HPV vaccination intentions to get the vaccine in the next year were associated with higher HPV vaccine knowledge (aOR, 0.93 [95% CI,

0.89–0.98] for those aged 18–26 and aOR, 0.89 [95% CI, 0.85–0.93] for those aged 27–45 years).

Among those aged 18 to 26 years, respondents who were Black/African American had higher intentions to receive the HPV vaccination compared with White adults (aOR, 1.66 [95% CI, 1.16–2.36]). Receiving a flu shot (aOR, 1.68 [95% CI, 1.30–2.17]) and reporting it is very easy to understand health written information versus not very easy (aOR, 1.54 [95% CI, 1.17–2.02]) were positively associated with increased intentions (Table 4). Among those aged 27 to 45 years who did not report prior vaccination, factors positively associated with increased intentions to obtain the HPV vaccine in the next year included: perceived self-efficacy (aOR, 1.48 [95% CI, 1.23–1.78]) and perceived barriers (aOR, 1.19 [95% CI, 1.04–1.36]). Higher intentions to receive HPV vaccination were associated with educational attainment level, with intentions elevated for those having a graduate degree versus less than a high school diploma (aOR, 1.54 [95% CI, 1.06–2.23]), and having heard information about HPV vaccine from at least one media information source (aOR, 1.50 [95% CI, 1.16–1.96]). In the cohort aged 27 to 45 years, lower adjusted odds of reporting intentions to receive the vaccine in the next year were associated with having a history of Papanicolaou test, compared with reporting no history of Papanicolaou test among those eligible for Papanicolaou tests (aOR, 0.56 [95% CI, 0.38–0.80]; Table 4).

Discussion

The low proportions of HPV vaccination observed in our study demonstrate the urgent need for focused efforts to improve HPV vaccination uptake among age-eligible adults. These efforts would support the successful attainment of Healthy People 2030 goals to increase the proportion of vaccinated adults and reduce HPV-related infections and cancers among adults aged 19 years or older.[39] Consistent with previous studies,[22,40] our findings indicate that provider recommendations are strongly linked to uptake of HPV vaccination. This highlights the importance of health care access and the need for health care providers to consistently make strong HPV vaccination recommendations. Increasing communication skills among a wide range of providers (e.g., obstetricians/gynecologists, family medicine, pharmacists) who provide care to adult populations. Future studies should develop materials to educate providers about the HPV vaccine recommendations for their adult age–eligible patients and assess elements of effective shared clinical decision-making tailored to adults aged 27 to 45 years that could further improve patient-provider conversations and engagement. Similarly, educational materials should include strategies that promote patient-provider HPV vaccine communications.

Behavioral factors related to HPV vaccination receipt were similar for both age cohorts, excluding perceived barriers. Among adults aged 18 to 26 years, lower perceived barriers (i.e., cost, safety, and side effects) led to higher adjusted odds of having received the HPV vaccination. It is possible that individuals in this age cohort received the vaccine as children and thus their parents (as opposed to the respondents themselves) facilitated HPV vaccine receipt. In addition, this finding may reflect greater exposure to information campaigns for this age group that addressed their concerns about vaccine costs, risks, and safety. In the United States, vaccines are covered through private and public insurance for

most young adults,[41] which can help eliminate practical barriers such as vaccine costs. Additionally, findings suggest that HPV vaccine knowledge, perceived risk, descriptive norms, and attitudes seem to be important targets for health promotion and communication awareness campaign messages for both age groups, although effect sizes suggest that HPV vaccine attitudes had stronger contributions to vaccination receipt among adults aged 18 to 26 years. Thus, targeted messages that could aid in the formation of attitudes for this younger group might help in educational development. Our findings, which unexpectedly indicated that perceived self-efficacy was negatively linked to receipt of the vaccination, may be due to measurement and participant recall bias. Vaccinated participants were asked to recall their self-efficacy for obtaining the HPV vaccine months or years previously, or even as adolescents, when their parents may have made the decisions about getting them vaccinated.

Among those who did not report previous vaccination, perceived HPV risk, HPV vaccine attitudes, and HPV vaccine descriptive norms were positively related to HPV vaccination intentions in the next year. Prior research demonstrates beliefs about HPV vaccine effectiveness and protection against HPV infection are linked to vaccination intentions among adults aged 18 to 26[42] and those aged 27 to 45 years.[25] Among those who did not report prior HPV vaccination in our study, HPV vaccine knowledge was negatively associated with intentions to get the HPV vaccine in the next year. This finding could be explained by the timeframe in which these data were collected (i.e., 1 year into the COVID-19 pandemic). Timing could have influenced participants' intentions to obtain the vaccine in the next year, considering COVID-19–related restrictions limiting access to care and recognition that multiple vaccine doses (visits to providers) are needed. Post hoc analyses revealed that HPV knowledge mean scores were higher among vaccinated individuals (mean = 6 vs. mean = 3.6, vaccinated vs. individuals who did not report prior HPV vaccination, respectively; see supplementary material). Additionally, positive descriptive norms have been linked to higher intentions to get vaccinated in the next year among adults aged 18 to 26 years.[42] In our study, perceived barriers to HPV vaccination and perceived self-efficacy were positively associated with intentions to receive HPV vaccination in the next year among individuals aged 27 to 45 years, but not among those aged 18 to 26 years. Future educational interventions should address factors such as vaccine costs, possible side effects, and vaccine safety. Our findings also showed that higher intentions to obtain the HPV vaccine in the next year were associated with adequate health literacy (among those aged 18–26 years) or with having heard about HPV from at least one media source (among those aged 27–45 years). These findings can help inform targeted communication campaigns to increase awareness by age group, especially as it relates to creating content addressing individuals with differing levels of health literacy and accounting for different media usage. Last, interventionists should design and test the efficacy of persuasive messages that enhance HPV vaccination-related to mastery experiences and perceived self-efficacy, as such messages might lead to the formation of stronger intentions among adults aged 27 to 45 years.

We found that a larger number of sociodemographic factors were associated with receipt of HPV vaccination among adults aged 27 to 45 years. Adults aged 27–45 years with lower income, compared with those with the highest income, had lower adjusted odds

of receiving HPV vaccination; individuals (27–45 years) with a sexual orientation other than heterosexual/straight had higher adjusted odds of receiving the HPV vaccine. This may be partly because of increased efforts to reach at-risk populations such as men who have sex with men.[40] Having health insurance was associated with higher adjusted odds of receiving the HPV vaccine. This suggests that access to care and engagement with the health care system may play an important role among individuals aged 27 to 45 years. Although we did not study the pathways of this relationship, having insurance may indicate access to a provider who could recommend the vaccine. Greater educational attainment was associated with higher adjusted odds of increased intentions to get the HPV vaccine among individuals aged 27 to 45 years. Thompson and colleagues found that higher education was associated with intentions, but the relationship did not hold after adjusting for covariates.[25] Understanding sociodemographic characteristics that might contribute to HPV vaccination disparities is important not only for clinical practice, but also for public policy efforts to improve HPV vaccination uptake.

Strengths and limitations

One of the major strengths of our study is that we assessed factors related to HPV vaccine outcomes by different age cohorts with the intention to inform future age-appropriate interventions that reflect Advisory Committee on Immunization Practices recommendations for HPV vaccination. Previous studies assessed HPV vaccine–related outcomes among adults using a wider 18 to 45 age cohort[22,40] or cohorts that are inconsistent with age recommendations (i.e., aged 18–29, 18–30 years).[24,26,43] Additionally, we used a large national sample of United States adults, which enhanced the sample composition and generalizability of the study to populations with similar characteristics. This study also has limitations. First, the study was a cross-sectional survey, limiting the assessment of temporal relationships. However, examining associations enhanced our understanding of factors linked to vaccine outcomes that could inform the development of targeted interventions. Second, the study was conducted online, and this medium may have not captured populations that do not have internet access and may have fewer resources.[44] Third, this study was conducted during the COVID-19 pandemic, which may have influenced respondents' timeline for HPV vaccination, especially their intentions to receive the vaccine in the next year. We describe respondents' perceived impact of the pandemic on their vaccination timelines elsewhere.[45] More research is needed to confirm our findings, expand evidence of HPV vaccine safety and effectiveness among adult populations, support shared clinical decision-making about HPV vaccination between providers and their patients aged 27 to 45 years, and promote vaccination among adults aged 18 to 26 years. A manuscript describing our findings on the development of educational tools promoting HPV vaccination among young adults (aged 18–26 years) is under way.

Conclusions

HPV vaccination remains underused among age-eligible adults in the United States. This study provides information on behavioral constructs that are modifiable and could be addressed in future interventions to boost adult vaccination rates. Findings suggest that sociodemographics and health care–related covariates associated with the outcomes differ

by age cohort, and this could help target future age-relevant and more targeted educational interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

Description of measures used in the study

Variable	Description	No. of items	Response scale	Cronbach alpha	Details about scoring and analysis
Prior receipt of HPV vaccination	• Outcome variable • "Have you ever had the HPV vaccine?"	• 1	• Yes, No, or Don't know.	• NA	• Those responding "No" or "Don't know" were categorized as unvaccinated.
Intentions to receive HPV vaccination (among those not previously vaccinated or unsure of vaccination status)	• Outcome variable • "How likely is it that you will get the HPV vaccine in the next year?	• 1	• 7-point scale from very unlikely (1) to very likely (7).	• NA	• Only individuals who did not report that they had been previously vaccinated answered this item.
HPV vaccine knowledge	• Measured using a modified version of scales.[30,31] Sample item: "The HPV vaccine protects you from every type of HPV"	• 11	• True, False, Don't know.	• α = 0.80 (aged 18–26 years) and • α = 0.78 (aged 27–45 years).	• Correct responses received 1 point, and the scale scores were calculated as the sum of correct responses. • "Don't know" was counted as an incorrect response. • Higher scores indicated higher knowledge.
Perceived risk	• Measured using a modified version of a scale.[16] • Sample item: "How likely do you think you are to get genital warts in the future?"	• 6 items (participants assigned as female at birth) and • 4 items (participants assigned male sex at birth).	• 7-point scale from "No chance" (1) to "Certain I will get" (7).	• α = 0.91 for females • α = 0.92 for males • α = 0.91 (females aged 18–26 years) • α = 0.89 (males aged 18–26 years) • α = 0.91 (females aged 27–45 years) • α = 0.93 (males aged 27–45 years).	• Individual average scale scores were calculated for males and females (i.e., average of items for each male and each female). • Higher scores indicated greater perceived risk.
Perceived barriers	• Measured using a previously validated scale.[32]	• 3	• 4-point Likert scale ranging from "Not at all concerned" (1) to "Very concerned" (4).	• α = 0.73 (aged 18–26 years) and • α = 0.80 (aged 27–45 years).	• Higher scores indicated greater perceived barriers.
Self-efficacy	• Measured participants' perceived confidence to obtain HPV vaccination using a modified from a previous study.[33] • Sample item (unvaccinated): "I can make an appointment to get the HPV vaccine" • Sample item (vaccinated): "Before I was vaccinated, I felt I could find a way to pay for the HPV vaccine"	• 9	• 5-point Likert scale from "Strongly agree" (1) to "Strongly disagree" (5).	• α = 0.89 for both age groups.	• Higher scores indicated higher perceived self-efficacy.
HPV vaccine attitudes	• Assessed for all participants using a modified version of the Carolina HPV Immunization Attitudes and beliefs Scale (CHIAS).[34] • Sample item: "I think the HPV vaccine might cause short-term problems, like fever or discomfort."	• 8	• 5-point Likert scale from "Strongly agree" (1) to "Strongly disagree" (5).	• α = 0.71 (aged 18–26 years) and • α = 0.69 (aged 27–45 years).	• The scale contained 4 negatively worded items (which were subsequently reverse coded) and 4 positively worded items. • Higher scale scores indicate more positive attitudes.

Variable	Description	No. of items	Response scale	Cronbach alpha	Details about scoring and analysis
Descriptive norms	• Assessed with a modified item:[35] "In your best estimate, what percentage of peers (both men and women your age) do you think have received the HPV vaccine?"	• 1	• 0–100 scale.	• NA	
Health literacy	• Assessed with a single item from the Behavioral Risk Factor Surveillance System (BRFSS) Health Literacy module:[36] "In general, how difficult is it for you to understand written health information?"	• 1	• Very easy • Somewhat easy • Somewhat difficult • Very difficult • Don't know/not sure • I prefer not to answer	• NA	• For statistical analyses, responses were collapsed into three categories: very easy, not very easy (somewhat easy, somewhat difficult, and very difficult), and all other (I don't look for health information, I don't know/not sure, I prefer not to answer).
Sociodemographics	• Participants indicated their sex assigned at birth, race, ethnicity, educational attainment, annual income, marital status, employment status, insurance status, sexual orientation, whether they were born in the United States, whether their parents were born in the United States, and whether they were parents or guardians of one or more children, and state of residence (collapsed to geographic region of residence).	• See Table 2	• See Table 2	• NA	
Prior health behaviors and other covariates	• Prior vaccination behaviors (i.e., receipt of flu shot in the past 12 months, receipt of tetanus shot in the past 10 years)	• 2	• Yes, No, Don't know/Not sure, I prefer not to answer	• NA	• Variables were dichotomized (yes/no) for analysis.
	• Media sources (i.e., participants were asked whether they had heard about the HPV vaccine from various media information sources (e.g., television, radio, internet, newspaper, social media). Item modified from elsewhere.[37]	• 1	• Television • Radio • Internet • Newspaper/news website • Social media • Podcasts • Blog • None of the above	• NA	• Variables were dichotomized (yes/no) for analysis. Yes = at least 1 option selected; No = no option selected or selected "none of the above".
	• Provider recommendation was measured with 1 item: "Has a health care provider ever recommended that you get the HPV vaccination?"	• 1	• Yes, No, I don't know/I can't remember.	• NA	
	• Among those indicating female sex at birth, history of having had a Pap test was measured with: "Have you ever had a Pap Test?" with the following	• 1	• Yes, No, I don't know/Not sure, Not applicable.	• NA	• For analyses purposes, we coded those who reported being assigned male sex at birth as "not applicable" for this item.

Abbreviations: HPV, human papillomavirus; NA, not available.

TABLE 2

Sample characteristics by age cohort (N = 2722)

Variable	18–26 year cohort No. (%) (N = 1381)	27– 45 year cohort No. (%) (N = 1341)
Sex assigned at birth		
Female	740 (53.6)	783 (58.4)
Male	641 (46.4)	558 (41.6)
Race		
White	842 (61.1)	1092 (81.6)
Black/African American	200 (14.5)	114 (8.5)
Other[a]	337 (24.4)	133 (9.9)
Missing	2	2
Ethnicity		
Hispanic	316 (23.0)	131 (9.8)
Non-Hispanic	1059 (77.0)	1207 (90.2)
Missing	6	3
Born in the United States		
No	97 (7.0)	92 (6.9)
Yes	1282 (93.0)	1247 (93.1)
Missing	2	2
Parent born outside of the United States		
No	949 (69.7)	1109 (83.4)
Yes	412 (30.3)	221 (16.6)
Missing	20	11
Educational attainment		
High school or less	457 (33.2)	204 (15.2)
Some college/associate degree	510 (37.0)	360 (26.9)
Bachelor’s degree	318 (23.1)	439 (32.8)
Graduate school	93 (6.7)	336 (25.1)
Missing	3	2
Annual income		

$0–$19,999	221 (16.5)	110 (8.2)
$20,000–$49,999	378 (28.2)	295 (22.1)
$50,000–$74,999	291 (21.7)	267 (20.0)
$75,000–$99,999	222 (16.5)	234 (17.5)
$100,000 or more	230 (17.1)	428 (32.1)
Missing	39	7
Marital status		
Married/partner	437 (31.7)	966 (72.0)
All other[b]	942 (68.3)	375 (28.0)
Missing	2	-
Employment status		
Employed	860 (62.4)	1115 (83.3)
Unemployed	198 (14.4)	112 (8.4)
Other	321 (23.3)	112 (8.4)
Missing	2	2
Sexual orientation		
All other [c]	282 (20.7)	159 (12.2)
Heterosexual/straight	1083 (79.3)	1142 (87.8)
Missing	16	40
Health insurance status		
No	271 (19.7)	186 (13.9)
Yes	1108 (80.3)	1151 (86.1)
Missing	2	4
Parent of ≥1 child		
No	1157 (83.8)	439 (32.8)
Yes	223 (16.2)	900 (67.2)
Missing	1	2
Geographic region		
Midwest	321 (23.2)	262 (19.5)
Northeast	208 (15.1)	227 (16.9)
South	458 (33.2)	614 (45.8)
West	394 (28.5)	238 (17.7)

Receipt of flu shot in past 12 months		
No	804 (58.2)	715 (53.3)
Yes	557 (41.8)	626 (46.7)
Receipt of tetanus shot in past 10 years		
No	493 (35.7)	512 (38.2)
Yes	705 (51.0)	711 (53.0)
Don’t know/Not sure	183 (13.3)	118 (8.8)
Ever received a Papanicolaou test		
No	378 (27.4)	155 (11.6)
Yes	313 (22.7)	599 (44.7)
Don’t know/not sure	49 (3.5)	28 (2.1)
Not applicable (male sex at birth)	641 (46.4)	558 (41.6)
Missing	-	1
Information sources for HPV-related information		
No	607 (44.1)	406 (30.4)
Yes	770 (55.9)	931 (69.6)
Missing	4	4
Provider recommendation for HPV vaccination		
No	560 (40.6)	713 (53.2)
Yes	491 (35.6)	432 (32.3)
I don’t know/can’t remember	328 (23.8)	194 (14.5)
Missing	2	2
How difficult is it to understand written health information?		
Very easy	420 (30.5)	532 (39.9)
Not very easy[d]	875 (63.5)	755 (56.6)
Other[e]	83 (6.0)	48 (3.6)
Missing	3	6
Have you ever had the HPV vaccine?		
Yes	492 (35.6)	336 (25.1)
No/I don’t know	889 (64.4)	1005 (74.9)
Questions asked only of those who had already been vaccinated (*N* = 828)	*N* = 492	*N* = 336
How many shots of the HPV vaccine have you had?[f]		

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1 shot	45 (9.1)	38 (11.3)
2 shots	197 (40.0)	157 (46.7)
3 or more shots	123 (25.0)	71 (21.1)
At least 1 shot, but I don't know	37 (7.5)	16 (4.8)
At least 2 shots, but I don't know	56 (11.4)	26 (7.7)
I don't know	34 (6.9)	28 (8.3)
Missing	0	0
At what age did you receive the first shot of the HPV vaccine series?		
≤14 years	258 (52.7)	83 (24.8)
15–17 years	96 (19.6)	44 (13.1)
18–26 years	106 (21.6)	105 (31.3)
27–45 years	-	83 (24.8)
Don't know/not sure	30 (6.1)	20 (6.0)
Missing	2	1
Questions asked only of those who were unvaccinated or unsure of their vaccination status (*N* = 1894)	*n* = 889	*n* = 1005
How likely is it that you'll get the HPV vaccine in the next year?		
Very unlikely	210 (23.8)	238 (23.9)
Somewhat unlikely	101 (11.4)	116 (11.7)
A little unlikely	91 (10.3)	67 (6.7)
Neither unlikely nor likely	265 (30.0)	254 (25.5)
A little likely	111 (12.6)	115 (11.6)
Somewhat likely	64 (7.2)	124 (12.5)
Very likely	41 (4.6)	81 (8.1)
Missing	6	10

Continuous variables	**Mean (SD)** **Observed range**	**Mean (SD)** **Observed range**
HPV vaccine knowledge (total score)	4.10 (3.1)	4.6 (3.0)
	0–11	0–11
Perceived risk (average score)	2.67 (1.2)	3.03 (1.4)
	1–7	1–7
Perceived barriers (average score)	2.2 (0.9)	2.36 (0.92)

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	1–4	1–4
Self-efficacy (average score)	3.68 (0.7)	3.93 (0.7)
	1–5	1–5
Attitudes (average score)	3.29 (0.6)	3.3 (0.6)
	1–5	1–5
Descriptive norms (%)	46 (23.3)	44 (24.2)
	0–100	0–100

Note: Data are presented as *n* (%) except where noted otherwise. Abbreviation: HPV, human papillomavirus.

[a] Includes American Indian or Alaska Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, other Asian, Native Hawaiian, Guamanian or Chamorro, Samoan, other Pacific Islander, and none of these.

[b] Includes divorced, widowed, separated, dating exclusively, dating not exclusively, not currently dating, and never been married.

[c] Includes gay or lesbian, bisexual, other not listed but specified in a textbox.

[d] Includes somewhat easy, somewhat difficult, and very difficult.

[e] Includes I don’t look for health information, I don’t know/not sure, I prefer not to answer.

[f] Quantities may not add up to 100 because of rounding.

TABLE 3

Multivariable logistic regression examining the association between self-reported HPV vaccination uptake and behavioral, demographic and health care experience determinants among individuals aged 18–26 and 27–45 years

	18–26 year cohort (*N* = 1337)			27–45 year cohort (*N* = 1269)		
Variable	**OR (95% CI)**	**OR *p***	**Overall *p***	**OR (95% CI)**	**OR *p***	**Overall *p***
HPV vaccine knowledge	1.27 (1.19–1.36)	<.001	<.001	1.13 (1.05–1.21)	.001	.001
Perceived risk	1.19 (1.03–1.37)	.016	.016	1.16 (1.02–1.33)	.024	.024
Perceived barriers	0.62 (0.50–0.77)	<.001	<.001	-	-	-
Perceived self-efficacy	0.45 (0.35–0.58)	<.001	<.001	0.48 (0.36–0.64)	<.001	<.001
HPV vaccine attitudes	2.40 (1.70–3.40)	<.001	<.001	1.46 (1.06–2.02)	.022	.022
Descriptive norms	1.03 (1.02–1.04)	<.001	<.001	1.02 (1.02–1.03)	<.001	<.001
Provider recommendation						
No	Ref		<.001	Ref		<.001
Yes	11.63 (7.70–17.56)	<.001		14.26 (9.52–21.38)	<.001	
Don’t know/can’t remember	2.56 (1.63–4.01)	<.001		1.59 (0.90–2.83)	.113	
Parent born outside of the United States			.006			.011
No	Ref			Ref		
Yes	1.65 (1.15–2.36)	.006		1.77 (1.14–2.73)	.011	
Receipt of flu shot in past 12 months			.041			
No	Ref			-		
Yes	1.42 (1.02–2.00)	.041		-		
Receipt of tetanus shot ≤10 years			.069			.050
No	Ref			Ref		
Yes	1.51 (1.03–2.21)	.035		1.58 (1.08–2.32)	.019	
Don’t know/not sure	1.01 (0.58–1.76)	.980		1.66 (0.86–3.23)	.133	
Ever had a Pap test			<.001			<.001
No	Ref			Ref		
Yes	2.73 (1.73–4.31)	<.001		3.19 (1.73–5.89)	<.001	
Don’t know/not sure	1.26 (0.45–3.58)	.659		2.71 (0.76–9.63)	.124	
Not applicable	1.30 (0.87–1.94)	.198		1.61 (0.88–2.95)	.120	

Variable	18–26 year cohort (*N* = 1337)			27–45 year cohort (*N* = 1269)		
	OR (95% CI)	**OR *p***	**Overall *p***	**OR (95% CI)**	**OR *p***	**Overall *p***
Has heard of HPV from information sources			.030			
No	Ref			-		
Yes	1.48 (1.04–2.10)	.030		-		
Annual income						.032
$0–$19,999	-			0.24 (0.10–0.58)	.002	
$20,000–$49,999	-			0.72 (0.43–1.20)	.212	
$50,000–$74,999	-			0.77 (0.48–1.24)	.288	
$75,000–$99,999	-			0.68 (0.41–1.13)	.134	
$100,000 or more	-			Ref		
Employment status						.042
Employed	-			Ref		
Unemployed	-			1.68 (0.82–3.46)	.156	
Other[a]	-			0.47 (0.22–1.03)	.059	
Sexual orientation	-					.017
Heterosexual/straight	-			Ref		
Other [b]				1.87 (1.12–3.11)	.017	
Have health insurance	-					.051
No	-			Ref		
Yes				1.82 (1.00–3.31)	.051	

Abbreviations: HPV, human papillomavirus; OR, odds ratio; Pap, Papanicolaou.

[a]Includes homemaker/full-time parent, student, retired, disabled/unable to work, and other specified in a textbox.

[b]Includes gay or lesbian, bisexual, other not listed but specified in a textbox.

TABLE 4

Multivariable ordered logistic regression examining the association between intentions to obtain the HPV vaccination and behavioral, demographic and health care experience determinants among individuals aged 18–26 and 27–45 years

	18–26 cohort (*N* = 863)			**27–45 cohort (*N* = 983)**		
Variable	**OR (95% CI)**	***p***	**Overall *p***	**OR (95% CI)**	***p***	**Overall *p***
HPV vaccine knowledge	0.93 (0.89–0.98)	.003	.003	0.89 (0.85–0.93)	<.001	<.001
Perceived risk	1.74 (1.56–1.94)	<.001	<.001	1.40 (1.27–1.55)	<.001	<.001
Perceived barriers	-			1.19 (1.04–1.36)	.011	.011
Perceived self-efficacy	-			1.48 (1.23–1.78)	<.001	<.001
HPV vaccine attitudes	2.45 (1.91–3.15)	<.001	<.001	2.19 (1.72–2.78)	<.001	<.001
Descriptive norms	1.01 (1.00–1.01)	.050	.050	1.02 (1.01–1.03)	<.001	<.001
Provider recommendation			<.001			<.001
No	Ref			Ref		
Yes	1.97 (1.38–2.83)	<.001		1.82 (1.31–2.52)	<.001	
Don’t know/can’t remember	1.38 (1.03– 1.84)	.029		1.60 (1.17–2.18)	.003	
Race			.014			
White	Ref			-		
Black/African American	1.66 (1.16–2.36)	.005		-		
Other [a]	0.97 (0.73–1.30)	0.859		-		
Educational attainment						.010
High school or less	-			Ref		
Some college/associate’s degree	-			0.87 (0.61–1.23)	.418	
Bachelor’s degree	-			1.10 (0.79–1.55)	.570	
Graduate school	-			1.54 (1.06–2.23)	.024	
Receipt of flu shot in past 12 months			<.001	-		
Yes	1.68 (1.30–2.17)	<.001		-		
No	Ref					
Difficulty understanding health information			.008			
Not very easy [b]	Ref			-		
Very easy	1.54 (1.17–2.02)	.002		-		

Variable	18–26 cohort (*N* = 863)			27–45 cohort (*N* = 983)		
	OR (95% CI)	*p*	Overall *p*	OR (95% CI)	*p*	Overall *p*
Other [c]	0.94 (0.59–1.51)	.801		-		
Ever had a Pap test						<.001
No	-			Ref		
Yes	-			0.56 (0.38–0.80)	.002	
Don’t know/Not sure	-			0.79 (0.34–1.84)	.576	
Not applicable [d]	-			1.08 (0.75–1.54)	.687	
Has heard of HPV from information sources						.003
No	-			Ref		
Yes	-			1.50 (1.16–1.96)	.003	

Abbreviations: HPV, human papillomavirus; Pap, Papanicolaou.

[a] Includes American Indian or Alaska Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, other Asian, Native Hawaiian, Guamanian or Chamorro, Samoan, other Pacific Islander, and none of these.

[b] Includes somewhat easy, somewhat difficult, and very difficult.

[c] Includes I don’t look for health information, I don’t know/not sure, I prefer not to answer.

[d] Includes male sex at birth.