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Predictors of HPV vaccination in the southern US: A survey of caregivers from 13 states

Lavanya Vasudevan, Ph.D., M.P.H., C.P.H.[a,b,*], **Jan Ostermann, Ph.D.**[b,c,d], **Yunfei Wang, Dr.P.H.**[e], **Sayward E. Harrison, Ph.D., M.A., C.A.S.**[d,f], **Valerie Yelverton, M.Sc.**[c], **Jodi-Ann McDonald, B.S.**[e], **Laura J. Fish, Ph.D.**[a,g], **Charnetta Williams, M.D.**[h], **Emmanuel B. Walter, M.D., M.P.H.**[b,e,i]

[a]Department of Family Medicine and Community Health, Duke University School of Medicine, 2200 W. Main Street, Suite 600, Durham, NC 27705, USA.

[b]Duke Global Health Institute, 310 Trent Dr, Durham, NC 27710, USA

[c]Department of Health Services Policy & Management, 915 Greene Street, University of South Carolina, Columbia, SC 29208, USA

[d]South Carolina Smart State Center for Healthcare Quality, University of South Carolina, 915 Greene Street, Columbia, SC 29208, USA

[e]Duke Vaccine and Trials Unit, Duke Human Vaccine Institute, 2608 Erwin Road, Suite 210, Durham, NC 27705, USA

[f]Department of Psychology, University of South Carolina, 1512 Pendleton Street, Barnwell College, Suite #220, Columbia, SC 29208, USA

[g]Duke Cancer Institute, 2424 Erwin Rd, Suite 602, Durham, NC 27710, USA

[h]Immunization Services Division, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention (CDC), 1600 Clifton Road, Atlanta, GA 30329, USA

[i]Department of Pediatrics, Duke University School of Medicine, Box 3675, DUMC, Durham, NC 27710, USA

Abstract

Background and objectives: Despite a high burden of human papillomavirus (HPV)-attributable cancers, the southern US lags other regions in HPV vaccination coverage. This study sought to characterize and contextualize predictors of HPV vaccination in the southern US.

Methods: From December 2019 – January 2020, parents of adolescents (ages 9–17 years) living in thirteen southern US states were recruited from a nationally-representative online survey panel and completed a cross-sectional survey. The primary study outcome was initiation of HPV vaccination.

Results: Of 1,105 parents who responded to the survey, most were ≥35 years of age and of female gender. HPV vaccination initiation was reported only among 37.3% of adolescents and

[*]**Address correspondence to:** Lavanya Vasudevan; 2200 W. Main Street, Suite 600, Durham, NC 27710. Phone: +19196131423; lavanya.vasudevan@duke.edu.

was highest at age 12. Cumulative HPV vaccination coverage was highest at age 15 (60%) but lower than coverage for tetanus-diphtheria-acellular pertussis (Tdap, 79.3%) and Meningococcal vaccines (MenACWY, 67.3%). Provider recommendation was strongly associated with higher odds of HPV vaccination (aOR: 49.9, 95%CI: 23.1–107.5). In alternative predictive models, home/online (vs. public) schooling and parents' working status were associated with lower odds of vaccination; health care visits in the past 12 months and shorter travel times to adolescents' usual health care provider were associated with greater odds of vaccination.

Conclusions: Our findings suggest missed opportunities for HPV vaccination in the southern US and support strengthening provider recommendation for on-time initiation of HPV vaccination among adolescents. Other strategies to increase HPV vaccinations may include encouraging co-administration with other adolescent vaccines, increasing vaccine access, and promoting vaccinations for home/online-school students.

Keywords

Human Papillomavirus; Immunization; Adolescents; Southern United States; Provider recommendation

INTRODUCTION

In the United States (US), approximately 44,000 cancer cases are attributed annually to human papillomavirus (HPV) infection.[1] Vaccinations against HPV are known to prevent 92% of HPV-related cancers, including almost all cases of cervical cancer, other anogenital cancers, and oropharyngeal cancer.[2,3] Half of all HPV infections are estimated to occur between the ages of 15–24 years; hence, initiating vaccination in early adolescence is critical in order to prompt an immune response prior to sexual debut.[4] The Advisory Committee on Immunization Practices (ACIP) recommends two doses of the HPV vaccine for adolescents ages 11–12 years, and vaccinations may be initiated as early as age 9 years.[5] Three doses of the HPV vaccine are required to achieve full protection if vaccination is initiated at ≥15 years of age.[5] Despite the availability of an effective vaccine, only 1 in 2 US adolescents is fully vaccinated against HPV.[6] Identifying and mitigating missed opportunities for HPV vaccination is critical for reducing the burden of HPV-attributable cancers in the US.

Some of the highest burden of HPV-attributable cancers in the US is in the southern states, thus highlighting a critical need for high HPV vaccination coverage in the region.[7,8] At present, regions 4 and 6, comprising the southern US, rank the lowest in HPV vaccination coverage in the US.[9] Identifying region-specific barriers may help with adaptation of existing evidence-based interventions to promote HPV vaccinations in the southern US. Known barriers to HPV vaccination include structural and systems-level factors, caregiver and adolescent factors (e.g., socio-demographic factors, HPV knowledge, attitudes towards vaccination), and adherence factors (i.e., for completion of multi-dose series).[10] Data from the 2019 National Immunization Survey-Teen (NIS-Teen), a principal source of information on immunization coverage among teens at the national and regional levels, highlight disparities in HPV vaccination based on race, ethnicity, socio-economic status (SES), health insurance status, and rural/urban residence.[6] However, the NIS-Teen survey is limited to adolescents who are 13–17 years of age and past the ACIP-recommended age

for vaccination initiation. Additionally, it relies on adolescents' medical providers for most data on vaccinations, yet many of the barriers to HPV vaccination correlate with a lack of a consistent medical provider.[11,12] To identify predictors of HPV vaccination, we need data from household surveys that include HPV vaccine-eligible adolescents who are younger than 13 years of age, irrespective of their access to a consistent medical provider.

As part of a study to characterize and address disparities in HPV vaccination in the southern US, we conducted a cross-sectional survey of caregivers in 13 southern states to assess HPV vaccination among adolescents (ages 9–17 years), factors associated with HPV vaccination, and reasons for non-vaccination. The study methodology and findings are presented below.

METHODS

The methods of this study are reported in accordance with the *STrengthening the Reporting of OBservational studies in Epidemiology (STROBE)*[13] statement for cross-sectional studies (Supplementary Table 1).

Ethical approval

The study protocol was approved by the Duke University Health System's (DUHS) Institutional Review Board (Pro00101137), and the University of South Carolina's Institutional Review Board (Authorization agreement for reliance on DUHS IRB; Pro00085811). Since the Centers for Disease Control and Prevention (CDC) only had access to de-identified data, it was determined that the CDC was not engaged in human subjects research and CDC's IRB approval was not required.

Study design and setting

From December 2019 – January 2020, caregivers (i.e., parents and legal guardians) of adolescents (ages 9–17 years) residing in 13 southern states comprising US regions 4 and 6 were recruited through an established and nationally-representative online survey panel. Adolescent vaccine requirements in the 13 states are summarized in Supplementary Table 2. Notably, the HPV vaccine was not required for public school enrollment in any of these states at the time of our survey.

Sampling frame

The sampling frame comprised members of a large online survey panel of US households, which has been widely used to derive nationally-representative estimates of patient perceptions and health outcomes, including those associated with vaccinations.[14–20] The online survey panel uses address-based sampling to recruit members; the sampling frame is the universe of all US residential addresses, secured from the latest Delivery Sequence File of the US Postal Service, regardless of telephone or internet connectivity. To minimize sampling bias, enrolled households without internet access are provided complementary tablets or laptop computers and internet access for survey participation. Geographic and demographic variables are used for weighting the online survey panel samples to ensure they are representative of the US population.

Study eligibility and recruitment

Electronic survey links were sent to the online survey panel members who were:

- of age 18 years or older;
- residing in one of 13 states in US regions 4 and 6 - Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, New Mexico, North Carolina; Oklahoma, South Carolina, Tennessee, and Texas;
- a parent or legal guardian of an adolescent between 9–17 years of age;
- English language survey takers.

Invited members were pre-screened to determine study eligibility. An implied consent script, presented at the beginning of the survey, communicated the survey purpose and contact information of the Principal Investigator. Responses to all survey questions beyond an eligibility screen were optional. Panel members self-administered the survey electronically using an online survey platform. Recruitment continued until the sample size target was reached.

Variables

The survey included questions about socio-demographic characteristics of the members and their adolescent children, adolescents' vaccination status, access to healthcare providers, and barriers to HPV vaccine uptake. The primary outcome was the receipt of ≥1 dose of the HPV vaccine (i.e., HPV vaccination initiation). The full list of survey variables and response options described in this manuscript is presented in Supplementary Table 3.

Data sources/Measurement

When responding to survey questions, participating panel members (henceforth "caregivers") were asked to refer to their child who was between the ages of 9 – 17 years (henceforth "adolescents") and who had the most recent birthday at the time of the survey. Data on socio-demographic characteristics of participating members were provided by the online survey panel company. All other data presented in this analysis reflect caregivers' responses to the survey.

Bias

Geo-demographically calibrated weights were used to control for sampling biases resulting from non-response, and to ensure that findings are representative of all households with adolescents ages 9–17 in the 13 southern states.

Sample size and justification

The target sample size of 1000 parents was based on the availability of eligible survey panel households in the 13 states and anticipated response rates.

Statistical methods

Survey data were analyzed using SAS 9.4 (SAS Institute, Cary, NC) with bivariable and multivariable survey-analytic regression methods.

All quantitative variables were treated either as categorical or interval variables; categories and intervals presented in this manuscript maximize comparability with NIS-Teen while accounting for the distribution of responses in the sample. Receipt of ≥1 dose of the HPV vaccine ("yes" vs. "no") was the primary dependent variable. Parametric ($\chi 2$) tests were used to compare weighted differences in this outcome variable by diverse characteristics of survey respondents and their adolescents.

Weighted multivariable logistic regression models assessed correlations between the primary dependent variable and characteristics of parents and adolescents. Survey weights were used in all analyses to ensure that results are statistically representative of the target population. Clustering at the state level accounted for error correlation within states. Missing values were grouped with other response categories or excluded from the analysis (Supplementary Table 3). Odds ratios and 95% confidence intervals describe the extent to which differences in vaccination rates were associated with systematic variation in covariates; p-values <0.05 were considered statistically significant.

RESULTS

Of 2,262 sampled online panel members, 1,250 (55.2%) opted-in to the survey. After excluding 71 ineligible respondents and 74 incomplete responses, the analysis cohort comprised 1,105 caregivers. Table 1 summarizes the characteristics of caregivers and their adolescents aged 9–17 years, stratified by adolescent's HPV vaccination status. Detailed descriptive statistics are presented in Supplementary Tables 4 and 5. Only 368 (37.3%) caregivers reported that their adolescent ever received the HPV vaccine. HPV vaccine uptake was lower among younger adolescents (9–12 years, 15.5%) compared to older adolescents (13–17 years; 54.2%). A majority of caregivers were parents, ages 35 years or older and of female gender. The HPV vaccination status of adolescents did not differ significantly by adolescents' gender or race and ethnicity. Differences in HPV vaccination status were noted by rural vs. urban residence, and the adolescents' type of school.

Patterns of vaccine uptake and decision-making are presented in Table 2. Adolescents who had received the HPV vaccine also reported higher rates of vaccination for Tdap, MenACWY, and the influenza vaccine. Among the adolescents who had received the HPV vaccine, most (75.5%) received the first dose between ages 11–14 years. Among the adolescents who initiated HPV vaccination, 70.5% had completed all recommended doses. A breakdown of vaccination rates by state is presented in Supplementary Table 6. In all states, gaps in HPV vaccination coverage persisted compared with vaccination coverage with Tdap, MenACWY and the influenza vaccine. The coverage of HPV vaccination by age is shown in Figure 1. Highest initiation was seen at age 12 years and first-dose coverage appeared to plateau by age 14 years.

Caregivers cited healthcare provider recommendation (61.1%) more often than personal preference (i.e., "I wanted it"; 31.5%) as the primary reason for HPV vaccination. Fewer than half the adolescents (41.9%) were involved in the decision to get the HPV vaccine. Compared to caregivers of partially vaccinated adolescents, more caregivers with unvaccinated adolescents reported that their adolescent was somewhat likely or very likely to

get an/another dose of the HPV vaccine in the next 12 months. Reasons for not vaccinating varied as shown in Table 2. Caregivers with partially vaccinated adolescents were more likely to cite medical reasons (10.7%), financial concerns (4.6%), and low access to health providers (1.6%) whereas caregivers with unvaccinated adolescents were more likely to report concerns about the HPV vaccine (20.6%), personal beliefs against vaccines (6.8%), and a perceived lack of need for HPV vaccination (33.1%).

A majority of the caregivers identified healthcare providers as the most trusted resource on HPV vaccination. Only a few caregivers mentioned resources such as social media, websites/blogs, and family members as sources of HPV information. Although the overall percentage of caregivers who reported seeking vaccination exemptions was small (n=41, 4.3%), more caregivers with unvaccinated adolescents reported having sought religious or philosophical exemptions from daycare or school vaccination requirements.

Responses related to healthcare provider access and recommendations for HPV vaccination are summarized in Table 3 and Supplementary Table 5. Compared to caregivers of unvaccinated adolescents (84.8%), more caregivers of vaccinated adolescents (92.2%) reported that their child had visited a healthcare provider in the last year. The doctor's office was the most common location for care-seeking by both groups (94.1% among vaccinated adolescents and 91.4% among unvaccinated adolescents), although caregivers of unvaccinated adolescents reported slightly higher use of urgent care (3.96% compared with 0.7% in vaccinated adolescents). Adolescents were most likely to see a pediatrician compared to other provider types (Supplementary Table 5). Most caregivers reported spending <15 minutes to travel to their adolescent's primary healthcare provider; however, more caregivers of unvaccinated adolescents reported longer travel times compared to those with vaccinated adolescents. In both groups, private health insurance was most common, followed by public insurance. Most caregivers of vaccinated adolescents (86.8%) reported speaking with a healthcare provider about the HPV vaccine and receiving a recommendation (94.6%) for their adolescent to receive the vaccine. In contrast, only a quarter of caregivers of unvaccinated adolescents reported having had a conversation with a provider or receiving a provider recommendation for the vaccine.

Table 4 shows the results of three regression models predicting HPV vaccination status among adolescents aged 9–17 years. Model 1 describes demographic and socioeconomic correlates of HPV vaccination: higher age of adolescents was associated with increased odds of HPV vaccination, whereas having caregivers who were currently working, and adolescents' home/online schooling were associated with lower odds of HPV vaccination. Model 2 describes health care access: adolescents who visited a healthcare provider in the past 12 months and those able to reach their healthcare provider in <15 minutes had greater odds of HPV vaccination. Model 3 represents a prediction model that retains demographic characteristics, significant correlates from models 1 and 2, and provider recommendations for HPV vaccination. In this model, provider recommendation was strongly associated with increased odds of HPV vaccination.

DISCUSSION

Improving adolescent HPV vaccination rates is critical for reducing the burden of HPV-attributable cancers in the southern US. In our study, the reported coverage of ≥1 dose of the HPV vaccine among adolescents (9–17 years) was only 37.3%. Among adolescents ages 13–17, the coverage estimate of 54.2% is comparable to 2019 NIS-Teen household reports for the same geographic area (55%); however, these rates remain far below the HealthyPeople2030 goal of 80% coverage.[6] The HPV vaccination rate lags significantly behind rates of Tdap (90%), MenACWY (83.2%), and seasonal influenza vaccinations (54.2%) in our survey, consistent with data from NIS-Teen.[6] Combined with our finding that 88% of adolescents had a healthcare provider visit in the past year, our findings suggest substantial missed opportunities for HPV vaccination among adolescents in the southern US.

The strongest predictor of HPV vaccination in our study was provider recommendation for the vaccine. This finding is consistent with recent data from NIS-Teen, as well as other publications in the literature.[7,21–29] A previous study reported lower rates of provider recommendation for adolescents living in the southern US.[30] In our study, overall only 46% of caregivers reported having received a provider recommendation for the HPV vaccine. This lower rate compared to the NIS-Teen data (69%) is reflective of the younger age groups of adolescents included in our survey – 63% of adolescents ages 13–17 had received a provider recommendation. Since HPV vaccination initiation plateaus by age 14 years, future efforts might focus on improving provider recommendations for initiating HPV vaccinations on time at ages 11–12 years. Such a strategy may also help to address low rates of vaccination completion, as younger adolescents are more likely to have annual wellness visits, thus providing additional opportunities for vaccinations prior to initial exposure to HPV.

In previous studies, health insurance coverage was a key predictor of HPV vaccination status.[6] In our study, arguably due to a small number of uninsured adolescents in the sample, the association between insurance coverage and HPV vaccination was not statistically significant at conventional levels. Proximity to a health provider and a recent healthcare visit increased the odds of HPV vaccination, while having working parents was associated with reduced odds of HPV vaccination. Adolescents' insurance coverage, healthcare access, and use of health services are correlated with sociodemographic variables and provider recommendations, and should thus be considered jointly when developing policies for improving HPV vaccinations in the southern US. Another interesting finding of our study is with respect to reasons for non-vaccination. Interventions for promoting HPV vaccination initiation may need to focus on correcting misconceptions, improving vaccination beliefs, and reinforcing the need for vaccinations, whereas reducing access barriers may be more important for HPV vaccination series completion. Given the diversity of barriers to HPV vaccination, coordinated interventions with multiple targets (e.g., individual, provider, and systems-level), such as those identified by the Community Preventive Services Task Force, should be considered for reducing vaccination disparities in the southern US.[31,32]

Our findings indicate lower odds of HPV vaccination among adolescents attending home or online school compared to public school. This finding may reflect missed opportunities

for reaching adolescents outside the public school system with vaccination services, and may gain additional relevance following COVID-19 related shifts toward online and home schooling. Since many public school systems are equipped with school nurses and school health programs, these resources may be tapped to expand HPV vaccine coverage in areas with lower healthcare access (e.g., lack of public transportation, long distance to providers). Policy amendments by the Department of Health and Human Services to allow pharmacies to provide routine immunizations to children younger than 18 during the COVID-19 pandemic may help reduce barriers to vaccinations, especially in rural areas where vaccine access may be an issue.[33] Notably, none of the 13 states in our study mandate HPV vaccination for school entry. Public education-linked mandates for Tdap, MenACWY, and HPV, where implemented, have been highly effective at increasing uptake of those vaccines and merit attention from the research and policy communities.[34]

Strengths and Limitations

This study has several strengths: Our study identifies predictors of HPV vaccination across 13 states in the southern US. By doing so, our study highlights several key disparities in adolescent HPV vaccination rates and contextualizes the landscape of HPV vaccination in the southern US. A fifth of our survey respondents resided in rural areas, underscoring the relevance of our study findings to the southern US. Another strength of the study is the expanded age range of adolescents (9–17 years) compared to other surveys. Our findings provide important context and data in light of ACIP guidelines that enable HPV vaccination to begin as early as age 9 years.

Our study is subject to several limitations. First, adolescents' HPV vaccination status was caregiver-reported, and thus subject to recall bias.[35,36] This approach was selected because many rural adolescents do not have a medical home, and use of provider-reported data would thus have disproportionately omitted data from rural respondents.[6,11,12] Some caregivers, especially fathers, did not know the HPV vaccination status of their adolescent. Since we did not verify receipt of vaccines with official immunization records, we were unable to reclassify responses where the vaccination status was unknown. To minimize recall bias, we excluded don't know and missing responses from the analysis. Future research is needed to better understand fathers' knowledge and beliefs about the HPV vaccine in order to effectively engage them in HPV vaccine decision making for their children. Second, covariates such as insurance coverage, schooling, and characteristics of health providers were collected at a single point in time; these covariates may change over time or may have been different at the time of the vaccination decision. Third, our study excluded non-English language survey takers, though our sample was diverse in terms of race/ethnicity, with more than one quarter of parents reporting Hispanic ethnicity. Finally, limitations that apply to all studies involving surveys include selection bias and self-reported measures of eligibility. As described in the methods, use of Address-Based Sampling to generate online survey panel as well as application of post-hoc, geo-demographically-calibrated survey weights mitigate this limitation.

CONCLUSIONS

Rates of HPV vaccination in the southern US are lower than the national average as well as rates of other adolescent vaccinations. Our findings suggest that older adolescents are less likely to initiate HPV vaccination. Hence, increasing provider recommendation for on-time initiation of HPV vaccination may be an effective strategy in the southern US. Other strategies may include encouraging co-administration of HPV vaccinations with other adolescent vaccines, removing access barriers (e.g., via strengthening community-based vaccination sites such as schools), and promoting vaccinations for online/home-school students.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Declaration of interests

Dr. Walter is an investigator for Pfizer vaccine studies, an unfunded co-investigator for a Moderna vaccine study, and a member of an advisory board for Vaxcyte. All other authors have no conflicts of interests to declare.
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The Centers for Disease Control and Prevention provided input on the study design, interpretation of data, manuscript preparation, and the decision to submit the manuscript for publication but was not directly involved in data collection and analysis.

Abbreviations

ACIP	Advisory Committee on Immunization Practices
aOR	Adjusted odds ratio
CDC	Centers for Disease Control and Prevention
DUHS	Duke University Health System
EMR	Electronic medical record

HPV	Human papillomavirus
IRB	Institutional Review Board
MenACWY	Meningococcal serogroup A,C,W,Y
NIS-Teen	National Immunization Survey-Teen
SES	Socio-economic status
STROBE	Strengthening the Reporting of Observational studies in Epidemiology
Tdap	Tetanus-diphtheria-acellular pertussis
US	United States
VFC	Vaccines for Children

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HIGHLIGHTS

- Southern adolescents have the lowest HPV vaccination coverage in the US.
- HPV vaccination reported in 37.3% of adolescents, with highest initiation at 12 years.
- Compared with other adolescent vaccinations, uptake of HPV vaccination is lower.
- Strengthening provider recommendation may improve on-time HPV vaccination.

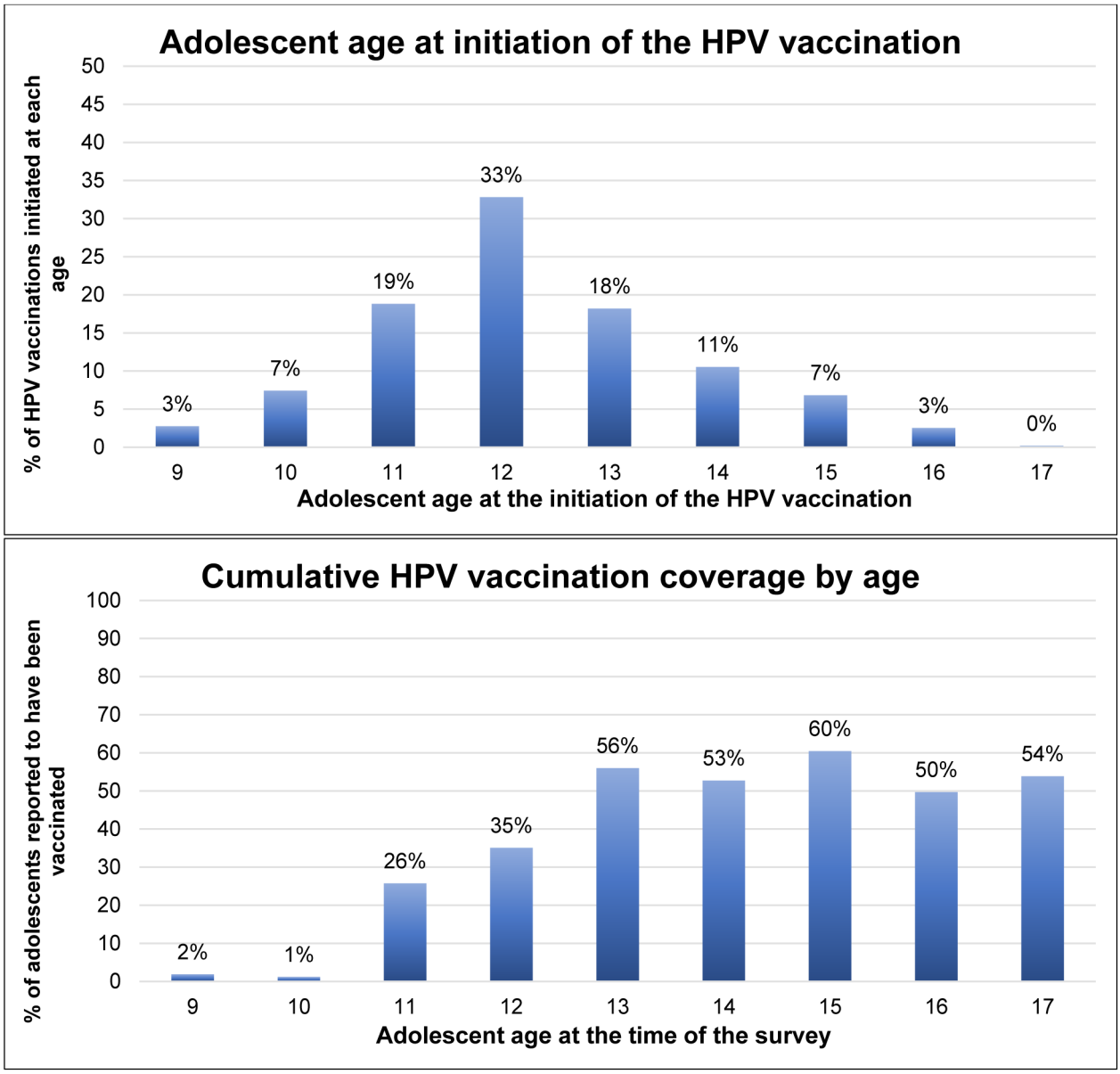

Figure 1:
HPV vaccination initiation and cumulative coverage by adolescents' age

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Table 1:

Characteristics of caregivers and their adolescent aged 9–17 years (N=987).

Covariate	Level	Has your adolescent ever received the HPV vaccine? Yes N=368	No N=619	Parametric P-value[a]
Characteristics of caregivers				
Residence[b]	Urban	308 (83.65)	486 (78.48)	**0.05**
	Rural	60 (16.35)	133 (21.52)	
Education	Bachelor's degree or higher	125 (33.88)	202 (32.66)	0.70
	Less than Bachelor's degree	243 (66.12)	417 (67.34)	
Currently working	Yes	284 (77.31)	508 (82.11)	0.07
	No/Don't know	83 (22.69)	111 (17.89)	
Attends religious services	Ever	267 (72.5)	478 (77.17)	0.10
	Never	101 (27.5)	141 (22.83)	
Characteristics of adolescents aged 9–17 years				
Age	9 to 10 years	3 (0.93)	224 (36.17)	**<.001**
	11 years	25 (6.82)	73 (11.72)	
	12 years	37 (9.93)	67 (10.83)	
	13–14 years	122 (33.23)	103 (16.56)	
	15–17 years	181 (49.1)	153 (24.73)	
Gender	Male	182 (49.51)	310 (50.12)	0.85
	Female	186 (50.49)	309 (49.88)	
Race and ethnicity	Non-Hispanic Black or African American	60 (16.39)	96 (15.57)	0.30
	Non-Hispanic White	153 (41.56)	279 (45.08)	
	Hispanic	120 (32.57)	171 (27.64)	
	Other	35 (9.48)	72 (11.7)	
Type of school	Public school	315 (85.69)	493 (79.58)	**<.001**
	Home/Online school	10 (2.83)	70 (11.37)	
	Other school	42 (11.48)	56 (9.05)	

Abbreviations: HPV, Human Papillomavirus

Number of observations may not add up to 987 due to missing values on HPV vaccination status or other variable of interest. Percentage values for some responses may not add up to 100 due to rounding.

Recoded variables are documented in Supplementary Table 3.

[a]The parametric p-value is calculated by chi-square test.

[b]Rural-urban residence status was assigned based on Census definition: https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html. For 66 records with zip codes in non-residential areas, rural-urban designation was based on the USDA FIPS code: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx.

Table 2:

Patterns of vaccine uptake and decision-making for adolescents aged 9–17 years (n=987).

Covariate	Level	Has your adolescent ever received the HPV vaccine?		Parametric P-value[a]
		Yes N=368	No N=619	
Since age 11, has your adolescent received any of the following vaccines? - Tdap vaccine (tetanus, diphtheria or pertussis/whooping cough)	Yes	306 (94.26)	303 (86.09)	**<.001**
	No	19 (5.74)	49 (13.91)	
Since age 11, has your adolescent received any of the following vaccines? - Meningococcal (meningitis) vaccine	Yes	265 (90.98)	252 (76.35)	**<.001**
	No	26 (9.02)	78 (23.65)	
Did your adolescent receive the seasonal flu vaccine during the last flu season (2018/19)?	Yes	240 (65.48)	283 (47.29)	**<.001**
	No	127 (34.52)	315 (52.71)	
At what age did your adolescent receive the first dose of the HPV vaccine?	9 – 10 years	35 (9.63)	-- [b]	
	11 – 14 years	278 (75.49)	--	
	15 −17 years	33 (8.94)	--	
	Don’t know	22 (5.94)	--	
What made you decide to vaccinate?	Health provider recommended it	225 (61.12)	-- [b]	
	I wanted it	116 (31.51)	--	
	Other	27 (7.37)	--	
Was your adolescent involved in the decision to get or not get the HPV vaccine?	Yes	154 (41.89)	-- [b]	
	No/ Don’t know	214 (58.11)	--	
How many dose(s) of the HPV vaccine has your adolescent received so far?	1	70 (18.95)	-- [b]	
	2	140 (37.97)	--	
	3	123 (33.53)		
	Don’t know	35 (9.54)		
As far as you know, has your adolescent completed all recommended doses of the HPV vaccination?	Yes	259 (70.53)	-- [b]	
	No/ Don’t know	108 (29.47)	--	
How likely is it that your adolescent will receive an/another HPV vaccine dose in the next 12 months?[c]	Not likely at all	45 (41.4)	61 (9.93)	**<.001**
	Not very likely	16 (14.83)	90 (14.46)	
	Somewhat likely	1 (0.99)	101 (16.38)	
	Very likely	9 (8.26)	205 (33.09)	

Covariate	Level	Has your adolescent ever received the HPV vaccine? Yes N=368	No N=619	Parametric P-value[a]
	Not sure	38 (34.51)	162 (26.14)	
What are the reasons why your adolescent will not receive the HPV vaccine in the next 12 months?[d]	Medical reasons (e.g., illness, allergy or pregnancy)	5 (10.66)	3 (0.71)	**<.001**
	Financial concerns	2 (4.59)	4 (0.91)	
	Access to health care provider	1 (1.59)	5 (1.03)	
	Concern about the HPV vaccine	1 (1.24)	96 (20.55)	
	Personal beliefs	0 (0.79)	32 (6.78)	
	Adolescent does not need the vaccine	8 (16.83)	155 (33.08)	
	Other reason	9 (20.14)	78 (16.74)	
	Don’t know	20 (44.16)	95 (20.19)	
Which of the following is your most trusted source of information about vaccines?	Health Provider/Other Medical Professional	313 (86.98)	458 (75.94)	**<.001**
	Non-medically trained family member/friend	2 (0.61)	10 (1.6)	
	Government websites (e.g., cdc.gov, vaccines.gov)	11 (3.01)	17 (2.86)	
	Websites of professional medical societies (e.g., American Medical Association, American Pediatrics)	25 (6.82)	77 (12.75)	
	Other Websites/Blogs	6 (1.71)	11 (1.85)	
	Social media (Facebook, Twitter, Instagram etc.)	0 (0.1)	8 (1.25)	
	Other Sources of Info	3 (0.76)	23 (3.74)	
Have you ever sought an exemption from daycare or school requirements for vaccinations?	Yes	11 (3.03)	30 (4.85)	0.17
	No/ Don’t know	357 (96.97)	589 (95.15)	
What was the reason for the exemption?	Religious Only	0 (0)	11 (35.04)	**0.001**
	Philosophical Only	0 (0)	9 (28.64)	
	Medical Only	10 (89.37)	7 (22.74)	
	Other or multiple exemptions	1 (10.63)	4 (13.57)	

Abbreviations: HPV, Human Papillomavirus

Number of observations may not add up to 987 due to missing values on HPV vaccination status or other variable of interest. Percentage values for some responses may not add up to 100 due to rounding.

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Recoded variables are documented in Supplementary Table 3.

[a]The parametric p-value is calculated by chi-square test.

[b]Question was only displayed to participants who reported HPV vaccination for their adolescent.

[c]Question was only displayed to those participants whose adolescent had never received a dose of the HPV vaccine or had not completed all recommended doses.

[d]Question was only displayed to participants who answered “not very likely”, “not likely at all”, or “not sure/don’t know” when asked how likely would their adolescent receive an/another HPV vaccine dose in the next 12 months.

Table 3:

Healthcare provider access for adolescents aged 9–17 years (n=987).

Covariate	Level	Has your adolescent ever received the HPV vaccine?		Parametric P-value *a*
		Yes N=368	No N=619	
Last visit to a health care provider (<1 year ago)	Yes	339 (92.21)	526 (84.89)	**0.001**
	No/ Don't know	29 (7.79)	94 (15.11)	
Where does your adolescent most often go for health care visits?	Doctor's Office	346 (94.08)	566 (91.38)	**0.02**
	Health Department	6 (1.64)	6 (1.04)	
	Hospital based Clinic	4 (1.21)	6 (1.01)	
	School based Clinic	4 (1.09)	0 (0)	
	Urgent care Provider	3 (0.71)	24 (3.96)	
	ER	2 (0.54)	4 (0.65)	
	Pharmacy	0 (0)	3 (0.48)	
	Other	0 (0.08)	1 (0.17)	
	No usual place of care	2 (0.55)	7 (1.11)	
	Don't know	0 (0.1)	1 (0.22)	
Type of usual health care provider	Pediatrician	253 (68.66)	414 (66.81)	0.55
	Other	115 (31.34)	206 (33.19)	
Travel time to usual health care provider	<15 minutes	203 (55.11)	293 (47.3)	**0.02**
	≥15 minutes	165 (44.89)	326 (52.7)	
Health insurance coverage	Public	149 (41.16)	233 (37.65)	0.17
	Private	190 (52.4)	323 (52.16)	
	Other	14 (3.86)	31 (4.98)	
	None	9 (2.58)	32 (5.21)	
Have you ever talked with a health care provider about the HPV vaccine (Gardasil) for your adolescent?	Yes	319 (86.76)	150 (24.15)	**<.001**
	No	49 (13.24)	470 (75.85)	
Has a health care provider ever recommended that your adolescent receive the HPV vaccine?	Yes	348 (94.57)	155 (24.98)	**<.001**
	No/Don't know	20 (5.43)	464 (75.02)	
Has a health care provider ever recommended AGAINST your adolescent receiving the HPV vaccine?	Yes	13 (3.52)	11 (1.74)	0.08
	No/ Don't know	355 (96.48)	608 (98.26)	

Abbreviations: HPV, Human Papillomavirus

Number of observations may not add up to 987 due to missing values on HPV vaccination status or other variable of interest. Percentage values for some responses may not add up to 100 due to rounding.

Recoded variables are documented in Supplementary Table 3.

[a]The parametric p-value is calculated by chi-square test.

Table 4:

Multivariable regression models describing association of socio-economic characteristics and healthcare access with uptake of ≥1 dose of the HPV vaccine among adolescents ages 9–17 years (n=987)

VARIABLES		1. Socio-economic model		2. Healthcare access model		3. Prediction model[a]	
		OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Residence	*Rural*	0.7(0.43,1.15)	0.16	0.77(0.41,1.43)	0.41		
	Urban	Ref		Ref			
Adolescent's race and ethnicity	*Hispanic*	1.17(0.48,2.85)	0.72	1.29(0.57,2.9)	0.54	1.25(0.57,2.74)	0.57
	Non-Hispanic, Black or African American	1.05(0.6,1.84)	0.85	1.01(0.55,1.88)	0.97	1.71(0.76,3.85)	0.19
	Non-Hispanic, Other race	0.74(0.5,1.09)	0.13	0.94(0.59,1.51)	0.81	0.68(0.47,0.99)	**0.04**
	Non-Hispanic, White	Ref		Ref		Ref	
Adolescent's gender	*Female*	1.04(0.76,1.43)	0.79	1.04(0.78,1.39)	0.81	0.7(0.52,0.94)	**0.02**
	Male or other	Ref		Ref		Ref	
Adolescent's age	*In years*	1.47(1.4,1.54)	**<0.001**	1.49(1.42,1.57)	**<0.001**	1.34(1.25,1.43)	**<0.001**
Adolescent's type of school	*Home/Online school*	0.16(0.07,0.37)	**<0.001**			0.13(0.05,0.31)	**<0.001**
	Other school	1(0.56,1.81)	0.99			1.28(0.71,2.3)	0.41
	Public School	Ref				Ref	
Caregivers' education	*Bachelor's degree or higher*	1.26(0.84,1.9)	0.27				
	Less than bachelor's degree	Ref					
Caregiver currently working	*Yes*	0.43(0.2,0.92)	**0.03**			0.34(0.15,0.82)	**0.02**
	No/Don't know	Ref				Ref	
Adolescent's health insurance coverage	*Private health insurance*			0.77(0.51,1.15)	0.20		
	No health insurance			0.47(0.21,1.07)	0.07		
	Public health insurance			Ref			
Healthcare visit for adolescent in the past 12 months	*Yes*			2.64(1.2,5.83)	**0.02**		
	No			Ref			
Travel time to usual health care provider	*<15 min*			1.58(1.14,2.19)	**0.006**	1.94(1.37,2.76)	**<0.001**

VARIABLES		1. Socio-economic model		2. Healthcare access model		3. Prediction model[a]	
		OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
	15 min or more			Ref		Ref	
Provider type	*Pediatrician*			1.28(0.79,2.06)	0.32		
	Other			Ref			
Provider recommendation for HPV vaccine	*Yes*					49.88(23.14,107.51)	**<0.001**
	No/Don't know					Ref	
Degrees of freedom		**10**		**11**		**10**	
-2 Log L		**1068.6**		**1074.1**		**689.3**	

[a]Predictors were determined using stepwise logistic regression.