HHS Public Access

Author manuscript

Vaccine. Author manuscript; available in PMC 2025 January 12.

Published in final edited form as:

Vaccine. 2025 January 12; 44: 126560. doi:10.1016/j.vaccine.2024.126560.

Human papillomavirus vaccination coverage among adolescent boys and girls in the United States: A birth year cohort analysis of the National Immunization Survey-Teen, 2016–2022

Ponesai Nyika[*], **David Yankey**, **Laurie D. Elam-Evans**, **S. Meyer**, **C. Pingali**, **Shannon Stokley**, **James A. Singleton**

Immunization Services Division, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA

Abstract

Objective: To evaluate human papillomavirus (HPV) vaccination coverage among adolescents in the U.S. using birth cohort analysis.

Methods: We conducted a birth cohort analysis among adolescents born during 1999–2009 using National Immunization Survey-Teen (NIS-Teen), a random-digit dialed household telephone survey that also includes vaccination data from providers. We analyzed 131,553 records from 2016 to 2022 NIS-Teen data to determine: trends in coverage with ≥1 HPV vaccine dose before age 13 years and cumulative coverage from age 13–17 years; sociodemographic factors associated with HPV vaccination before age 13 years; missed HPV vaccination opportunities and the potential achievable coverage if opportunities were not missed; and trends in completion of HPV vaccination series. Regression analysis and Kaplan-Meier method provided the average percentage increase in coverage, and cumulative coverage from age 13–17 years stratified by birth cohorts, respectively.

Results: HPV vaccination initiation before age 13 years increased from 27.0 % among adolescents born in 1999 to 69.8 % among those born in 2009. Overall, cumulative percent with ≥1 HPV vaccine dose increased from 51.3 % before age 13 years to 74.9 % through age

[*]Corresponding author at: 1600 Clifton Rd N E, Mailstop H24-5, Atlanta, GA 30333, United States. mpq0@cdc.gov (P. Nyika).

CRediT authorship contribution statement

Ponesai Nyika: Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **David Yankey:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Laurie D. Elam-Evans:** Writing – review & editing, Visualization, Validation, Project administration, Methodology, Conceptualization. **S. Meyer:** Writing – review & editing, Validation, Supervision, Resources, Conceptualization. **C. Pingali:** Writing – review & editing, Validation, Resources, Methodology. **Shannon Stokley:** Writing – review & editing, Visualization, Validation, Supervision, Resources. **James A. Singleton:** Writing – review & editing, Visualization, Validation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

17 years. Having a preventive visit at ages 11–12 years and being insured were associated with higher ≥1 HPV vaccine dose coverage. Among the 38,568 (29.3 %) adolescents unvaccinated for HPV, 31,513 (82.5 %) missed ≥1 HPV vaccination opportunity. The potential achievable coverage if opportunities were not missed was 94.8 %. Completion of HPV vaccination series before age 13 years increased from 10.3 % among adolescents born in 1999 to 42.2 % among those born in 2009.

Conclusions: Coverage with ≥1 HPV vaccine dose increased by birth cohort among adolescents born 1999–2009 but remained suboptimal, especially among uninsured adolescents. Missed opportunities may be reduced by effective HPV vaccination implementation and uptake strategies and by administering all recommended vaccines during the same visit.

Keywords

Human papillomavirus; Vaccination; Coverage; HPV vaccine; Birth year cohorts; United States

1. Introduction

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States; over 42 million people are infected with types of HPV that are known to cause disease, and approximately 13 million new infections occur every year [1,2]. HPV causes approximately 37,000 cancers annually: 21,500 among women and 15,500 among men [3]. HPV vaccination can prevent more than 90 % of cancers caused by HPV. There are three HPV vaccines licensed for use in the United States: a bivalent vaccine (2vHPV) for use in females, protecting against HPV subtypes 16 and 18; a quadrivalent vaccine (4vHPV) for use in males and females, protecting against HPV subtypes 6, 11, 16 and 18; and a 9-valent (9vHPV) vaccine for use in males and females, protecting against HPV subtypes 6, 11, 16, 18, 31, 33, 45, 52 and 58 [3-5]. As of late 2016, only 9vHPV vaccine is distributed in the United States. This vaccine protects individuals against seven HPV types that can cause HPV-associated cancers two types that cause anogenital warts [1,3,4].

HPV vaccination is most effective when given in early adolescence before exposure to HPV through sexual contact [7-9]. Routine HPV vaccination was first recommended for girls in 2006 and for boys in 2011 as a 3-dose schedule. Currently, the Advisory Committee on Immunization practices (ACIP) recommends routine HPV vaccination for both boys and girls at age 11 or 12 years, but vaccination can start at age 9 years. The HPV vaccination series is recommended to be completed before the 13th birthday, but catch-up vaccination is recommended after age 13 years. Beginning in 2016, ACIP recommended a 2-dose schedule for adolescents who initiate the vaccination series before age 15 years, and 3 doses for those who initiate the vaccination series at ages 15 through 26 years and for immunocompromised persons [9]. HPV vaccination is recommended for all persons through age 26 years who are not adequately vaccinated and can be given to adults aged 27 through 45 years based on shared clinical decision-making [10].

Although coverage with ≥1 dose HPV vaccination among adolescents aged 13–17 years has increased from 60.4 % in 2016 to 76.0 % in 2022, it is still considerably lower than the coverage for other adolescent vaccines such as the tetanus toxoid, reduced diphtheria

toxoid, and acellular pertussis (Tdap) vaccine (89.9 %) and the meningococcal conjugate (MenACWY) vaccine (88.6 %) [11,12]. The proportion of adolescents who had completed the HPV vaccination series in 2022 was low (62.6 %) [11,12].

This evaluation focuses on adolescent boys and girls born during 1999–2009. The purpose of the evaluation is to determine: (1) trends in coverage with ≥1 dose HPV vaccine before age 13 years, comparing between boys and girls, (2) cumulative coverage with ≥1 HPV vaccine dose from 13 to 17 years across birth year cohorts, (3) sociodemographic factors associated with receipt of ≥1 dose HPV vaccine before age 13 years, (4) percentage of adolescents who had missed opportunities for HPV vaccination initiation before age 13 years, and the potential achievable coverage if these opportunities had not been missed, (5) trends in completion of the recommended HPV vaccination series before age 13 years, comparing between boys and girls, and (6) cumulative completion of the HPV vaccination series from 13 to 17 years by birth year cohort. The findings of this study will be used to guide focused interventions to improve HPV vaccination coverage in order to reduce morbidity and mortality from HPV infection and associated cancers.

2. Methods

2.1. Data sources

We used National Immunization Survey-Teen (NIS-Teen) data from 2016 to 2022 for this analysis. NIS-Teen collects data in two phases: a random-digit dialed telephone survey of parents or guardians that identifies households with adolescents 13–17 years old, followed by a mailed survey sent to vaccination providers of adolescents whose parents consented to the release of the adolescents' provider-reported vaccination histories [15]. The household survey provided sociodemographic characteristics, insurance status, and access to care information, such as number of times teen has seen provider in the last 12 months, preventative visit at age 11–12 years, and number of vaccination providers. We also requested consent to obtain vaccination histories from providers. Vaccination histories included information on vaccination types, doses, dates administered and administrative data such as, provider visits, number of vaccination providers, facility type and facility location. These data obtained from providers were used to estimate coverage.

For the survey years 2016–2017, the NIS-Teen sampling frame included both landlines and cellular telephones (dual frame). From 2018, the NIS-Teen switched to a single cell-phone frame sampling design to increase efficiency. From 2016 to 2022, the Council of American Survey Research organization household response rates for NIS-Teen ranged from 19.7 % to 32.7 %. The proportion of completed interviews that included adequate provider data[1] ranged from 41.0 % to 53.9 %. This activity was reviewed by Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and CDC policy. [2].

[1]Teens with at least one non–COVID-19 vaccination reported by a provider and those who had received no vaccinations were considered to have adequate provider data. "No vaccinations" indicates that the vaccination status is known because the parent or guardian indicated there were no vaccinations and the providers returned no immunization history forms or returned them indicating that no vaccinations had been administered. Teens with unknown vaccination status or with missing dates of vaccination were considered to have inadequate provider data.

2.2. Definitions and outcome measures

Receipt of ≥1dose of HPV vaccine (HPV vaccination initiation) was the primary outcome measure of coverage before age 13 years and from 13 to 17 years. Beginning in 2016, adolescents who had completed the HPV vaccination series included those with ≥3 doses, and those with 2 doses when the first HPV vaccine dose was initiated at age < 15 years and with ≥5 months minus 4 days between the first and second dose [9]. Prior to 2016, an adolescent was considered to have completed the HPV vaccination series with 3 or more doses of HPV vaccine, regardless of age at vaccination initiation. Date of birth and date of HPV vaccination were used to determine age at vaccination. Age at vaccination was used to calculate HPV vaccination coverage for adolescents before they reached age 13 years (up to the day before the 13th birthday), and from age 13–17 years by birth year cohorts. We combined NIS-Teen data collected from the 2016 to 2022 surveys and grouped adolescents by their year of birth (1999 through 2009).

We then determined the proportion of adolescents who missed opportunities for vaccination, and the potential achievable coverage with ≥1 dose HPV vaccine before age 13 years in the combined 1999–2009 birth year cohorts. At least one missed opportunity for HPV vaccination was defined as a provider visit occurring on or after age 11 years and before the 13th birthday during which an adolescent who was unvaccinated for HPV received at least one vaccine but did not receive the first dose of HPV vaccine. Achievable coverage was defined as the coverage with ≥1 dose of HPV vaccine that could have been attained if HPV vaccination opportunities had not been missed.

2.3. Statistical analyses

We conducted our analyses in six parts, (1) trends in coverage with ≥1 dose HPV vaccine before age 13 years (on-time initiation), (2) trends in cumulative coverage with ≥1 dose HPV vaccine from 13 to 17 years (catch-up or late initiation), (3) sociodemographic factors associated with on-time initiation of HPV vaccination, and (4) proportion of adolescents who had missed opportunities for HPV vaccination before age 13 years, and the potential achievable coverage if these opportunities had not been missed, (5) trends in completion of the HPV vaccination series before age 13 years (on-time completion of all recommended doses), and (6) trends in cumulative completion of the HPV vaccination series from 13 to 17 years (catch up or late completion of all recommended doses). We used SAS-callable SUDAAN (version 11, RTI International) to compute the weighted coverage by sociodemographic factors for the birth year cohorts 1999–2009.

For (1) and (5), we used Microsoft excel to generate trends in weighted coverage with ≥1 dose HPV vaccine before age 13 years and completion of the HPV vaccination series before age 13 years. For (1), we also used regression analysis to compute the average percentage point increase in HPV vaccination initiation before age 13 years across the birth year cohorts. The average birth year cohort percentage point increase was defined as the slope of the linear regression line [15]. For (2) and (6), we used the Kaplan-Meier method to estimate the cumulative percent receiving ≥1-dose HPV vaccine from age 13–17 years, stratified by

[2]45C.F.R. part 46.102(l)(2); 21C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S. C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

annual birth year cohort. For (3), the analysis of sociodemographic factors associated with vaccination before age 13 years, birth cohorts were grouped into 1999–2006 and 2007–2009. The 2007–2009 group provides most recent associations which are more reflective of the current situation while the 1999–2006 group provides historical associations which help to show changes over time. We used SAS-callable SUDAAN (version 11, RTI International) to conduct bivariate analysis of HPV vaccination coverage and socio-demographic factors among boys and girls within each of the birth year cohorts for 1999–2009. For (4), we added missed opportunities for HPV vaccination before age 13 years, to the observed coverage with ≥1 dose HPV vaccine to determine the potential achievable coverage if opportunities had not been missed. For all the analyses, we used survey weights designed to increase the representativeness of the weighted sample. The reciprocal of the estimated variance of vaccination coverage estimates was used for weights. HPV vaccination trends within birth year cohorts were assessed with weighted least squares linear regression models [14].

3. Results

We analyzed a total of 131,553 records for adolescents aged 13–17 years born during 1999–2009 and included in the 2016–2022 NIS-Teen surveys. Table 1 shows the demographic characteristics of the sample. The proportion of boys in the sample was 51 %, and the proportion of girls was 49 %.

4. Trends in coverage with ≥1 dose HPV vaccine before age 13 years

Fig. 1 shows estimated HPV vaccination coverage with ≥1 dose before age 13 years by sex and birth year cohort. Vaccination coverage significantly increased (test for trend, $P < .05$) from 27.0 % among adolescents born in 1999 to 69.8 % among those born in 2009; coverage for girls increased from 37.4 % to 73.4 % and coverage for boys increased from 16.9 % to 65.9 %. Coverage increased with each subsequent birth year cohort, except for the 2008 birth year cohort, where there was a decline in coverage. The average birth year percentage point increase was 4.6 and was statistically significant ($P < .05$). Among the 1999–2007 birth year cohorts, coverage with ≥1 dose HPV vaccine before age 13 years was higher among girls when compared with boys. In the 2008 and 2009 birth year cohorts, coverage with ≥1 dose HPV vaccine was similar between boys and girls.

1. Trends in cumulative coverage from age 13–17 years

Fig. 2 shows the cumulative percent with ≥1 dose of HPV vaccine by age for each birth year cohort. Cumulative coverage increased with age for each birth year cohort. For birth years assessed for vaccination before their 18th birthday (born 1999–2005), ≥1 dose coverage increased from <13 years to <18 years by a range of 20.0 to 37.7 percentage points across the birth years (e.g., for those born in 2005, coverage increased from 58.7 % by <13 years to 78.7 % by <18 years, a 20.0 percentage point increase). The 2007–2009 birth year cohorts reached higher coverages earlier than the 1999–2001 birth year cohorts. For example, the 2007–2009 birth year cohorts achieved at least 70 % coverage with ≥1 dose HPV vaccine before age 14 years whereas the 1999–2001 birth year cohorts had not reached 70 % coverage by age 17 years. Increases in cumulative coverage with ≥1 dose of HPV

vaccination for all birth year cohorts appeared to slow around age 16 years, with none of the cohorts reaching 80 % coverage before age 18 years.

5. Sociodemographic factors associated with on-time HPV vaccination initiation

Table 2 compares coverage with ≥1 dose HPV vaccine before 13 years for the combined 2007–2009 and 1999–2006 birth year cohorts and by select sociodemographic characteristics. For the 2007–2009 birth year cohorts, the characteristics that were significantly associated with a higher coverage with ≥1 dose HPV vaccine before age 13 years compared with the referent group included female sex (68.8 %), being Hispanic (71.2 %) or non-Hispanic Black (71.2 %), those whose mothers were never married (70.6 %), households below poverty level (72.9 %), those who had any Medicaid insurance (69.6 %), those who had a preventative visit at age 11 or 12 years (74.5 %), and those living in Midwest (68.9 %) and West (69.7 %) census regions ($P < .05$). Characteristics significantly associated with lower coverage included those whose mothers had some college education or were college graduates (63.2 %), those without insurance (50.3 %), those living in Non-Principal City Metropolitan Statistical Area (64.3 %) and Non-Metropolitan Statistical Area (Non-MSA) (63.7 %), and those who receive care from a military/Women, Infants and Children clinic or a pharmacy (30.3 %) ($P < .05$). Notably, coverage with ≥1 dose HPV vaccine before 13 years was significantly higher among the most recent cohorts of 2007–2009 compared with the 1999–2006 birth year cohorts across all the sociodemographic factors examined. Also, the 2007–2009 birth cohorts show narrowing of sociodemographic differences compared to the 1999–2006 birth cohorts.

6. Missed HPV vaccination opportunities and potential achievable coverage if opportunities were not missed

Table 3 shows observed coverage, missed HPV vaccination opportunities, and potentially achievable coverage with ≥1 dose HPV vaccine for the combined cohorts by sociodemographic characteristics. A total of 38,568 (29.3 %) adolescents had not received any HPV vaccine dose (unvaccinated) before age 13 years. Among those who were unvaccinated, 31,513 (82.5 %) had at least one missed opportunity for HPV vaccination before age 13 years, defined as unvaccinated adolescents having had a provider visit where another vaccine was administered but the HPV vaccine was not. Overall, if HPV vaccination opportunities had not been missed, coverage with ≥1 dose HPV vaccine would have increased from the observed 70.6 % to 94.8 %. Population groups with the highest proportion of missed opportunities among the unvaccinated included those who had a well child visit at 11 or 12 years (94.9 %), those living in the Northeast Census region (89.3 %), those born outside the U.S. (88.5 %) and those obtaining services from a mixture of facilities (88.3 %). Groups with the largest percentage point difference between observed and potential coverage included those receiving services from a military/Women, Infants and Children clinic or a pharmacy (49.9 percentage points), those living in Non-metropolitan Statistical Areas (29.6 percentage points), those with preventative visit at 11 or 12 years (29 percentage points) and Non-Hispanic Whites (28.1 percentage points).

7. Trends in completion of the recommended HPV vaccination series before age 13 years

Fig. 3 shows trends in completion of the recommended HPV vaccination series by age 13 years for each birth year cohort. The proportion of adolescents who were up to date with their HPV vaccination before age 13 years increased from 10.3 % for the 1999 birth year cohort to 42.2 % for the 2009 birth year cohort, an increase of 31.9 percentage points from the oldest birth year cohort to the most recent one: coverage for girls increased from 15.8 % to 43.8 % and coverage for boys increased from 5.0 % to 40.5 %. The percentage of adolescents who had completed the HPV vaccination series was higher among girls when compared with boys from the 1999 birth year cohort through the 2005 cohort, except for the 2004 birth year cohort where the difference was not statistically significant. For the 2006–2009 birth year cohorts, the percent of adolescents who had completed the HPV vaccination series was similar among boys and girls.

8. Trends in cumulative completion of the HPV vaccination series from 13 to 17 years

Fig. 4 shows the cumulative proportion of adolescent boys and girls who had completed the recommended HPV vaccination series, stratified by birth year cohort. The proportion of adolescents who had completed the HPV vaccination series increased with age for each birth year cohort. For adolescents born during 1999–2005 for which information was available to assess coverage before age 18 years, the proportion who had completed the HPV vaccination series increased from <13 years to <18 years by a range of 34.9 to 41.0 percentage points. For example, for the 2003 birth year cohort, the proportion of adolescents who had completed the HPV vaccination series increased from 24.3 % before age 13 years to 62.2 % before age 18 years, an increase of 41.0 percentage points. Also, the proportion of adolescent who had completed the HPV vaccination series increased across birth year cohorts. For example, the proportion of adolescents who had completed the HPV vaccination series before age 17 years increased from 50.0 % for the 1999 birth year cohort to 66.9 % for the 2005 birth year cohort. For these birth year cohorts (1999–2005), the highest proportion of adolescents who had completed the HPV vaccination series before age 18 years was achieved by the 2005 birth cohort (66.9 %), followed by the 2004 birth cohort (64.7 %) and the 2003 birth cohort (62.2 %).

9. Discussion

The sample sizes were variable for the different birth year cohorts because of the sampling design of the NIS-Teen. Each survey year includes five birth years meaning that each birth year will be sampled five times before that birth year is no longer eligible for the NIS-Teen survey. The 2009 birth year is smaller because they were aged 13 years in 2023, and this was the first survey year in which the 2009 birth year was eligible for the NIS-Teen survey. The 1999 and 2000 birth years are also lower because these birth years were sampled while NIS-Teen was a landline only survey. Sample sizes increased when NIS-Teen went to a landline and cellphone survey.

Although the coverage of HPV vaccination initiation before age 13 years (on-time initiation) significantly increased from adolescents born in 1999 (27.0 %) through adolescents born in 2009 (69.8 %), it remains lower than coverage for other vaccines recommended for adolescents [11-14]. Among adolescents born in 2009 who reached their 13th birthday in 2022, 31.2 % did not initiate HPV vaccination by age 13 years as recommended. However, coverage with ≥1 dose HPV vaccination reached at least 64.7 % before age 18 years for those born in 2004 and 71.4 % before age 14 years for those born in 2009. The dip in vaccination coverage observed among adolescents born in 2008 coincides with the peak of the COVID-19 pandemic, demonstrating the impact of disruptions to health care during this period [16]. The low coverage and delayed initiation of HPV vaccination may be a result of failure by providers to fully endorse the HPV vaccine and provide strong recommendations, presenting it as an 'optional' vaccine that could be delayed [18,19]. This may be coupled with lower confidence by providers and parents or guardians to consider HPV vaccination for younger adolescents [20-22]. Delaying HPV vaccination might reduce the likelihood of HPV vaccine series completion, given less frequent preventive visits for adolescents as they get older [23,24]. This, and the failure to vaccinate altogether could increase the likelihood of HPV infection and development of HPV-associated cancers later in life, leading to excess morbidity and mortality which could be prevented by receiving all the recommended doses on time.

Parents and providers could consider HPV vaccination starting at age 9 years as allowable by ACIP recommendations [6,31]. This would increase the time available for vaccination before age 13 years and spread out the number of vaccine doses received by adolescents at one time among parents concerned with the number of vaccine doses at one visit [33].

The gender gap in coverage with ≥1 dose HPV vaccine before age 13 years decreased from 20.5 % in the 1999 cohort to 7.5 % in the 2009 cohort. The differences were statistically significant for the 1999 through 2007 birth year cohorts but similar for the 2008 and 2009 birth year cohorts. Part of the reason there may not be statistically significant differences in recent birth cohorts despite remaining albeit smaller differences in point estimates is the small sample size for the more recent birth years. The overall progress in reducing difference in HPV vaccination coverage between genders is encouraging, and catch-up vaccination could target older boys who may have not received a recommendation for HPV vaccination by a provider. The remaining disparities observed might be a result of providers being less likely to recommend HPV vaccination to parents of adolescent boys than adolescent girls [26,27,29], and lower perceived risk of HPV infection among boys and their parents [17,18]. The misperception that HPV affects only females might still exist because the vaccine was initially introduced for girls only and promoted as a means to prevent cervical cancer. The current education should include oropharyngeal cancer, which has overtaken cervical cancer and is more common in men [28]. We noted earlier that routine HPV vaccination was recommended for girls in 2006, and for boys in 2011.While this may have contributed to the vaccination coverage gaps between boys and girls, the uptake of the HPV vaccine among boys may have benefited from the 5 years of experience implementing HPV vaccination for girls during which some of the uptake barriers such as supply logistics, vaccine knowledge gaps and misinformation, safety concerns and general vaccine hesitancy may have been addressed to some extent.

Our evaluation identified several groups where >50 % of adolescents had not initiated HPV vaccination before age 13 years. These were non-Hispanic Whites, those whose mothers had at least some college education, those whose mothers were married or living with a partner, those born outside the United States, those at or above poverty level, those who were uninsured, those without a preventive care visit at 11 or 12 years, those living in Non-Metropolitan Statistical Areas (non-MSA's) and those living in Northeast and South Census Regions. All the groups examined reached at least 65 % coverage with HPV vaccination initiation except for those uninsured, those without a preventive care visit at 11 or 12 years, and those living in non-MSAs. Previous studies showed lower coverage [13], and higher proportions of delay and refusal of HPV vaccination in these groups [23,25,40]. Identification of groups less likely to initiate HPV vaccination before age 13 year provides an opportunity for targeted interventions to increase HPV vaccine coverage before age 13 years.

Our findings underscore the importance of programs such as the Vaccines for Children (VFC) program which provides vaccines to eligible children below the age of 19 years at no cost, including those without insurance. However, uninsured adolescents had the lowest HPV vaccination rate, suggesting that more efforts may be needed to expand awareness of and access to VFC vaccination locations. Also, uninsured people might need help accessing healthcare generally, not just free vaccines.

There were substantial missed HPV vaccination opportunities across all of the sociodemographic groups examined. Overall, 82.5 % of adolescents who had not received any HPV vaccine dose had at least one encounter with a provider where one or more non-HPV vaccines were administered but the first dose of HPV vaccine was not received. Among those who were unvaccinated who had a preventive visit at 11 or 12 years, 94.9 % had at least one missed HPV vaccination opportunity. Preventive care visits are the visit type most associated with vaccination [32], and vaccination during these visits should not be missed [34,35]. These findings strongly suggest differential recommendation and uptake of the HPV vaccine compared to other vaccines recommended for adolescents. Previous studies showed that there are numerous missed opportunities for HPV vaccination and that some providers perceived parents as hesitant, leading to weak and poor-quality recommendations for HPV vaccine, or no recommendation at all [14,17-19,22,32]. Studies have also identified parental barriers such as limited knowledge about the vaccine, the belief that the child is too young for the vaccine, perceived low risk, perceived low effectiveness of the vaccine and safety concerns [17,19,20,25]. The minimum potential achievable coverage across sociodemographic subgroups was 89.7 % (range 89.7 % to 98.8 %), suggesting that sociodemographic disparities would have been substantially reduced if HPV vaccination opportunities had not missed.

Although the proportion of adolescents who had completed the HPV vaccination series increased from 10.3 % among those born in 1999 to 42.2 % among those born in 2009, vaccine coverage remains suboptimal [31]. Despite this increase in the completion of the HPV vaccination series across birth year cohorts, and with catch up vaccination, none of the cohorts reached the 60 % coverage mark before age 18 years. This progress may not be enough to reach the U.S. Department of Health and Human Services' Healthy People

2030 target of 80 % of adolescents ages 13 through 15 years who received the recommended doses of the HPV vaccine [30,32].

The limitations of this study include the fact that the NIS–Teen excludes households without any telephone service and landline only households. Also, response rates were low. Although weighting adjustments were done to minimize nonresponse bias and incomplete representation of the target population by the sampling frame, some residual bias may remain [41]. Despite this, the NIS-Teen Error Profile reports which include estimations of bias and compare NIS estimates to other data sources such as publicly available IIS dashboards show that our estimates generally agree with high quality Immunization Information Systems (IIS) estimates [41]. Also, there were smaller sample sizes for the most recent birth year cohorts, and for the oldest birth year cohorts because of the sampling design. The potentially achievable coverage that could be obtained if HPV vaccination opportunities were not missed assumes that all parents would accept the HPV vaccine. However, some parents may not be willing to accept the vaccine even if the provider recommended the vaccine. Thus, the potential vaccination coverage may be overestimated. Potential vaccination coverage could also be underestimated because provider visits during which no vaccinations were given were not included as missed opportunities.

10. Conclusions

The coverage of HPV vaccination initiation before age 13 years increased by birth year cohort among adolescents born 1999–2009 but remains suboptimal. However, a substantial amount of HPV vaccination initiation is occurring after the 13th birthday leading to improved coverage with ≥1 dose HPV vaccination before age 18 years. There are significant sociodemographic disparities in HPV vaccination initiation before age 13 years. Identifying these disparities presents opportunities for developing and implementing focused interventions to improve HPV vaccination coverage. The proportion of adolescents who had completed the recommended HPV vaccination series is low and the progress being made may not be enough to reach the Healthy People 2030 target of 80 % [32]. Opportunities for HPV vaccination before age 13 years are being missed and if these were not missed, coverage would be much higher, and sociodemographic disparities would be reduced.

Missed HPV vaccination opportunities can be reduced by effective and strong provider recommendations for HPV vaccination [37,38]. Recent studies have shown that high quality provider recommendations lead to higher HPV vaccine uptake [19,33,36-38]. Providers in all vaccination settings should aim to administer all vaccines recommended for adolescents during the same visit, particularly at the 11 or 12-year preventive care visit when these vaccination opportunities are likely to occur. Efforts should include parent reminder, recall, and follow up systems [22,39]. Offering HPV vaccination starting as early as age 9 years could also increase opportunities for HPV vaccination before age 13 years and improve coverage. Additionally, providers should actively review the vaccination status of all adolescents at every visit, particularly those that are uninsured and provide information on the availability of the Vaccines for Children program [39]. Parents and guardians of uninsured adolescents should take full advantage of these programs to ensure that their children are protected from HPV infection. Targeted interventions aimed at improving

adolescents and parents' knowledge about risk of HPV infection, HPV-associated cancers, and HPV vaccination, and reducing misperceptions about safety should be implemented [19,20,22].

Funding

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

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data availability

The data that has been used is confidential.

References

[1]. Centers for Disease control and Prevention (CDC). About HPV. https://www.cdc.gov/hpv/about/index.html; 2024 [Accessed 2 September 2024].

[2]. Lewis RM, Laprise JF, Gargano JW, Unger ER, Querec TD, Chesson HW, et al. Estimated prevalence and incidence of disease-associated human papillomavirus types among 15- to 59-year-olds in the United States. Sex Transm Dis 2021;48(4):273–7. [PubMed: 33492097]

[3]. Centers for Disease Control and Prevention (CDC). Cancers Linked with HPV Each Year. https://www.cdc.gov/cancer/hpv/cases.html; 2024 [Accessed 2 September 2024].

[4]. Food and Drug Administration. Prescribing information [package insert]. Gardasil 9 (human papillomavirus 9-valent vaccine, recombinant). Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration; 2018. https://www.fda.gov/media/90064/downloadexternal.icon.

[5]. Food and Drug Administration. Prescribing information [package insert]. Gardasil (human papillomavirus quadrivalent [types 6, 11, 16, and 18] vaccine, recombinant). Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration; 2015. https://www.fda.gov/media/74350/downloadexternal.icon.

[6]. Food and Drug Administration. Prescribing information [package insert]. Cervarix (human papillomavirus bivalent [types 16 and 18] vaccine, recombinant). Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration; 2016. https://www.fda.gov/media/78013/downloadexternal.icon.

[7]. Markowitz LE, Dunne EF, Saraiya M, Chesson HW, Curtis CR, Gee J, et al. Human papillomavirus vaccination: recommendations of the advisory committee on immunization practices (ACIP). MMWR Recomm Rep 2014;63(RR-05). https://www.cdc.gov/mmwr/preview/mmwrhtml/rr6305a1.htm

[8]. Petrosky E, Bocchini JA Jr, Hariri S, Chesson H, Curtis CR, Saraiya M, et al. Centers for Disease Control and Prevention (CDC). Use of 9-valent human papillomavirus (HPV) vaccine: updated HPV vaccination recommendations of the advisory committee on immunization practices. MMWR Morb Mortal Wkly Rep 2015;64 (11):300–4 [PubMed: 25811679]

[9]. Meites E, Kempe A, Markowitz LE. Use of a 2-dose schedule for human papillomavirus vaccination—updated recommendations of the advisory committee on immunization practices. MMWR Morb Mortal Wkly Rep 2016;65:1405–8. [PubMed: 27977643]

[10]. Meites E, Szilagyi PG, Chesson HW, 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;68:698–702. 10.15585/mmwr.mm6832a3externalicon. [PubMed: 31415491]

[11]. Walker TY, Elam-Evans LD, Singleton JA, Yankey D, Markowitz LE, Fredua B, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years — United States, 2016. MMWR Morb Mortal Wkly Rep 2017;66:874–82. 10.15585/mmwr.mm6633a2. [PubMed: 28837546]

[12]. Pingali C, Yankey D, Elam-Evans LD, Markowitz LE, Valier MR, Fredua B, et al. Vaccination Coverage Among Adolescents Aged 13–17 Years — National Immunization Survey–Teen, United States, 2022. MMWR Morb Mortal Wkly Rep 2023;72:912–9. 10.15585/mmwr.mm7234a3. [PubMed: 37616185]

[13]. Walker TY, Elam-Evans LD, Yankey D, Markowitz LE, Charnetta WL, Mbaeyi SA, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years — United States, 2017. MMWR Morb Mortal Wkly Rep 2018;67:909–17. 10.15585/mmwr.mm6733a1. [PubMed: 30138305]

[14]. Santibanez TA, Black CL, Zhou T, Srivastav A, James A, Singleton JA, et al. Parental hesitancy about COVID-19, influenza, HPV, and other childhood vaccines. Vaccine 2024. 10.1016/j.vaccine.2024.07.040. ISSN 0264-410X, https://www.sciencedirect.com/science/article/pii/S0264410X24008028.

[15]. Centers for Disease Control and Prevention. About the National Immunization Surveys (NIS), https://www.cdc.gov/nis/about/index.html?CDC_AAref_Val=https://www.cdc.gov/vaccines/imz-managers/nis/about.html#nis-teen; 2024. Accessed 2 September 2024.

[16]. Pingali C, Yankey D, Chen M, et al. National Vaccination Coverage among Adolescents Aged 13–17 years — National Immunization Survey-Teen, United States, 2023. MMWR Morb Mortal Wkly Rep 2024;73:708–14. 10.15585/mmwr.mm7333a1.

[17]. Holman DM, Benard V, Roland KB, Watson M, Liddon N, Stokley S. Barriers to human papillomavirus vaccination among US adolescents: a systematic review of the literature. JAMA Pediatr 2014;168:76–82. [PubMed: 24276343]

[18]. Gilkey MB, McRee AL. Provider communication about HPV vaccination: a systematic review. Hum Vaccin Immunother 2016;12(6):1454–68. 10.1080/21645515.2015.1129090. [Epub 2016 Feb 2]. [PubMed: 26838681]

[19]. 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):1187–92. doi: 10.1016/j.vaccine.2016.01.023.Epub 2016 Jan 24. [PubMed: 26812078]

[20]. Zhu X, Jacobson RM, MacLaughlin KL, Sauver JS, Griffin JM, Finney Rutten LJ. Parent-reported barriers and parental beliefs associated with intentions to obtain HPV vaccination for children in a primary care patient population in Minnesota, USA. J Community Health 2023;48(4):678–86. 10.1007/s10900-023-01205-9. [Epub 2023 Mar 15.] [PubMed: 36920709]

[21]. Gilkey MB, Calo WA, Marciniak MW, Brewer NT. Parents who refuse or delay HPV vaccine: Differences in vaccination behavior, beliefs, and clinical communication preferences. Hum Vaccin Immunother 2017;13(3):680–6. 10.1080/21645515.2016.1247134. Epub 2016 Oct 20. [PubMed: 27763818]

[22]. Walling EB, Dodd S, Bobenhouse N, Reis EC, Sterkel R, Garbutt J. Implementation of strategies to improve human papillomavirus vaccine coverage: a provider survey. Am J Prev Med 2019;56(1):74–83. 10.1016/j.amepre.2018.07.038. [PubMed: 30573149]

[23]. Jeyarajah J, Elam-Evans LD, Stokley S, Smith PJ, Singleton JA. Human Papillomavirus Vaccination Coverage Among Girls Before 13 Years: A Birth Year Cohort Analysis of the National Immunization Survey-Teen, 2008–2013. Clin Pediatr (Phila) 2016;55(10):904–14. 10.1177/0009922815616245. Epub 2015 Nov 24. [PubMed: 26603581]

[24]. Rand CM, Shone LP, Albertin C, Auinger P, Klein JD, Szilagyi PG. National health care visit patterns of adolescents: implications for delivery of new adolescent vaccines. Arch Pediatr Adolesc Med 2007;161:252–9. [PubMed: 17339506]

[25]. American Academy of Pediatrics. Human Papillomavirus (HPV). https://www.aap.org/en/news-room/campaigns-and-toolkits/human-papillomavirus-hpv/; 2024.

[26]. Burdette AM, Gordon-Jokinen H, Hill TD. Social determinants of HPV vaccination delay rationales: evidence from the 2011 National Immunization Survey-Teen. Prev Med Rep 2014;2(1):21–6. 10.1016/j.pmedr.2014.09.003. [PubMed: 26844047]

[27]. Lindley MC, Jeyarajah J, Yankey D, Curtis CR, Markowitz LE, Stokley S. Comparing human papillomavirus vaccine knowledge and intentions among parents of boys and girls. Hum Vaccin Immunother 2016;12(6):1519–27. 10.1080/21645515.2016.1157673. Epub 2016 Mar 22. [PubMed: 27003108]

[28]. Sriram S, Ranganathan R. Why human papilloma virus vaccination coverage is low among adolescents in the US? A study of barriers for vaccination uptake. J Family Med Prim Care 2019;8(3):866–70. 10.4103/jfmpc.jfmpc_107_19. [PubMed: 31041215]

[29]. Roman BR, Aragones A. Epidemiology and incidence of HPV-related cancers of the head and neck. J Surg Oncol 2021;124(6):920–2. 10.1002/jso.26687. Epub 2021 Sep 23. [PubMed: 34558067]

[30]. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion: Increase the proportion of adolescents who get recommended doses of the HPV vaccine — IID-08. https://health.gov/healthypeople/objectives-and-data/browse-objectives/vaccination/increase-proportion-adolescents-who-get-recommended-doses-hpv-vaccine-iid-08; 2024.

[31]. White JL, Grabowski MK, Quinn TC, Tobian AAR, Patel EU. Trends in HPV vaccination before age 13 years in the US National Immunization Survey–Teen. JAMA Pediatr 2024;178(2):203–5. 10.1001/jamapediatrics.2023.5238. [PubMed: 38109082]

[32]. U.S. Department of Health and Human Services. https://health.gov/healthypeople/objectives-and-data/browse-objectives/vaccination; 2024. Accessed 10 January 2024.

[33]. Srivastava T, Head KJ, O'Dell SM, Feemster KA, Panozzo CA, Zimet GD, et al. Characterizing U.S. mothers with high human papillomavirus vaccine intent yet unvaccinated adolescents. Prev Med 2023;169:107472. 10.1016/j.ypmed.2023.107472. Epub 2023 Feb 26. [PubMed: 36854366]

[34]. Broder KR, Cohn AC, Schwartz B, Klein JD, Fisher MM, Fishbein DB, et al. Adolescent immunizations and other clinical preventive services: a needle and a hook? Pediatrics 2008;121(Suppl. 1):S25–34. [PubMed: 18174318]

[35]. Perkins RB, Clark JA, Apte G, Vercruysse JL, Sumner JJ, Wall-Haas CL, et al. Missed opportunities for HPV vaccination in adolescent girls: a qualitative study. Pediatrics 2014;134:e666–74. [PubMed: 25136036]

[36]. Stokley S, Cohn A, Jain N, McCauley MM. Compliance with recommendations and opportunities for vaccination at ages 11 to 12 years: evaluation of the 2009 National Immunization Survey-Teen. Arch Pediatr Adolesc Med 2011;165:813–8. [PubMed: 21893647]

[37]. Kornides ML, Fontenot HB, McRee AL, Panozzo CA, Gilkey MB. Associations between parents' satisfaction with provider communication and HPV vaccination behaviors. Vaccine 2018;36(19):2637–42. 10.1016/j.vaccine.2018.03.060 [Epub 2018 Apr 4]. [PubMed: 29627236]

[38]. Fenton AT, Eun TJ, Clark JA, Perkins RB. Indicated or elective? The association of providers' words with HPV vaccine receipt. Hum Vaccin Immunother 2018;14(10):2503–9. 10.1080/21645515.2018.1480237 [Epub 2018 Jun 28]. [PubMed: 29847201]

[39]. Finney Rutten LJ, Griffin JM, St Sauver JL, MacLaughlin K, Austin JD, Jenkins G, et al. Multilevel implementation strategies for adolescent human papillomavirus vaccine uptake: a cluster randomized clinical trial. JAMA Pediatr 2024;178(1):29–36. 10.1001/jamapediatrics.2023.4932. [PubMed: 37983062]

[40]. Dorell CG, Yankey D, Santibanez TA, Markowitz LE. Human papillomavirus vaccination series initiation and completion, 2008–2009. Pediatrics 2011;128:830–9. [PubMed: 22007006]

[41]. Centers for Disease Control and Prevention (CDC). https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/downloads/error-profile-2022-nis-teen.pdf; 2024 [Accessed 29 April 2024].

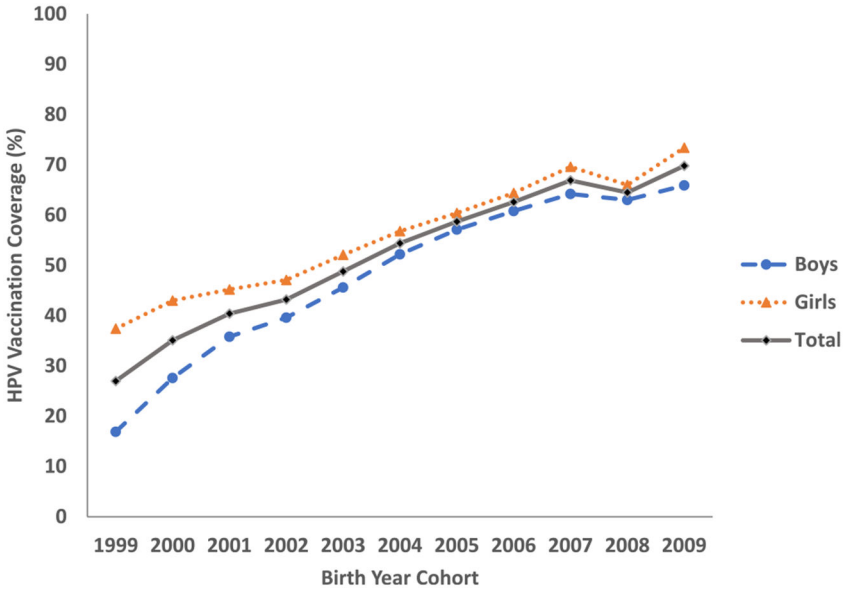

Fig. 1.

Coverage with ≥1 dose HPV vaccine before age 13 years among adolescent boys and girls stratified by birth year cohorts, National Immunization Survey-Teen, United States, 2016–2022.

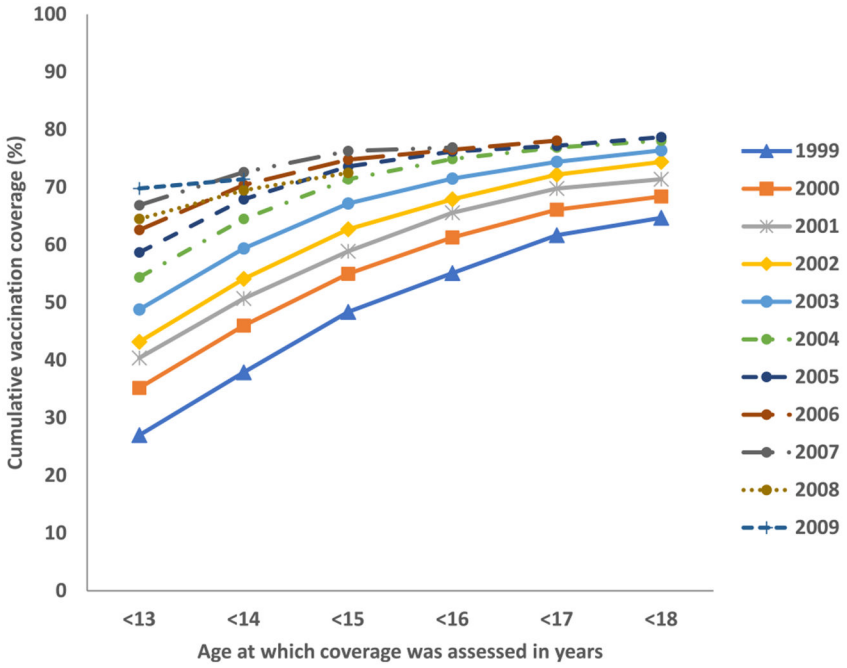

Fig. 2.

Cumulative percent with ≥1 dose HPV vaccine by age of adolescents, stratified by birth year cohorts, National Immunization Survey-Teen, United States, 2016–2022. The x-axis represents the age in years by which the cumulative percent vaccinated is assessed; it includes up to but not include the day the adolescent reached the indicated age.

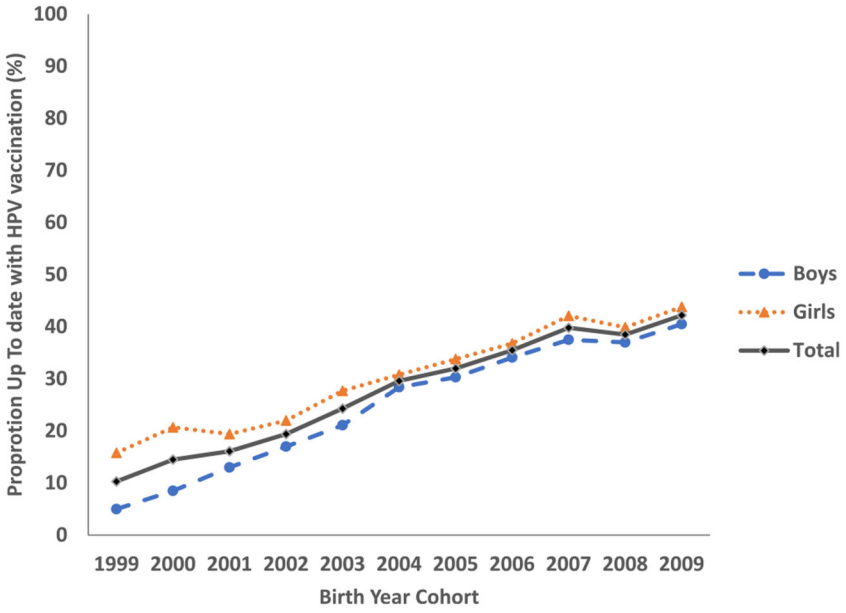

Fig. 3.

Proportion of adolescent boys and girls who had competed the HPV vaccination series before age 13 years, stratified by birth year cohort, National Immunization Survey-Teen, United States, 2016–2022.

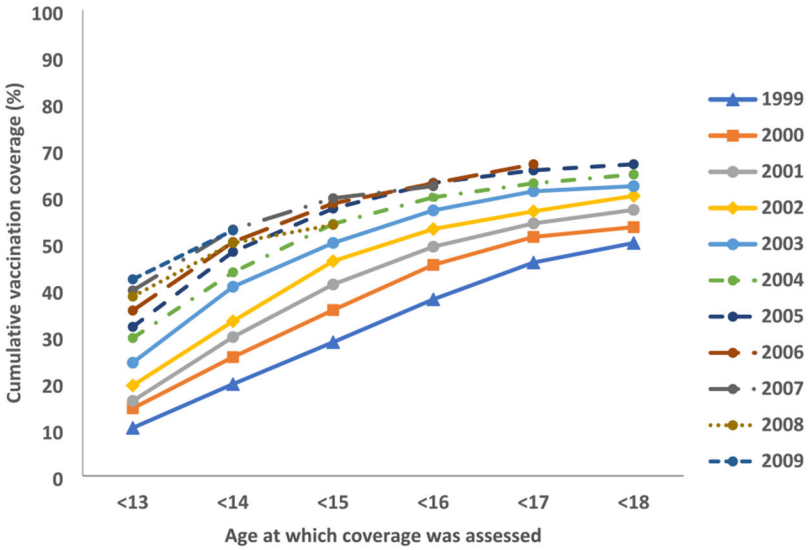

Fig. 4.

Cumulative proportion of adolescent boys and girls who had completed the HPV vaccination series, stratified by birth year cohort, National Immunization Survey-Teen, United States, 2016–2022. The x-axis represents the age in years by which the cumulative percent who had completed the series was assessed; it includes up to but not including the day the adolescent reached the indicated age.

Table 1

Demographic Characteristics of Boys and Girls Aged 13–17 Years, National Immunization Survey-Teen (NIS-Teen), United States, 2016–2022.

Demographic Characteristics	Sample (n)	Weighted % (95 % CI)
Birth Cohort Year	131,553	100 (—)
1999	5685	4.1 (3.4–4.9)
2000	9740	7.2 (6.3–8.2)
2001	13,761	10.3 (9.2–11.4)
2002	17,478	12.6 (11.6–13.7)
2003	20,082	14.3 (13.5–15.3)
2004	18,908	14.6 (13.7–15.6)
2005	16,723	13.0 (12.1–14.0)
2006	13,251	10.4 (9.4–11.5)
2007	9234	7.3 (6.4–8.4)
2008	5036	4.6 (3.7–5.6)
2009	1655	1.6 (1.1–2.2)
Age at Interview	131,553	100 (—)
13 years	27,436	20.2 (19.8–20.6)
14 years	27,928	20.3 (19.9–20.7)
15 years	26,717	21.0 (20.6–21.4)
16 years	26,696	20.5 (20.1–20.9)
17 years	22,776	18.0 (17.6–18.5)
Age grouped at Interview	131,553	
13–15 years	82,081	61.5 (61.0–61.9)
16–17 years	49,472	38.5 (38.1–39.0)
Sex	131,553	100 (—)
Boys	69,316	51.0 (50.8–51.2)
Girls	62,237	49.0 (48.8–49.2)
Race and Ethnicity [a]	131,553	
Non-Hispanic White	81,347	50.8 (48.0–53.6)
Non-Hispanic Black	11,382	13.6 (12.4–14.8)
Hispanic	23,413	24.6 (21.7–27.7)
Other	15,411	11.0 (10.3–11.8)
Mother's educational level	131,553	100 (—)
<High School	12,458	12.3 (11.5–13.2)
High School	19,767	21.6 (21.2–22.0)
Some college or college graduate	33,557	23.8 (23.3–24.3)
>College graduate	65,771	42.3 (41.4–43.2)
Mother's married status	131,553	100 (—)
Married/Living with partner	91,943	67.8 (67.0–68.6)
Widowed/divorced/separated	22,089	22.4 (21.8–23.1)

Demographic Characteristics	Sample (n)	Weighted % (95 % CI)
Never married	8502	9.8 (9.3–10.2)
Missing/Unknown	9019	
Mother's Age	131,553	100 (—)
≤34 years	9304	7.8 (7.5–8.1)
35–44 years	55,263	43.8 (43.1–44.6)
≥45 years	66,986	48.4 (47.5–49.3)
Immigration status	131,553	100 (—)
Born in U.S.	125,041	94.6 (94.2–95.0)
Born outside U.S.	5605	5.4 (5.0–5.8)
Missing/Unknown	907	
Poverty Status [b]	131,553	100 (—)
At or above poverty level	107,290	80.3 (79.6–81.0)
Below poverty level	19,762	19.7 (19.0–20.4)
Missing/Unknown	4501	
Health Insurance Status	131,553	100 (—)
Private Only	76,998	52.6 (51.6–53.5)
Any Medicaid[c]	39,642	36.3 (35.2–37.4)
Other[d]	10,520	7.2 (6.7–7.7)
Uninsured	4392	3.9 (3.5–4.4)
Number of times teen has seen provider in last 12 months	131,553	100 (—)
0	17,274	15.7 (15.0–16.4)
1	38,448	30.8 (30.2–31.5)
2–3	47,396	35.1 (34.5–35.8)
4+	27,265	18.3 (17.8–18.9)
Missing/Unknown	1170	
Preventative visit at age 11–12 years	131,553	100 (—)
Yes	63,304	46.6 (45.4–47.9)
No	27,072	19.6 (18.8–20.4)
Don't know	41,177	33.8 (32.4–35.3)
Number of vaccination providers	131,553	100 (—)
1	72,877	57.6 (56.8–58.5)
2	36,977	27.7 (27.2–28.2)
≥3	21,247	14.7 (14.1–15.3)
Missing/Unknown	452	
Metropolitan statistical area (MSA)	131,553	100 (—)
MSA Principal City	52,636	41.3 (39.1–43.5)
MSA Non-Principal City	53,913	47.6 (45.5–49.7)
Non-MSA	25,004	11.1 (10.0–12.3)
Census Region	131,553	100 (—)
Northeast (ref)	25,635	16.0 (12.2–20.8)
Midwest	28,496	21.2 (16.7–26.6)

Demographic Characteristics	Sample (n)	Weighted % (95 % CI)
South	48,704	38.8 (32.1–46.0)
West	28,718	24.0 (17.4–32.1)
Vaccination Provider Facility Type	131,553	100 (—)
All public facilities	62,733	51.2 (49.9–52.5)
All hospital facilities	17,793	14.4 (13.6–15.1)
All private facilities (ref)	17,050	11.1 (10.4–11.8)
All other facilities	2049	1.8 (1.7–2.0)
Mixed[e]	29,022	20.2 (19.5–20.9)
Other (Military/WIC/Pharmacy)	2003	1.4 (1.2–1.5)

Abbreviations: WIC, Women, Infant and Children program; HPV, human papillomavirus.

[a]Reported by parent/guardian respondent. Adolescents of Hispanic ethnicity may be of any race. ‘Other’ indicates that the adolescents identified as American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander or multiracial.

[b]Poverty is defined as an individual or family’s income being below the federal annual threshold.

[c]Any Medicaid: Teen covered by Medicaid with or without any other type of insurance. Teen with any mention of Medicaid coverage will belong to this category of insurance.

[d]Other insurance: Teen covered by insurance type other than private or Medicaid.

[e]Mixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, military, WIC and pharmacy.

Table 2

Coverage with ≥1 dose HPV vaccine by age 13 years by birth year cohorts, stratified by sociodemographic characteristics, National Immunization Survey-Teen, United States, 2016–2022.

	Total (*N* = 131,553)		Born in 1999–2006 (*N* = 115,628)		Born in 2007–2009 (*N* = 15,925)		Difference Born in (2007–2009) - (1999–2006) (*N* = 131,553)	
	n	weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)
Total	67,158	51.3 (50.0–52.5)	56,313	48.9 (48.4–49.5)	10,845	66.4 (64.9–67.9)	**131,553**	**17.5 (15.9–19.1)**[c]
Sex								
Male[b]	33,166	47.8 (46.3–49.3)	27,635	45.4 (44.6–46.1)	5531	64.0 (61.8–66.1)	69,316	18.6 (16.4–20.9)[c]
Female	33,992	54.9 (53.6–56.1)	28,678	52.6 (51.8–53.5)[c]	5314	68.8 (66.7–70.9)[c]	62,237	16.2 (14.0–18.4)[c]
Race and Ethnicity [b]								
Non-Hispanic White[a]	38,531	45.9 (44.9–47.0)	32,175	43.5 (42.8–44.1)	6356	62.8 (60.9–64.6)	81,347	19.3 (17.4–21.2)[c]
Non-Hispanic Black	6493	56.1 (54.2–58.0)	5369	53.9 (52.3–55.5)[c]	1124	71.2 (67.0–75.0)[c]	11,382	17.3 (12.9–21.6)[c]
Hispanic	13,894	59.5 (57.4–61.6)	11,942	57.6 (56.1–59.0 [c]	1952	71.2 (67.4–74.6)[c]	23,413	13.6 (9.7–17.5)[c]
Other	8240	51.4 (48.6–54.2)	6827	48.9 (47.2–50.6)[c]	1413	65.7 (61.4–69.8)	15,411	16.8 (12.3–21.4)[c]
Mother's educational level								
<High School[a]	7389	60.9 (58.2–63.5)	6667	59.4 (57.5–61.2)	722	70.9 (64.9–76.3)	12,458	11.6 (5.6–17.6)[c]
High School	10,446	52.9 (51.2–54.5)	8859	50.8 (49.4–52.2)[c]	1587	66.9 (63.2–70.4)	19,767	16.1 (12.3–20.0)[c]
Some college or college graduate	16,652	49.9 (48.4–51.3)	14,032	47.7 (46.6–48.9)[c]	2620	63.2 (60.2–66.2)[c]	33,557	15.5 (12.3–18.7)[c]
>College graduate	32,671	48.5 (47.1–49.9)	26,755	45.5 (44.8–46.3 [c]	5916	66.8 (64.8–68.7)	65,771	21.2 (19.2–23.3)[c]
Mother's married status								
Married/Living with partner[a]	44,921	48.3 (47.0–49.7)	37,480	45.8 (45.1–46.5)	7441	64.5 (62.6–66.3)	91,943	18.7 (16.7–20.7)[c]
Widowed/divorced/separated	11,757	53.1 (51.5–54.8)	10,130	51.1 (49.8–52.4)[c]	1627	68.1 (64.6–71.5)	22,089	17.1 (13.4–20.8)[c]
Never married	5253	61.3 (59.6–62.9)	4335	59.6 (57.5–61.7)[c]	918	70.6 (65.8–75.0)[c]	8502	11.0 (5.9–16.1)[c]
Mother's Age								
≤34 years[a]	5444	58.8 (56.8–60.9)	4351	57.3 (55.1–59.5)	1093	65.3 (60.3–69.9)	9304	8.0 (2.7–13.2)[c]
35–44 years	29,156	53.0 (51.5–54.4)	23,961	50.8 (49.9–51.7)[c]	5195	65.2 (63.0–67.3)	55,263	14.4 (12.1–16.7)[c]

	Total (*N* = 131,553)		Born in 1999–2006 (*N* = 115,628)		Born in 2007–2009 (*N* = 15,925)		Difference Born in (2007–2009) - (1999–2006) (*N* = 131,553)	
	n	weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)
≥45 years	32,558	48.5 (47.1–50.0)	28,001	46.0 (45.3–46.8)[c]	4557	68.2 (65.8–70.5)	66,986	22.2 (19.7–24.6)[c]
Immigration status								
Born in U.S.[a]	64,123	51.6 (50.3–52.8)	53,722	49.2 (48.6–49.8)	10,401	66.6 (65.1–68.1)	125,041	17.4 (15.8–19.0)[c]
Born outside U.S.	2599	46.4 (44.0–48.8)	2247	44.6 (41.9–47.4)[c]	352	60.8 (51.0–69.8)	5605	16.2 (6.3–26.1)[c]
Poverty Status [f]								
At or above poverty level[a]	53,192	49.1 (47.8–50.3)	44,098	46.5 (45.9–47.1)	9094	65.1 (63.4–66.7)	107,290	18.6 (16.9–20.4)[c]
Below poverty level	11,698	60.6 (58.7–62.5)	10,236	59.0 (57.6–60.3)[c]	1462	72.9 (69.0–76.5)[c]	19,762	14.0 (9.9–18.0)[c]
Health Insurance Status								
Private Only[a]	37,245	47.0 (45.7–48.4)	30,908	44.2 (43.5–45.0)	6337	65.5 (63.4–67.5)	76,998	21.2 (19.1–23.4)[c]
Any Medicaid[g]	22,886	59.3 (57.8–60.7)	19,421	57.6 (56.5–58.6)[c]	3465	69.6 (67.0–72.0)[c]	39,642	12.0 (9.3–14.7)[c]
Other[h]	5208	48.4 (46.6–50.3)	4390	45.9 (44.0–47.9)	818	64.9 (59.9–69.5)	10,520	18.9 (13.7–24.1)[c]
Uninsured	1819	39.6 (36.9–42.4)	1594	38.1 (35.3–41.0)[c]	225	50.3 (40.4–60.1)[c]	4392	12.1 (1.7–22.5)[c]
Number of times teen has seen provider in last 12 months								
0[a]	7992	48.1 (45.8–50.4)	6676	46.4 (44.8–48.0)	1316	57.8 (53.4–62.1)	17,274	11.4 (6.8–16.0)[c]
1	19,650	50.9 (49.5–52.4)	16,173	48.1 (47.1–49.2)	3477	68.5 (65.8–71.0)[c]	38,448	20.4 (17.5–23.2)[c]
2–3	24,674	52.3 (51.0–53.7)	20,821	50.1 (49.2–51.1)[c]	3853	66.9 (64.4–69.3)[c]	47,396	16.8 (14.1–19.4)[c]
4+	14,187	52.0 (50.5–53.5)	12,073	49.6 (48.4–50.8)[c]	2114	69.8 (66.5–72.9)[c]	27,265	20.2 (16.8–23.6)[c]
Well child visit at age 11–12 years								
Yes	36,195	57.2 (55.8–58.7)	30,667	54.6 (53.8–55.4)[c]	5528	74.5 (72.6–76.4)[c]	63,304	19.9 (17.8–22.0)[c]
No[b]	10,427	38.3 (36.7–39.8)	9052	37.0 (35.8–38.2)	1375	49.1 (45.3–52.9)	27,072	12.1 (8.0–16.1)[c]
Don’t know	20,536	50.6 (48.5–52.7)	16,594	48.2 (47.1–49.2)[c]	3942	63.7 (61.2–66.2)[c]	41,177	15.6 (12.8–18.3)[c]
Number of providers								
1	37,762	52.0 (50.6–53.4)	32,295	50.0 (49.2–50.7)[c]	5467	66.8 (64.6–69.0)	72,877	16.9 (14.5–19.2)[c]
2	18,747	50.7 (49.1–52.3)	15,457	48.1 (47.0–49.2)	3290	65.9 (63.3–68.4)	36,977	17.8 (15.0–20.6)[c]

	Total (*N* = 131,553)		Born in 1999–2006 (*N* = 115,628)		Born in 2007–2009 (*N* = 15,925)		Difference Born in (2007–2009) - (1999–2006) (*N* = 131,553)	
	n	weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)	n	Weighted % (95 % CI)
≥3[a]	10,647	50.0 (48.3–51.7)	8559	46.7 (45.3–48.1)	2088	66.7 (63.4–69.8)	21,247	20.0 (16.5–23.4)[c]
Metropolitan statistical area (MSA)								
MSA Principal City[a]	29,241	55.3 (54.0–56.6)	24,588	53.1 (52.2–54.0)	4653	69.6 (67.2–71.9)	52,636	16.5 (14.0–19.0)[c]
MSA Non-Principal City	26,085	48.7 (47.0–50.4)	21,679	46.3 (45.5–47.1)[c]	4406	64.3 (62.0–66.5)[c]	53,913	18.0 (15.6–20.3)[c]
Non-MSA	11,832	47.2 (45.6–48.7)	10,046	44.8 (43.6–46.0)[c]	1786	63.7 (60.1–67.0)[c]	25,004	18.9 (15.2–22.5)[c]
Census Region								
Northeast[a]	13,097	48.3 (45.6–51.0)	10,949	46.0 (44.9–47.0)	2148	64.0 (61.3–66.7)	25,635	18.1 (15.1–21.0)[c]
Midwest	14,779	50.5 (48.1–52.9)	12,278	47.7 (46.8–48.6)[c]	2501	68.9 (66.5–71.2)[c]	28,496	21.2 (18.7–23.7)[c]
South	23,965	48.9 (46.8–51.0)	20,170	46.5 (45.7–47.3)	3795	64.0 (61.6–66.4)	48,704	17.5 (15.0–20.1)[c]
West	15,317	57.8 (55.3–60.2)	12,916	55.9 (54.2–57.5)[c]	2401	69.7 (65.7–73.5)[c]	28,718	13.9 (9.6–18.1)[c]
Provider Facility Type								
All public facilities	31,482	50.0 (48.5–51.4)	26,686	47.6 (46.9–48.4)[c]	4796	66.9 (64.7–69.1)[c]	62,733	19.3 (16.9–21.6)[c]
All hospital facilities	8907	51.5 (49.4–53.7)	7704	49.6 (48.0–51.3)[c]	1203	65.1 (60.1–69.9)[c]	17,793	15.5 (10.4–20.7)[c]
All private facilities[a]	9416	55.2 (53.4–57.1)	7861	53.1 (51.5–54.8)	1555	67.5 (63.3–71.4)	17,050	14.4 (10.0–18.7)[c]
All other facilities[e]	953	48.7 (44.2–53.3)	809	46.1 (41.4–50.8)[c]	144	71.6 (59.8–81.1)[c,e]	2049	25.5 (13.8–37.3) [c,e]
Mixed[i]	15,719	54.7 (53.2–56.2)	12,679	51.8 (50.5–53.0)	3040	69.2 (66.4–71.9)	29,022	17.4 (14.5–20.4)[c]
Other (Military/WIC/Pharmacy)	680	30.9 (26.4–35.8)	573	31.1 (27.3–35.1)[c]	107	30.3 (22.4–39.5)[c]	2003	−0.8 (−10.3,8.7)

Abbreviations: WIC, Women, Infant and Children program; HPV, human papillomavirus; CI, Confidence Interval.

[a]Reference group.

[b]Reported by parent/guardian respondent. Adolescents of Hispanic ethnicity may be of any race. ‘Other’ indicates that the adolescents identified as American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander or multiracial.

[c]Statistically significant ($P < .05$) compared with the reference group.

[e]Estimate might be unreliable because CI half-width is >10.

[f]Poverty is defined as an individual or family’s income being below the federal annual threshold.

[g] Any Medicaid: Teen covered by Medicaid with or without any other type of insurance. Teen with any mention of Medicaid coverage will belong to this category of insurance.

[h] Other insurance: Teen covered by insurance type other than private or Medicaid.

[i] Mixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, military, WIC and pharmacy.

Table 3

Missed Opportunities for HPV Vaccination before Age 13 years and Potentially Achievable Coverage for 1999–2009 Birth Year Cohorts, National Immunization Survey-Teen, United States, 2016–2022.

Demographic Characteristics	Overall Coverage With ≥ 1 Dose HPV Vaccine (Total Sample Size *N* = 131,553)		Unvaccinated Adolescents With ≥ 1 Missed Opportunities for HPV Vaccination. (Total *N* = 38,568)		Potential Coverage With ≥ 1 Dose of HPV Vaccine If No Missed Opportunity. (Total N = 131,553)	
	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)
Total	92,985	70.6 (69.6–71.6)	31,513	82.5 (81.4–83.5)	124,498	94.8 (94.5–95.2)
Age at Interview						
13 years [a]	18,056	65.0 (63.3–66.7)	7490	80.5 (78.7–82.1)	25,546	93.2 (92.5–93.8)
14 years	19,491	69.7 (68.2–71.1)	6969	84.2 (82.1–86.0)	26,460	95.2 (94.5–95.8)
15 years	19,272	72.2 (70.9–73.5)	6182	84.0 (82.6–85.4)	25,454	95.6 (95.1–96.0)
16 years	19,431	72.5 (71.2–73.8)	5940	81.2 (79.2–83.1)	25,371	94.8 (94.2–95.4)
17 years	16,735	74.0 (72.8–75.2)	4932	82.7 (80.3–84.9)	21,667	95.5 (94.8–96.1)
Age grouped at Interview						
13–15 years [a]	56,819	69.0 (67.9–70.1)	20,641	82.7 (81.5–84.0)	77,460	94.7 (94.2–95.0)
16–17 years	36,166	73.2 (72.2–74.2)	10,872	81.9 (80.1–83.6)	47,038	95.2 (94.6–95.6)
Sex						
Male [a]	47,547	68.4 (67.3–69.6)	17,726	81.8 (80.6–83.0)	65,273	94.3 (93.8–94.7)
Female	45,438	72.9 (71.8–73.9)	13,787	83.2 (81.8–84.5)	59,225	95.4 (95.1–95.8)
Race and Ethnicity [b]						
Non-Hispanic White [a]	55,195	66.5 (65.5–67.5)	21,792	83.9 (82.9–84.8)	76,987	94.6 (94.2–95.0)
Non-Hispanic Black	8515	74.1 (72.5–75.7)	2259	83.2 (81.1–85.2)	10,774	95.7 (95.1–96.2)
Hispanic	17,931	76.3 (74.7–77.8)	4272	78.7 (75.8–81.3)	22,203	94.9 (94.3–95.5)
Other	11,344	72.7 (70.7–74.6)	3190	80.8 (78.1–83.1)	14,534	94.7 (93.8–95.6)
Mother's educational level						
<High School [a]	9514	77.5 (75.5–79.3)	2140	75.6 (71.7–79.1)	11,654	94.5 (93.7–95.2)
High School	13,857	70.2 (68.7–71.6)	4626	79.8 (77.6–81.8)	18,483	94.0 (93.3–94.6)
Some college or college graduate	22,460	67.1 (65.9–68.2)	8914	82.2 (80.7–83.6)	31,374	94.1 (93.6–94.6)
>College graduate	47,154	70.9 (69.6–72.1)	15,833	85.5 (84.3–86.7)	62,987	95.8 (95.4–96.1)
Mother's married status						

Demographic Characteristics	Overall Coverage With ≥ 1 Dose HPV Vaccine (Total Sample Size *N* = 131,553)		Unvaccinated Adolescents With ≥ 1 Missed Opportunities for HPV Vaccination. (Total *N* = 38,568)		Potential Coverage With ≥ 1 Dose of HPV Vaccine If No Missed Opportunity. (Total N = 131,553)	
	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)
Married/Living with partner [a]	63,577	68.7 (67.6–69.8)	23,619	84.0 (82.7–85.3)	87,196	95.0 (94.6–95.4)
Widowed/divorced/separated	15,997	72.0 (70.5–73.4)	4802	79.3 (77.6–80.9)	20,799	94.2 (93.6–94.7)
Never married	6589	76.1 (74.4–77.7)	1447	80.2 (76.5–83.5)	8036	95.3 (94.4–96.0)
Mother's Age						
≤34 years [a]	6657	72.0 (70.1–73.7)	1989	73.7 (70.1–76.9)	8646	92.6 (91.4–93.6)
35–44 years	38,240	69.8 (68.5–71.1)	13,743	81.6 (80.1–83.0)	51,983	94.4 (94.0–94.9)
≥45 years	48,088	71.2 (70.1–72.2)	15,781	84.6 (83.3–85.9)	63,869	95.6 (95.2–95.9)
Immigration status						
Born in U.S. [a]	88,203	70.4 (69.4–71.4)	30,079	82.1 (81.0–83.2)	118,282	94.7 (94.4–95.0)
Born outside U.S.	4163	74.5 (72.0–76.9)	1201	88.5 (85.5–90.9)	5364	97.1 (96.3–97.7)
Poverty Status [c]						
At or above poverty level [a]	74,790	69.1 (68.0–70.1)	26,873	83.0 (81.7–84.2)	101,663	94.7 (94.3–95.1)
Below poverty level	14,993	76.9 (75.2–78.5)	3625	79.2 (77.2–81.1)	18,618	95.2 (94.7–95.6)
Health Insurance Status						
Private Only [a]	53,824	68.9 (67.8–70.1)	19,586	85.2 (83.9–86.4)	73,410	95.4 (95.0–95.8)
Any Medicaid[d]	29,474	75.2 (74.0–76.3)	7915	79.0 (77.3–80.6)	37,389	94.8 (94.4–95.2)
Other[e]	7044	66.5 (64.9–68.1)	2790	80.9 (77.7–83.8)	9834	93.6 (92.5–94.6)
Uninsured	2643	59.3 (56.3–62.2)	1221	76.2 (72.5–79.6)	3864	90.3 (88.8–91.6)
Number of provider visits last 12 months						
0 [a]	10,572	63.3 (61.3–65.2)	4881	76.2 (74.5–77.9)	15,453	91.3 (90.5–92.0)
1	27,096	70.6 (69.4–71.7)	9253	82.8 (81.2–84.4)	36,349	94.9 (94.4–95.4)
2–3	34,567	72.6 (71.5–73.7)	10,810	84.1 (82.4–85.6)	45,377	95.6 (95.2–96.1)
4+	19,876	72.9 (71.6–74.1)	6353	85.7 (83.6–87.6)	26,229	96.1 (95.5–96.7)
Preventative visit at age 11–12 years[‡]						
Yes	48,725	76.5 (75.4–77.6)	13,858	94.9 (94.2–95.6)	62,583	98.8 (98.6–99.0)
No [a]	16,294	60.7 (59.1–62.2)	8032	73.8 (71.6–75.9)	24,326	89.7 (88.7–90.6)
Don't know	27,966	68.3 (66.8–69.8)	9623	75.9 (74.2–77.4)	37,589	92.4 (91.8–92.9)

Vaccine. Author manuscript; available in PMC 2025 January 12.

Demographic Characteristics	Overall Coverage With ≥ 1 Dose HPV Vaccine (Total Sample Size *N* = 131,553)		Unvaccinated Adolescents With ≥ 1 Missed Opportunities for HPV Vaccination. (Total *N* = 38,568)		Potential Coverage With ≥ 1 Dose of HPV Vaccine If No Missed Opportunity. (Total N = 131,553)	
	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)	n	Weighted % (95 % C.I.)
Number of providers						
1	52,959	72.2 (71.1–73.3)	16,751	85.0 (83.9–86.1)	69,710	95.8 (95.5–96.2)
2	25,705	69.7 (68.4–70.9)	9157	81.1 (79.0–83.1)	34,862	94.3 (93.7–94.8)
≥3 [a]	14,319	66.9 (65.4–68.4)	5603	78.9 (76.6–81.0)	19,922	93.0 (92.2–93.8)
Metropolitan statistical area (MSA)						
MSA Principal City [a]	39,297	74.2 (73.2–75.3)	10,646	80.3 (78.4–82.1)	49,943	94.9 (94.5–95.4)
MSA Non-Principal City	37,499	69.2 (67.9–70.6)	13,723	84.5 (83.4–85.6)	51,222	95.2 (94.8–95.6)
Non-MSA	16,189	63.2 (61.7–64.7)	7144	80.5 (78.9–82.1)	23,333	92.8 (92.1–93.5)
Census Region						
Northeast[a]	19,765	74.2 (72.2–76.0)	5115	89.3 (87.8–90.7)	24,880	97.2 (96.8–97.6)
Midwest	20,350	70.7 (69.1–72.4)	6719	83.8 (82.3–85.2)	27,069	95.3 (94.7–95.8)
South	32,891	67.1 (65.3–68.9)	12,976	82.9 (81.7–84.0)	45,867	94.4 (93.8–94.9)
West	19,979	73.9 (72.1–75.6)	6703	75.6 (72.9–78.1)	26,682	93.6 (92.9–94.3)
Provider Facility Type						
All public facilities	44,984	70.9 (69.8–71.9)	15,020	84.7 (83.3–86.1)	60,004	95.6 (95.1–95.9)
All hospital facilities	12,057	69.1 (67.3–70.9)	4478	77.0 (74.6–79.3)	16,535	92.9 (92.1–93.6)
All private facilities [a]	12,645	73.5 (71.8–75.1)	3423	77.6 (75.4–79.7)	16,068	94.1 (93.3–94.8)
All other facilities	1343	69.5 (65.3–73.4)	570	82.4 (76.5–87.0)	1913	94.6 (92.7–96.1)
Mixed[f]	21,066	73.0 (71.6–74.3)	7092	88.3 (86.8–89.8)	28,158	96.8 (96.4–97.3)
Other (Military/WIC/Pharmacy)	889	39.8 (34.7–45.1)	928	82.8 (78.2–86.6)	1817	89.7 (86.6–92.1)

Abbreviations: WIC, Women, Infant and Children program; HPV, human papillomavirus; CI, Confidence Interval.

[a]Reference group.

[b]Reported by parent/guardian respondent. Adolescents of Hispanic ethnicity may be of any race. ‘Other’ indicates that the adolescents identified as American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander or multiracial.

[c]Poverty is defined as an individual or family’s income being below the federal annual threshold.

[d]Any Medicaid: Teen covered by Medicaid with or without any other type of insurance. Teen with any mention of Medicaid coverage will belong to this category of insurance.

[e]Other insurance: Teen covered by insurance type other than private or Medicaid.

[f] Mixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, military, WIC and pharmacy.