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Human papillomavirus vaccine administration opportunities at well visits in adolescents

Kunal Saxena^{1*}, Lei Ai¹, Amanda Martino¹, Aneesha Fathima Syed Mohamed¹, Dong Wang¹, Yi Zheng¹ and Kristin Oliver²

Abstract

Background Despite the effectiveness of the human papillomavirus (HPV) vaccine, uptake in the United States (US) remains suboptimal, with only about half of US adolescents completing the HPV vaccine series before the recommended age of 13. Adolescents are more likely to be vaccinated at annual well visits, making these visits key opportunities to promote HPV vaccination and improve overall completion rates of the HPV vaccination series. Further, it has been suggested that HPV vaccine initiation at age 9 may increase overall adolescent coverage of HPV vaccine. This study aimed to describe patterns in HPV vaccine administration during adolescent well visits and quantify potential HPV vaccination opportunities at age 9.

Methods This retrospective descriptive analysis included adolescents aged 9–14 years with continuous enrollment from 2018 to 2022 in the MarketScan Commercial or the Multi-State Medicaid databases. We analyzed percentages of well visits and administered vaccines for each age cohort and calendar year. We assessed potential opportunities for HPV vaccination among adolescents at the 9-, 10-, 11-, and 12-year well visits.

Results Most age 9 well visits showed no vaccine claims (89.0–91.7%) while claims for two and three concurrent vaccines at age 11 occurred in 22.2–37.2% of well visits, most often for meningococcal and Tdap vaccines. Claims for HPV vaccine initiation at 11 and 12 years remained suboptimal (17.9–24.3%). We identified several potential opportunities for HPV vaccination. Among adolescents who did not receive the HPV vaccine at their 9- or 10-year well visits, 34.8–36.9% did not have a well visit at 11 or 12 years. Among adolescents with an 11- and 12-year well visit, 20.6–30.0% had claims for vaccination, but not the HPV vaccine. Among adolescents with a well visit at 11 or 12 years who received one or more other vaccinations, but not the HPV vaccine, 40.6–46.1% had a well visit at 9 or 10 years and did not initiate the HPV vaccine then.

Conclusions Routine HPV vaccination beginning at age 9 well visits could optimize opportunities to improve vaccine coverage.

Keywords Human papillomavirus, Vaccination, Preventive health, Routine vaccination, Adolescents, Vaccination coverage

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Introduction

In the United States (US), approximately 37,000 people are diagnosed with human papillomavirus (HPV)-related cancers annually [1]. HPV vaccination has been recommended to prevent HPV-related diseases and cancers for girls since 2006 and for boys since 2011 in the US [2]. The Advisory Committee on Immunization Practices (ACIP) recommends initiating routine HPV vaccination series at 11–12 years and states that adolescents can start the vaccination series at 9 years [3, 4]. In an effort to increase HPV vaccine uptake, the American Academy of Pediatrics (AAP) also expanded their recommendation for HPV vaccination initiation to start between ages 9 and 12 [5, 6].

Despite the effectiveness of HPV vaccination and the fact that HPV-related deaths exceed those of other diseases preventable by the other vaccinations given at this age in the US [3, 6, 7], rates of vaccination against HPV continues to be suboptimal and remain below that of other routine vaccinations such as the quadrivalent meningococcal (MenACWY) vaccine and the tetanus, diphtheria, and pertussis (Tdap) vaccine [8, 9]. According to the 2023 National Immunization Survey-Teen data, among adolescents aged 13–17 years, 89.0% received ≥ 1 Tdap dose, 88.4% received ≥ 1 MenACWY dose, 76.8% received ≥ 1 HPV vaccine dose, and only 61.4% were up-to-date with HPV vaccination [8].

Given the recommendations in the ACIP and AAP guidelines, healthcare providers have greater flexibility in introducing the HPV vaccine before age 11. Studies have shown that initiating the HPV vaccine series at age 9 is associated with higher rates of on-time vaccination completion than later initiation [10–15]. However, data from the 2020 National Immunization Survey indicates that less than 5% of adolescents initiate HPV vaccination at their 9- or 10-year well visit [13]. Parents or adolescents who have vaccine “fatigue” and those who prefer not to receive the HPV vaccine concomitantly with other vaccines included in the vaccination schedule for 11- and 12-year-olds (i.e., MenACWY, Tdap, and yearly influenza vaccines) may also prefer earlier HPV vaccine introduction [6, 16]. A qualitative survey of healthcare providers in the US found that parental acceptance of proactive initiation of the HPV vaccination series is higher when the discussion of its benefits occurs at a younger age [17]. In addition, the reduced number of vaccines required per visit when starting the series earlier also plays a role in parental acceptance, as it helps to avoid the “over saturation” of vaccinations at age 11 well visits [17].

In adolescents, implementing HPV vaccination at the earliest opportunity results in a robust immune response, and HPV immunization is most effective when administered before sexual debut [18]. In the US, 7% of adolescents report their first sexual experience by age 13, with

30% of females and 34% of males being sexually active by age 16 [19]. Given the increase in sexual activity between ages 13 and 16, completing the HPV vaccination series by age 13 would provide greater population-level protection against HPV-related diseases [15]. Initiating the vaccine earlier also affords healthcare providers the opportunity to discuss HPV recommendations separate from discussions of sexuality that typically occur at visits with patients ages 11 or 12 and aids in preventing HPV-attributable cancers before sexual debut [6].

Missed opportunities for HPV vaccination are widespread and are a significant contributor to low vaccination rates [20–24]. Adolescents are more likely to be vaccinated at annual well visits; therefore, well visits provide opportunities to promote HPV vaccination per national guidelines and subsequently lead to higher completion rates of the HPV vaccination series [14, 25]. Understanding vaccination patterns and identifying potential opportunities among the adolescent population can help to inform vaccination strategies aimed at improving HPV vaccination rates. The objective of this study was to examine patterns in vaccine administration among US adolescents (9–14 years of age) at well visits by age and identify missed opportunities for initiating HPV vaccination.

Methods

Data sources

We performed a retrospective descriptive analysis using data from the Merative MarketScan Commercial Claims and Encounters Database and the MarketScan Multi-State Medicaid Database. These databases include health insurance claims across the continuum of care, including inpatient, outpatient, and outpatient pharmacy, and enrollment data from large employers and health plans across the US. The MarketScan Commercial Claims and Encounters Database (hereby referred to as ‘commercial’) is a medical and drug insurance claims database that includes approximately 174 million unique de-identified patients insured by employer-sponsored plans, including active employees, early retirees, COBRA continuers, and their dependents. The MarketScan Multi-State Medicaid Database (hereby referred to as ‘Medicaid’) includes approximately 60 million unique enrollees across 12 health plans, including employees of large employers (> 100 employees) from across the US, in addition to their spouses and dependents. The database covers 25 million annual lives from Medicaid-managed care programs in 28 US states. Both databases are primarily used for research purposes and fully comply with US privacy laws and regulations (e.g., HIPAA); therefore, the study did not require Institutional Review Board approval or specific informed consent.

Study sample

Adolescents aged 9–14 years residing in the US and with yearly continuous enrollment in these databases from January 1, 2018 through December 31, 2022 were eligible for inclusion in the study. During the study period, we included only adolescents who had at least one claim associated with an annual well visit.

Study measures

The outcome measures were the number and percentage of well visits, claims for the number of concurrent vaccines administered (categorized as 0, 1, 2, 3, or ≥ 4), and type of concurrent vaccination claims by age and year. We defined a well visit as one visit per service date for a unique patient. Well visits were classified as Current Procedural Terminology (CPT) codes 99,381, 99,382, 99,383, 99,384, 99,391, 99,392, 99,393, 99,394 or International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes Z00.121 or Z00.129. Supplemental Table 1 contains the CPT/Healthcare Common Procedure Coding System (HCPCS) codes for the vaccines of interest in the study, including HPV, Tdap, MenACWY, influenza, and catch-up vaccinations (hepatitis A [HepA]; hepatitis B [HepB], measles, mumps, rubella, and varicella [MMRV], and varicella [VAR]). We included vaccines administered during well visits if the vaccines were within two days of the well visit dates.

We assessed potential opportunities for HPV vaccination among adolescents at the 9- and 10-year well visit as well as the 11- and 12-year well visit. For the first analysis, we quantified opportunities in adolescents who attended a 9- or 10-year well visit but did not receive the HPV vaccine and did not return for an 11- or 12-year well visit (see Supplemental Fig. 1 for enrollment requirements). For the second analysis, we quantified three potential opportunities among adolescents with a well visit at 11 or 12 years. The first opportunity was among 11- and 12-year-olds who attended a well visit and received one or more vaccinations but did not receive the HPV vaccine. The second opportunity was among 12-year-olds who attended an 11-year well visit and received other vaccinations but did not receive the HPV vaccine, and did not receive the HPV vaccine at the 12-year well visit. The final opportunity was among adolescents who did not receive the HPV vaccine at their 11- or 12-year well visit, and had a well visit at age 9 or 10 and missed the opportunity to receive it.

Statistical analysis

We analyzed the commercial and Medicaid databases separately. We examined the distributions of adolescents with well visits and claims for the number and types of vaccinations received by year and age group. We also assessed distributions of HPV initiation and completion

by year and age groups. For each outcome, we report the numbers and percentages of patients. We use descriptive statistics to describe potential opportunities for HPV vaccine administration. Data were analyzed using R statistical software.

Results

Study population

The commercial and Medicaid study populations included 2,544,846 and 1,832,960 adolescents, respectively, who were 9–14 years of age, had full calendar year enrollment from 2018 to 2022, and had an annual well visit (Supplemental Fig. 2).

Well visits

The percentage of patients with well visits between 9 and 14 years in all age groups ranged from 55.8 to 72.4% in the commercial population (Fig. 1A, Supplemental Table 2) and from 38.9 to 53.0% in the Medicaid population (Fig. 1B, Supplemental Table 2). In the commercial population, well visits ranged from 55.8–62.2% at 9–10 years, and 65.5–71.1% at 11–12 years. In the Medicaid population, well visits ranged from 38.5–45.0% at age 9–10 years, and 42.5–53.0% at age 11–12 years.

Sample demographics

In the commercial and Medicaid populations, throughout 2018–2022, each age group included a similar percentage of adolescents (Table 1). For both populations, a slightly higher percentage of adolescents were males. The most common insurance type in the commercial population was preferred provider organization (PPO). In the Medicaid population, most coverage was provided by health maintenance organizations (HMOs).

Vaccine claims

In the commercial and Medicaid populations, most age 9 well visits showed no vaccine claims (89.0% and 91.7%, respectively; Fig. 2). In the commercial population, age 11 well visits showed 37.2% claims for two concurrent vaccines and 34.9% claims for three concurrent vaccines (Fig. 2A, Supplemental Table 3, Fig. 3). In the Medicaid population, age 11 well visits showed 22.2% claims for two concurrent vaccines and 34.3% claims for three concurrent vaccines (Fig. 2B, Supplemental Table 4, Fig. 3).

Vaccine claims by type of vaccine

In both the commercial and Medicaid populations, among 11-year-olds with concurrent vaccination claims, the most common claims were for MenACWY and Tdap vaccinations (Fig. 3). In the commercial population, 38.2–39.9% of the concurrent vaccination claims were for MenACWY and 36.0–37.4% were for Tdap and 17.9–19.4% were for HPV initiation (Supplemental Table 5). In

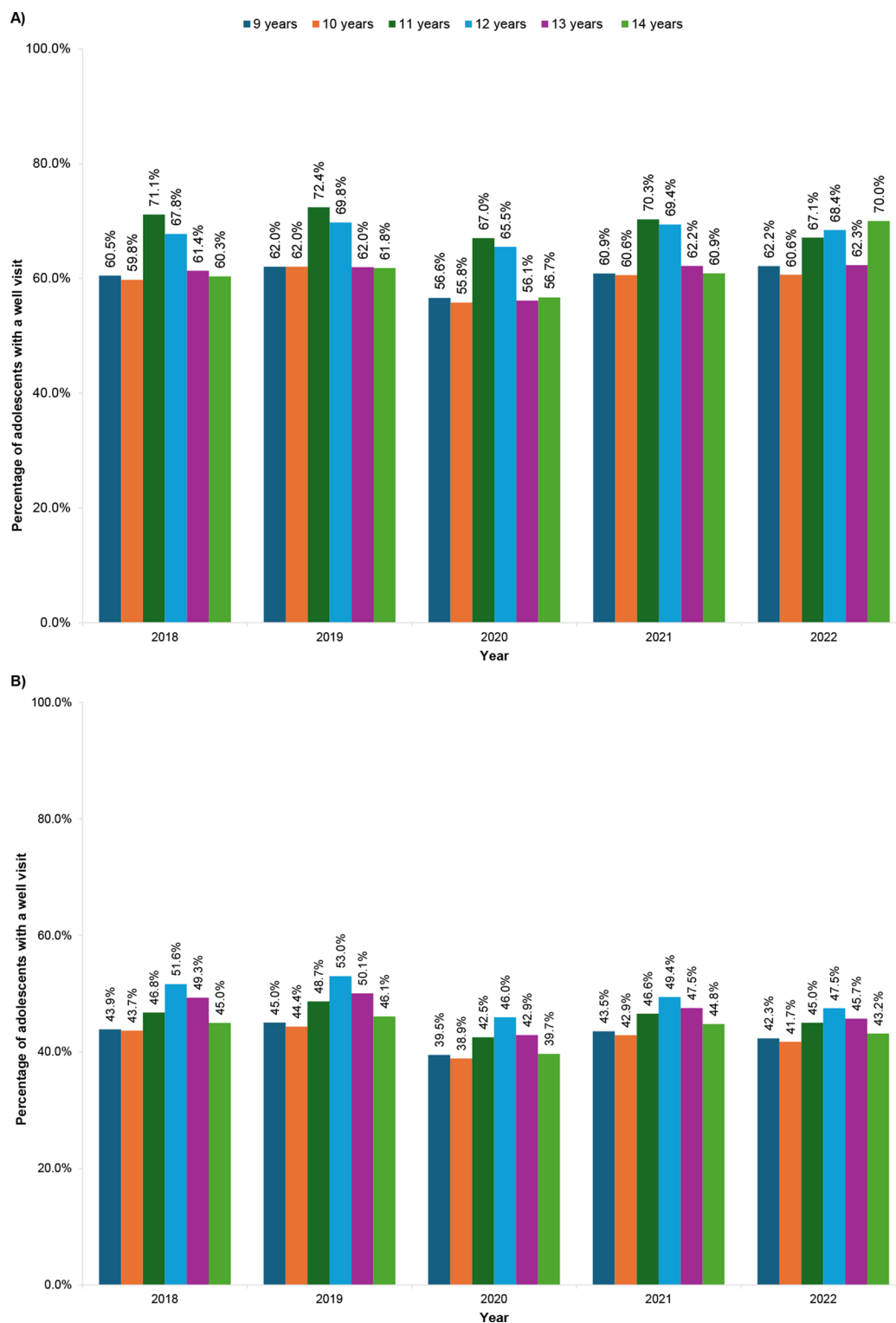


Fig. 1 Percentage of adolescents with annual well visits in the **A)** commercial and **B)** Medicaid populations, by age and year

the Medicaid population, 35.3–36.6% of the concurrent vaccination claims at age 11 well visits were for Men-ACWY, 35.3–36.2% were for Tdap, and 21.7–24.3% were for HPV initiation (Supplemental Table 6).

Potential opportunities

We assessed potential opportunities for HPV vaccination among adolescents with a well visit at ages 9 or 10 and ages 11 or 12 (Table 2). Among unique adolescents with

Table 1 Demographic characteristics of the commercial and medicaid populations ^A

Commercial population	2018 <i>n</i> = 1,028,387	2019 <i>n</i> = 964,756	2020 <i>n</i> = 857,168	2021 <i>n</i> = 841,192	2022 <i>n</i> = 783,178
Age					
9	152,104 (14.8)	142,179 (14.7)	126,074 (14.7)	124,579 (14.8)	119,680 (15.3)
10	155,690 (15.1)	145,545 (15.1)	126,192 (14.7)	125,569 (14.9)	118,076 (15.1)
11	191,817 (18.7)	177,350 (18.4)	156,705 (18.3)	149,477 (17.8)	138,756 (17.7)
12	186,792 (18.2)	177,356 (18.4)	159,944 (18.7)	152,988 (18.2)	139,710 (17.8)
13	169,970 (16.5)	161,241 (16.7)	142,026 (16.6)	143,254 (17.0)	132,030 (16.9)
14	172,014 (16.7)	161,085 (16.7)	146,227 (17.1)	145,325 (17.3)	134,916 (17.2)
Sex					
Male	526,686 (51.2)	492,947 (51.1)	436,609 (50.9)	430,404 (51.2)	400,211 (51.1)
Female	501,701 (48.8)	471,809 (48.9)	420,559 (49.1)	410,788 (48.8)	382,967 (48.9)
Region					
North central	231,845 (22.5)	208,467 (21.6)	191,858 (22.4)	201,541 (24.0)	178,699 (22.8)
Northeast	237,681 (23.1)	217,482 (22.5)	186,266 (21.7)	136,460 (16.2)	140,238 (17.9)
South	397,856 (38.7)	392,500 (40.7)	351,416 (41.0)	359,208 (42.7)	327,099 (41.8)
West	4,493 (0.4)	4,688 (0.5)	1,974 (0.2)	922 (0.1)	4,482 (0.6)
Unknown	156,512 (15.2)	141,619 (14.7)	125,654 (14.7)	143,061 (17.0)	132,660 (16.9)
Insurance type					
Basic/major medical	0 (0)	210 (<0.1)	31 (<0.1)	29 (<0.1)	29 (<0.1)
CDHP	117,608 (11.4)	115,544 (12.0)	106,017 (12.4)	100,617 (12.0)	92,625 (11.8)
Comprehensive	17,538 (1.7)	8,670 (0.9)	12,148 (1.4)	14,308 (1.7)	12,959 (1.7)
EPO	7,244 (0.7)	7,674 (0.8)	8,390 (1.0)	9,283 (1.1)	5,248 (0.7)
HDHP	147,575 (14.4)	145,520 (15.1)	138,398 (16.1)	159,423 (19.0)	153,044 (19.5)
HMO	127,222 (12.4)	116,744 (12.1)	105,670 (12.3)	105,045 (12.5)	104,648 (13.4)
POS	87,996 (8.6)	75,984 (7.9)	61,930 (7.2)	68,881 (8.2)	66,602 (8.5)
POS with capitation	9,367 (0.9)	9,756 (1.0)	940 (0.1)	781 (0.1)	847 (0.1)
PPO	488,262 (47.5)	469,926 (48.7)	402,087 (46.9)	368,371 (43.8)	333,564 (42.6)
Missing	25,575 (2.5)	14,728 (1.5)	21,557 (2.5)	14,453 (1.7)	13,612 (1.7)
Medicaid population	2018 <i>n</i> = 616,500	2019 <i>n</i> = 704,957	2020 <i>n</i> = 665,583	2021 <i>n</i> = 617,184	2022 <i>n</i> = 615,161
Age					
9	99,453 (16.1)	108,284 (15.4)	101,912 (15.3)	96,455 (15.6)	97,795 (15.9)
10	99,971 (16.2)	111,063 (15.8)	101,458 (15.2)	94,245 (15.3)	95,777 (15.6)
11	106,592 (17.3)	123,063 (17.5)	115,162 (17.3)	102,512 (16.6)	102,525 (16.7)
12	115,202 (18.7)	132,882 (18.8)	125,468 (18.9)	112,559 (18.2)	108,323 (17.6)
13	104,167 (16.9)	122,999 (17.4)	116,437 (17.5)	109,240 (17.7)	107,827 (17.5)
14	91,115 (14.8)	106,666 (15.1)	105,146 (15.8)	102,173 (16.6)	102,914 (16.7)
Sex					
Male	316,553 (51.3)	362,390 (51.4)	339,892 (51.1)	316,531 (51.3)	315,226 (51.2)
Female	299,947 (48.7)	342,567 (48.6)	325,691 (48.9)	300,653 (48.7)	299,935 (48.8)
Insurance					
Comprehensive	193,694 (31.4)	263,426 (37.4)	249,449 (37.5)	111,865 (18.1)	119,523 (19.4)
HMO	422,806 (68.6)	441,531 (62.6)	416,134 (62.5)	487,407 (79.0)	476,215 (77.4)
POS with capitation	0 (0.0)	0 (0.0)	0 (0.0)	17,912 (2.9)	8,615 (1.4)
Missing	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10,808 (1.8)

CDHP, consumer driven health plan; EPO, exclusive provider organization; HDHP, high deductible health plan; HMO, health maintenance organization; POS, point-of-service; PPO, preferred provider organization

^A Values are presented as n (%)

a well visit at ages 9 or 10 who did not receive the HPV vaccination at their 9- or 10-year well visit, 34.8–36.9% did not have a well visit at ages 11 or 12. Three potential opportunities were observed among adolescents with a well visit at ages 11 or 12. Among adolescents with an

11- or 12-year well visit, 20.6–30.0% received one or more other vaccinations but not the HPV vaccine, representing the first potential opportunity at this timepoint. Among adolescents with an 11-year well visit who received one or more other vaccinations but not the HPV vaccine and

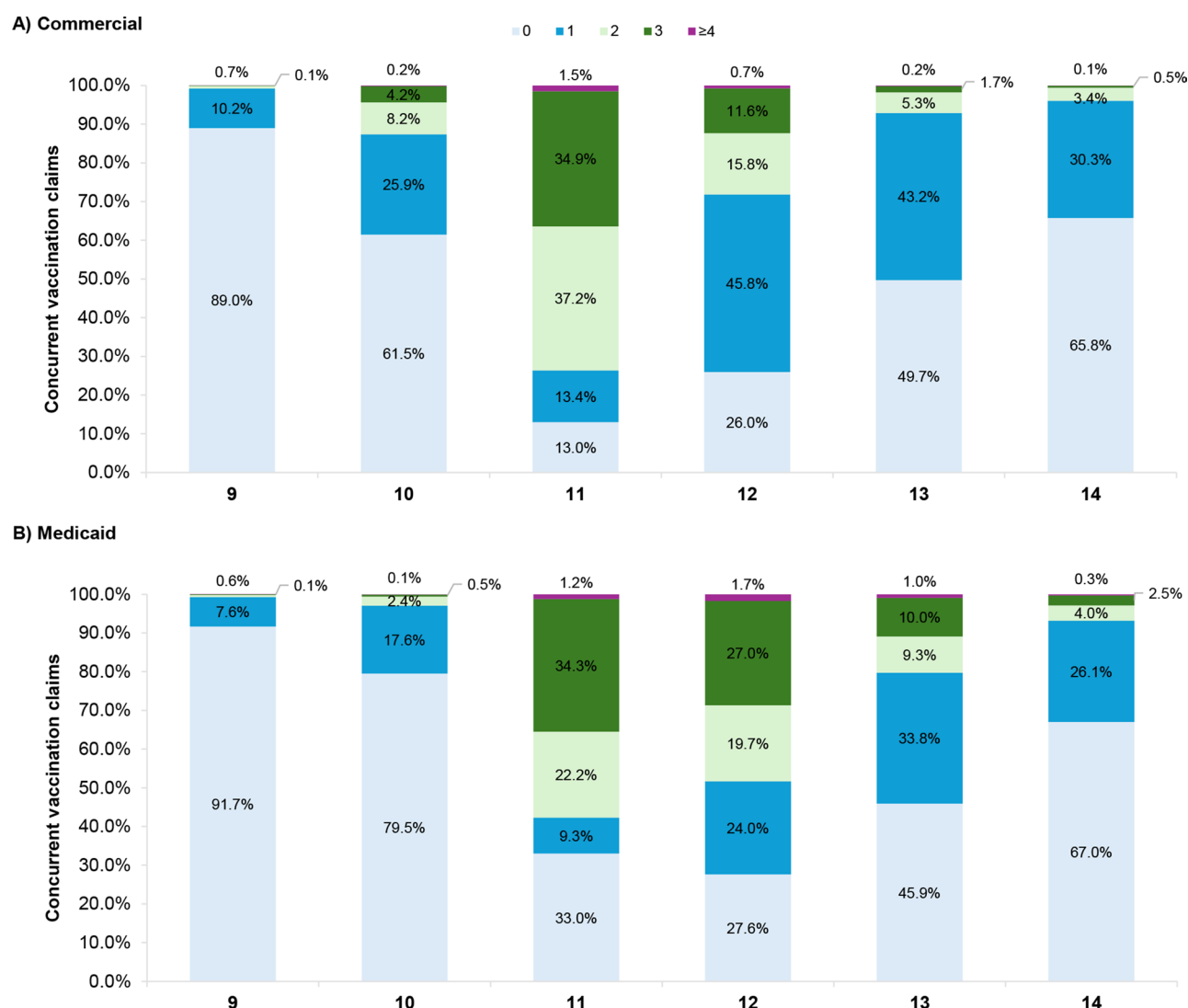


Fig. 2 Average (across 5 years) number of concurrent vaccinations administered in adolescents at well visits in the **A)** commercial and **B)** Medicaid populations ^A. ^A All percentages sum to 100%

had a 12-year well visit, 67.2–67.4% did not receive the HPV vaccine, representing the second potential opportunity at this timepoint. Finally, among adolescents with a well visit at ages 11 or 12 who received one or more other vaccinations, but not the HPV vaccine, 40.6–46.1% had a well visit at ages 9 or 10. Supplemental Table 7 displays the demographic characteristics for the commercial and Medicaid populations for potential opportunities.

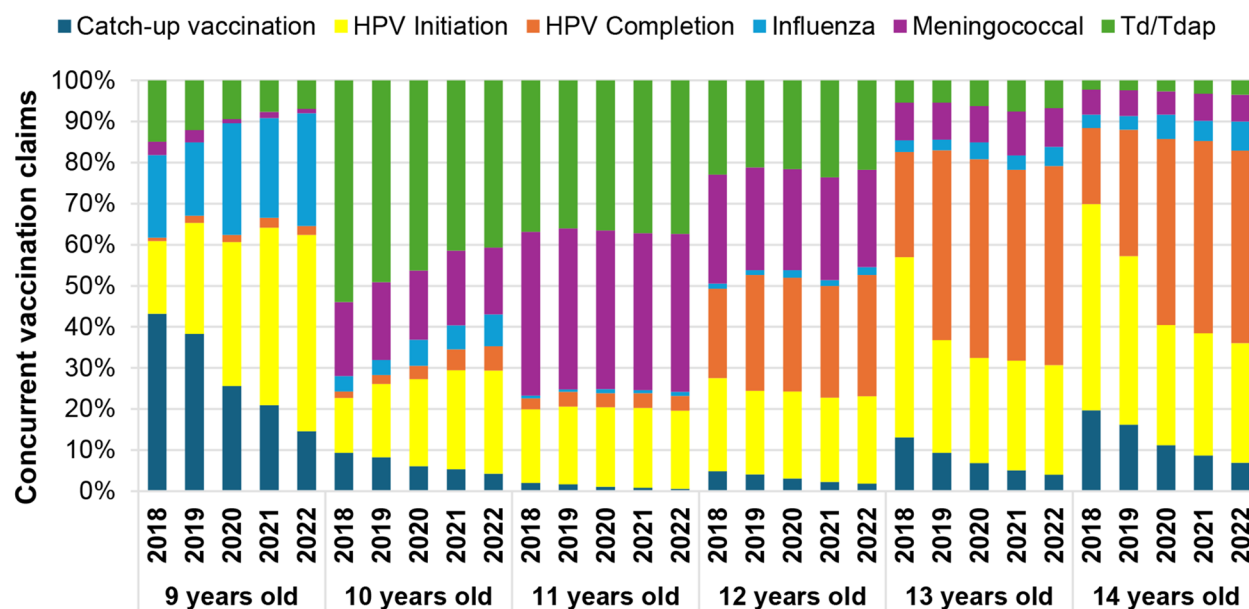
Discussion

Although the HPV vaccine has a proven safety and effectiveness record [26], only about half (50.1–52.8%) of US adolescents complete the series by the recommended age of 13 [8]. Current HPV vaccination rates are suboptimal and well below the 80% coverage goal set by the US Department of Health and Human Services Healthy People 2030 [9]. In fact, a recently published modeling study

predicted that, assuming current vaccination uptake rates, the 80% completion rate for adolescents aged 13–15 years would not be reached until year 2042 and beyond [27]. Well visits provide opportunities to initiate and promote HPV vaccine completion, but missed opportunities to initiate HPV vaccination during well visits are fairly common [14, 24, 25]. In the US President's Cancer Panel 2018 report, reducing missed opportunities for initiating the HPV vaccine when adolescents visit their healthcare provider for other preventive care services was identified as a top national priority for accelerating HPV vaccine uptake [28]. In this retrospective analysis using data from the commercial claims and Medicaid claims databases, we identified several potential opportunities for HPV vaccination among adolescents.

Adolescents are less likely to attend well visits as they age [25, 29]. A 2023 study of data from two pediatric

A) Commercial



B) Medicaid

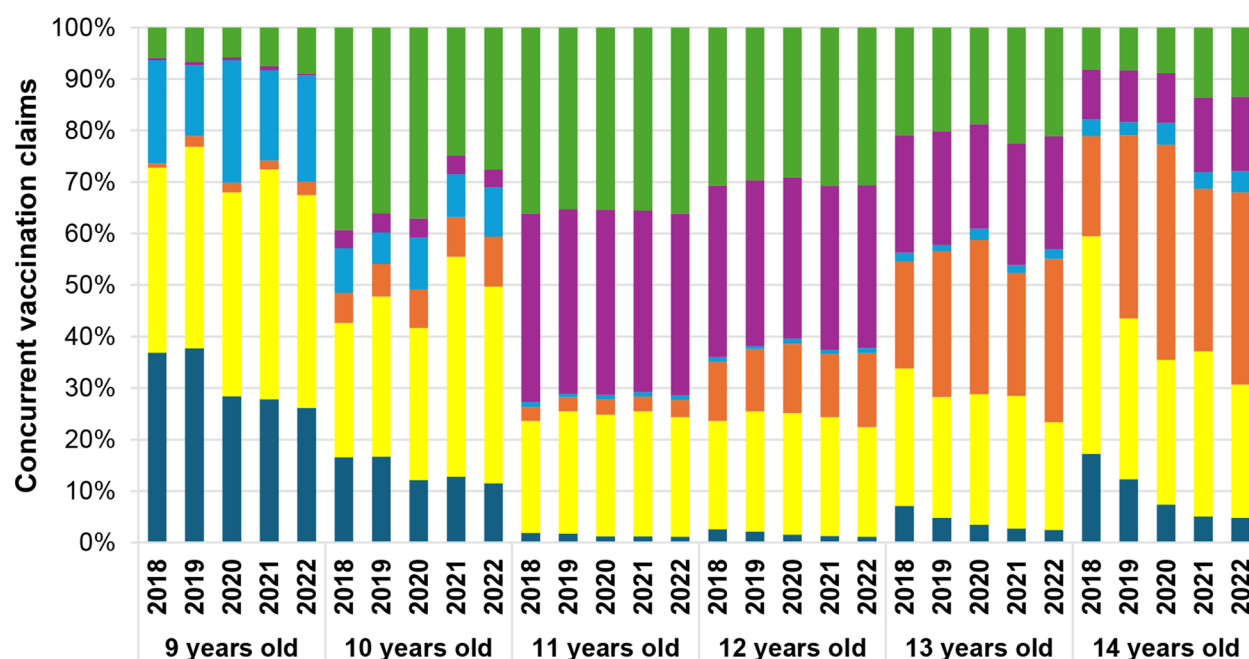


Fig. 3 Percentage of claims for vaccinations administered to adolescents in the **A)** commercial and **B)** Medicaid populations, by age and year ^A. HepA, hepatitis A; HepB, hepatitis B; HPV, human papillomavirus; MMRV, measles, mumps, rubella, and varicella; Td, tetanus-diphtheria; Tdap, tetanus-diphtheria-pertussis. ^A Among those who received vaccinations at the well visit. ^B Catch-up vaccination includes HepA, HepB, MMRV, and varicella

clinics in Washington between 2018 and 2022 reported that well visits decreased from a range of 62.6–76.2% in 9–10-year-olds to 62.8–72.2% in 11–12-year-olds and further decreased to a range of 50.2–65.6% in adolescents aged 13–17 years [25]. In our study, well visits were

highest among 11–12-year-olds, however, approximately one-third (34.8–36.9%) of adolescents in the present study had a well visit at ages 9 or 10 but did not have a well visit at ages 11 or 12. Encouraging HPV vaccination at age 9 could help reduce the impact of these missed well

Table 2 Potential opportunities for HPV vaccination among adolescents in the commercial and medicaid populations

Potential opportunity	Commercial	Medicaid
Adolescents who attended a 9- or 10-year well visit, n ^A	567,702	410,896
Potential opportunity: No HPV vaccine at 9- or 10-year well visit and no well visit at 11 or 12 years, n (%)	209,680 (36.9)	143,170 (34.8)
Adolescents who attended an 11- or 12-year well visit, n ^A	1,273,908	903,767
Potential opportunity: Received one or more other vaccinations, but not the HPV vaccine, n (%)	382,060 (30.0)	186,200 (20.6)
Potential opportunity: Adolescents who attended an 11-year well visit who received one or more other vaccinations, but not the HPV vaccine and who attended a 12-year well visit and did not receive the HPV vaccine, n (%)	98,197 (67.2)^B	33,422 (67.4)^B
Potential opportunity: Adolescents who attended an 11- or 12-year well visit who received one or more other vaccinations, but not the HPV vaccine and had a well visit at 9 or 10 years, n (%)	146,551 (46.1)^C	68,977 (40.6)^C

HPV, human papillomavirus

^A To identify a potential opportunity at 11 or 12 years, 9-year-olds were required to have a well visit in 2018 or 2019 and 10-year-olds were required to have a well visit in 2018–2020

^B Denominator was number of adolescents with a well visit at 11 years who received one or more other vaccinations, but not the HPV vaccine ($n=146,144$ for the Commercial population and $n=48,583$ for the Medicaid population)

^C Denominator was the number of adolescents with a well visit at 11 or 12 years who received one or more other vaccinations, but not the HPV vaccine and had enrollment in the 9- and 10-year period ($n=317,927$ for the Commercial population and $n=170,046$ for the Medicaid population)

visits especially among the Medicaid population. Adolescents in the Medicaid population reported lower percentages of well visits than the commercial population overall (38.9–53.0% vs. 55.8–72.4%). Routinely recommending HPV vaccination starting at age 9 could be particularly critical in populations with fewer well visits. We also observed that most age 9 well visits (89.0% and 91.7% in the commercial and Medicaid populations, respectively) showed no vaccine claims. However, at age 11 well visits, among both populations, 22.2–37.2% of claims were for two concurrent vaccines and 34.3–34.9% were for three concurrent vaccines. This demonstrates that the current adolescent vaccination platform at ages 11 or 12 may be working for some ACIP-recommended vaccines but may not be working as effectively for the HPV vaccine. Initiating HPV vaccination at age 9, when the majority of well visits did not have any vaccinations, may help avoid the oversaturation of vaccinations and potential deprioritization of HPV vaccination at age 11 well visits. In fact, a 2019 study reporting the results of qualitative interviews, noted that healthcare providers uniformly reported high

parental acceptance of the HPV vaccine before age 11 due to the opportunity to administer fewer vaccines at each visit [17]. In a national survey of pediatricians and family physicians, 35% of providers who did not almost always or always discuss the HPV vaccine at well visits reported that the reason was “the patient is already getting other vaccines at that visit” [30]. This lack of discussion further contributes to lower HPV vaccination rates. Among parents and guardians of girls aged 11 to 17, the most common reason for not vaccinating their daughters was the lack of a physician recommendation (44% of parents and guardians) [31]. Initiating HPV vaccination at age 9 well visits, when other vaccinations are not routinely occurring, may help improve HPV vaccination coverage rates.

While the ACIP recommends initiating routine HPV vaccination series at 11–12 years, with the option to vaccinate at age 9 [3, 4], the wording of this guideline may discourage providers from discussing the vaccine with parents during the 9–10-year well visit [32]. In a 2021 national provider survey, only 21% of primary care professionals reported that they routinely recommend HPV vaccination at ages 9 or 10 [33]. However, over half (61%) of the remaining respondents reported being somewhat or more willing to start routinely recommending vaccination at age 9 to 10 [33]. Aligning national guidelines to more strongly support initiation of the HPV vaccination at age 9 may help encourage providers to recommend the HPV vaccine at earlier well visits. Harmonized recommendations, therefore, may promote timely vaccination [34], result in higher completion rates of the HPV vaccination series [6, 10–15], and reduce rates of HPV infections and HPV-related cancers [16].

There are several limitations of the study. First, we only included adolescents with at least one claim associated with an annual well visit and did not capture HPV vaccination events that occurred outside of such visits or events that were not submitted for insurance reimbursement. However, adolescent vaccinations typically occur during well visits, with fewer than 1% of adolescents aged 13–17 years receiving an HPV vaccination in a non-medical setting (i.e., school, pharmacy, or other non-medical place) [35]. Therefore, we expect that HPV vaccination events outside of well visits were infrequent and would not affect our conclusions. Future research is needed to explore missed HPV vaccination opportunities in broader adolescent populations, including those without regular healthcare visits, to fully capture the scope of potential interventions. Further, potential inaccuracies in the study databases, such as coding errors, which are known inherent limitations of healthcare claims data, may limit our study’s interpretation. Second, even though MarketScan data has shown to be adequately representative of the US population, the generalizability of the current sample population may be limited. For instance,

there is a slight overrepresentation of adolescents from the southern regions of the US in the commercial database. Additionally, the Medicaid database comprises data reported anonymously by various states, which has the potential to introduce biases due to regional variations in demographic and clinical variables and health-care coverage. However, because we included patients from both the commercial and Medicaid populations, the study population may be more generalizable, and the inclusion of both databases help identify opportunities to increase HPV uptake in two different populations. Third, the study period is inclusive of the COVID-19 pandemic period. The pandemic disrupted several healthcare services, including routine well visits and corresponding immunizations in the US [36]. However, the well visit and vaccination patterns in our study show similar patterns prior to, and after 2020, so the direction of our findings and conclusion of our study may not change.

Conclusions

HPV vaccination rates by age 13 are suboptimal and remain below the 80% coverage goal set forth by Healthy People 2030. Our research is the first study that provides concrete evidence that initiation at age 9 may increase overall adolescent coverage of HPV vaccine. We demonstrate that over one-third of children who have a well visit at age 9 do not have a well visit at ages 11 and 12, representing a population who would benefit most from HPV vaccination opportunities at age 9. Shifting the routine initiation of HPV vaccination at age 9 well visits could optimize opportunities to improve HPV vaccination coverage in the US.

Abbreviations

ACIP	Advisory Committee on Immunization Practices
AAP	American Academy of Pediatrics
CPT	Current Procedural Terminology
HCPCS	Healthcare Common Procedure Coding System
HepA	hepatitis A
HepB	hepatitis B
HPV	human papillomavirus
ICD-10-CM	International Classification of Diseases, Tenth Revision, Clinical Modification
MenACWY	quadrivalent meningococcal vaccine
MMRV	measles, mumps, rubella, and varicella
Tdap	tetanus, diphtheria, and pertussis vaccine
US	United States
VAR	varicella

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-025-23235-9>.

Supplementary Material 1

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Author contributions

KS conceptualized the study and was responsible for the investigation and methodology, validating the results, drafting the initial manuscript, and critically reviewing and revising the manuscript. LA was responsible for data curation, formal analysis, investigation and methodology, software development, validating the results, visualization, and critically reviewing and revising the manuscript. AM conceptualized the study and was responsible for the investigation and methodology, drafting the initial manuscript, and critically reviewing and revising the manuscript. AFSM conceptualized the study and was responsible for the methodology, and critically reviewing and revising the manuscript. DW and YZ conceptualized the study and were responsible for investigation and methodology, and reviewing and revising the manuscript. KO conceptualized the study and was responsible for reviewing and revising the manuscript. All authors approve the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Data availability

No datasets were generated during the current study. The data that support the findings of this study are available from Merative MarketScan Commercial Claims and Encounters Database and the MarketScan Multi-State Medicaid Database, however, restrictions apply to the availability of these data, which were used under license for this study. Data are, however, available from the authors upon reasonable request and with permission of Merative MarketScan Commercial Claims and Encounters Database and the MarketScan Multi-State Medicaid Database.

Declarations

Ethics approval and consent to participate

This analysis used de-identified data from databases that comply with US privacy laws and regulations. No institutional review board approval or specific informed consent was required. The data that support the findings of this study are available from Merative MarketScan Commercial Claims and Encounters Database and the MarketScan Multi-State Medicaid Database, however, restrictions apply to the availability of these data, which were used under license for this study. Data are, however, available from the authors upon reasonable request and with permission of Merative MarketScan Commercial Claims and Encounters Database and the MarketScan Multi-State Medicaid Database.

Consent for publication

Not applicable.

Competing interests

KS, LA, AM, DW, and YZ are current employees of Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc., Rahway, NJ, USA, and may hold equity interest in Merck & Co., Inc., Rahway, NJ, USA. AFSM was an intern at Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc., Rahway, NJ, USA at the time of the study. KO has no conflicts of interest to report. This study was funded by Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc., Rahway, NJ, USA.

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