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Patterns of Use of Human Papillomavirus and Other Adolescent Vaccines in the United States

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A B S T R A C T

Purpose: The purpose of the study was to describe the patterns of use of universally recommended adolescent vaccines in the United States.
Methods: We identified 11-year-olds using the MarketScan insurance claims database (2009–2014). Human papillomavirus (HPV), tetanus-diphtheria-acellular pertussis (Tdap), and meningococcal (MenACWY) vaccination claims were identified using diagnosis and procedure codes. Generalized linear models estimated vaccination incidence rates and correlates of adolescent vaccination and timely vaccination.
Results: Among 1,691,223 adolescents, receipt of Tdap (52.1%) and MenACWY (45.8%) vaccinations exceeded receipt of HPV vaccination (18.4%). While both sexes had similar Tdap and MenACWY vaccination proportions, girls received HPV vaccination more frequently than boys (21.9% vs. 15.1%). Adolescents received HPV vaccination later (mean age: 11.8 years) than Tdap or MenACWY vaccination (mean age: 11.2 years for both). Half of vaccinated adolescents received Tdap and MenACWY vaccination only; however, coadministration with HPV vaccine increased with birth cohort. Western adolescents had the highest incidence rates of HPV vaccination, and Southern adolescents had the lowest. Rural adolescents were less likely than urban adolescents to receive each vaccination except in the Northeast, where they were more likely to receive HPV vaccination (incidence rate ratio: 1.09, 95% confidence interval: 1.2005–1.13). Timely HPV vaccination was associated with female sex, urbanicity, Western residence, and later birth cohort.
Conclusions: HPV vaccination occurred later than Tdap or MenACWY vaccination and was less frequent in boys and rural adolescents. Girls, Western and urban residents, and younger birth

IMPLICATIONS AND CONTRIBUTION

This study assessed vaccine coadministration and the dual influence of geography and urbanicity on adolescent vaccination using insurance claims. Access to and demand for vaccines should be improved in rural areas, and providers should encourage human papillomavirus vaccination and vaccine coadministration to all eligible adolescents.

Conflicts of interest: M.A.B. serves on a scientific advisory panel for Merck & Co. S.B.-D. is receiving an investigator-initiated research award from Pfizer for an unrelated study. J.S.S. has received research grants, served on paid advisory boards, and/or been a paid speaker for GlaxoSmithKline and Merck & Co., Inc. over the past 5 years. The other authors have no conflicts of interest to disclose.

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cohorts were more likely to receive timely HPV vaccination. Vaccine coadministration increased over time and may encourage timely and complete vaccination coverage.

The Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices (ACIP) recommended routine meningococcal conjugate (MenACWY) and tetanus-diphtheria-acellular pertussis (Tdap) vaccination for adolescents at age 11 years, in 2005 and 2006, respectively [1–3]. ACIP subsequently recommended routine human papillomavirus (HPV) vaccination for females aged 11–12 years on June 29, 2006, and for males aged 11–12 years on October 21, 2009 [4–6]. Phase III clinical trials of the prophylactic quadrivalent (4vHPV) and bivalent (2vHPV) HPV vaccines demonstrated over 90% efficacy against high-grade or greater cervical intraepithelial neoplasia (CIN-2+) associated with high-risk HPV (hrHPV) types 16 and 18 [7,8].

Despite ACIP's recommendations and strong evidence for the safety and efficacy of HPV vaccines, receipt of at least one dose of HPV vaccine (56.1%) among boys and girls aged 13–17 years lags behind receipt of Tdap (86.4%) or MenACWY (81.3%) vaccines in the United States, according to the 2016 nationally representative National Immunization Survey-Teen (NIS-Teen) [9].

In the NIS-Teen surveys, parents report their children's vaccination status and their children's vaccination providers are contacted to confirm vaccination status. However, vaccination status might be misclassified if parents do not accurately recall their children's vaccination providers, or if providers have inaccurate vaccination records [10]. Furthermore, the random digit dialing sampling strategy used for NIS-Teen results in low response rates, and the sample may not be generalizable to the U.S. population. Alternatively, insurance claims provide accurate data on adolescent vaccination for millions of individuals, eliminating the need to review medical records and reducing recall and information biases. Furthermore, insurance claims also allow monitoring of coadministration of vaccines on the same service date and trends over time in uptake of different vaccine combinations, which have only been recently reported in two studies using NIS-Teen data [11,12].

Here, we present data from employer-sponsored insurance claims to describe patterns of use of HPV, Tdap, and MenACWY vaccination among vaccine-eligible girls and boys in the United States. Results from this study will identify gaps in vaccination coverage and can inform targeted adolescent vaccination promotion strategies.

Methods

Study population

The MarketScan Commercial Claims and Encounters database captures patient-level medical claims provided by over 300 large employers in all 50 states, the District of Columbia, and Puerto Rico, including over 170 million unique enrollees since 1995 [13]. MarketScan provides patient demographic data, type and duration of health plan enrollment, claims for medical diagnoses and procedures using International Classification of Diseases–Ninth Revision (ICD-9) and Current Procedural Terminology (CPT) codes, respectively, and dates of medical services. We obtained MarketScan data between 2000 and 2014 from Truven Health Analytics.

The study period began in October 21, 2009—when ACIP supported HPV vaccination for boys—marking the first opportunity for all eligible adolescents to receive all three recommended vaccines. We included girls and boys who (1) turned 11 years of age between 2009 and 2014; (2) had no prior history of adolescent vaccination; and (3) had at least 1 year of continuous insurance plan enrollment before the start of follow-up.

Data analysis

We began observing adolescents from their 11th birthdays, when they became eligible for adolescent vaccination according to the ACIP recommendations. Because date of birth is protected health information, we searched monthly insurance enrollment files to identify the month in which the adolescent's age changed and then set the date of birth to the last day of that month. We followed adolescents from their estimated 11th birthdays (time 0) until vaccination, disenrollment, or the end of the study period on December 31, 2014.

We searched outpatient records for the first billed claim for 2vHPV (CPT code 90650) or 4vHPV (CPT code 90649), Tdap (CPT code 90715, ICD-9 code 9939), and MenACWY (CPT code 90734). We excluded Tdap claims related to injuries or accidents (ICD-9 codes 037.X, 87X–91X, V01–V02, all E codes) or receipt of antenatal care (ICD-9 codes V22.X–V39.X). While the HPV vaccination series includes multiple doses and MenACWY vaccine requires a booster, we only identified the first dose of each vaccine, as limited follow-up might prevent us from observing subsequent doses. Descriptive statistics summarized service-related characteristics at the time of vaccination, and the combinations of vaccines received by adolescents, including coadministered vaccines.

For each vaccine, we estimated time to vaccination as the difference between time 0 and the date of the first vaccination claim. We estimated total follow-up time as the difference between time 0 and the date of service for adolescents who received vaccination; or the difference between time 0 and the date of disenrollment or the end of the study period for adolescents who did not receive vaccination. We used generalized estimating equations with a Poisson distribution and a robust variance estimator to estimate vaccination incidence rates (IRs) per 10,000 person-months of observation, incidence rate ratios (IRRs) and 95% confidence intervals (CIs) for correlates of vaccination, and IRs of vaccine coadministration over time. IRs and cumulative incidence were stratified by covariates of interest, including sex; region (Northeast, North Central, South, West, per the U.S. Census Bureau [14]); urbanicity, as defined by urban residence (metropolitan statistical area with population $\geq$50,000) or rural residence (micropolitan statistical area with population $<$50,000); receipt of primary care in the year before observation; and insurance plan type. We also plotted the cumulative incidence of receiving the first dose of HPV vaccine at age 11 or 12 years (i.e., timely HPV vaccination), stratified by sex, urbanicity, region, and birth cohort.

As many as 18 states had offered at least one adolescent vaccine free of charge, regardless of income level, since 2006