Adolescent Vaccine Co-administration and Coverage in New York City: 2007–2013

WHAT'S KNOWN ON THIS SUBJECT: National adolescent vaccination coverage estimates in 2013 among 13- to 17-year-olds are 86% for Tdap vaccine and 78% for MCV4. Comparatively, coverage with ≥3 doses of HPV vaccine is 38% among girls and 14% among boys.

WHAT THIS STUDY ADDS: One-fourth of 11-year-olds had HPV vaccine co-administered with Tdap vaccine, compared with two-thirds who had MCV4 co-administered. Whereas by age 17 years, >92% received Tdap vaccine and MCV4, only half of girls and one-fifth of boys completed HPV vaccination.

abstract

OBJECTIVES: To investigate adolescent vaccination in New York City, we assessed tetanus, diphtheria, and acellular pertussis (Tdap), meningococcal conjugate (MCV4), and human papillomavirus (HPV) vaccine uptake, vaccine co-administration, and catch-up coverage over time.

METHODS: We analyzed data from the Citywide Immunization Registry, a population-based immunization information system, to measure vaccine uptake and co-administration, defined as a Tdap vaccination visit where MCV4 or HPV vaccine was co-administered, among 11-year-olds. Catch-up vaccinations were evaluated through 2013 for adolescents born 1996 to 2000, by birth cohort. HPV vaccination among boys included data from 2010 to 2013.

RESULTS: Adolescent vaccine administration was greatest during the back-to-school months of August to October and was highest for Tdap. Although MCV4 uptake improved over the study years, HPV vaccine uptake among girls stagnated; boys achieved similar uptake of HPV vaccine by 2012. By 2013, 65.4% had MCV4 co-administered with Tdap vaccine, whereas 28.4% of girls and 25.9% of boys had their first dose of HPV vaccine co-administered. By age 17, Tdap and MCV4 vaccination coverage increased to 97.5% and 92.8%, respectively, whereas ≥1-dose and 3-dose HPV vaccination coverage were, respectively, 77.5% and 53.1% for girls and 49.3% and 21.6% for boys. Age-specific vaccination coverage increased with each successive birth cohort ($P < .001$).

CONCLUSIONS: From 2007 to 2013, there were greater improvements in Tdap and MCV4 vaccination than HPV vaccination, for which co-administration with Tdap vaccine and coverage through adolescence remained lower. Parent and provider outreach efforts should promote timely HPV vaccination for all adolescents and vaccine co-administration. *Pediatrics* 2014;134:e1576–e1583

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KEY WORDS

HPV vaccine, Tdap, MCV4, adolescent immunization, co-administration

ABBREVIATIONS

CDC—Centers for Disease Control and Prevention
CI—confidence interval
CIR—Citywide Immunization Registry
HPV—human papillomavirus
IIS—immunization information system
MCV4—meningococcal conjugate vaccine
NIS-Teen—National Immunization Survey–Teen
NYC—New York City
Tdap—tetanus, diphtheria, and acellular pertussis

Ms Sull carried out analyses, drafted the manuscript, and revised the article for critical content; Ms Eavey assisted with analyses and interpretation of data and revised the article for critical content; Dr Papadouka assisted with conception, design, and interpretation of data and revised the article for critical content; Ms Mandell and Mr Hansen assisted with conception and design of the analyses and drafting of the article; Dr Zucker supervised study conceptualization and analysis and revised the article for critical content; and all authors approved the final manuscript as submitted.

The views expressed herein are those of the authors and do not necessarily reflect the views of the Centers for Disease Control and Prevention or the New York City Department of Health and Mental Hygiene.

www.pediatrics.org/cgi/doi/10.1542/peds.2014-1452

doi:10.1542/peds.2014-1452

Accepted for publication Sep 23, 2014

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Adolescent vaccination is an important part of the routine immunization schedule.[1] The Advisory Committee on Immunization Practices recommended routine vaccination of adolescents 11 to 12 years of age with tetanus, diphtheria, and acellular pertussis (Tdap) vaccine[2] and meningococcal conjugate vaccine (MCV4)[3] in 2005 and human papillomavirus (HPV) vaccine for girls[4] in 2006. In 2006, the Centers for Disease Control and Prevention (CDC) underscored the importance of these adolescent vaccinations with the addition of the 13- to 17-year-old age cohort to the National Immunization Survey–Teen (NIS-Teen)[5] to measure national adolescent immunization coverage. The CDC also launched the Preteen Vaccine Campaign[6] in 2007 to encourage uptake of adolescent vaccines, which was expanded in 2011 to include a digital media campaign intended to increase audience reach via mobile platforms and social networking sites.

Requiring immunizations for school entry is an effective strategy to increase adolescent immunization coverage.[7–10] As of the 2007 to 2008 school year, New York State required that all students ≥11 years receive 1 dose of Tdap vaccine to enter the sixth grade in all schools, including public, private, and parochial schools.[11,12] The visit to receive the Tdap vaccine is ideal for co-administration of recommended MCV4 and HPV vaccine, neither of which is required for school entry.

To investigate adolescent vaccinations in New York City (NYC), we used data from the Citywide Immunization Registry (CIR). The CIR is a population-based immunization information system (IIS) with birth records from NYC Vital Statistics uploaded twice weekly. Since 1997, NYC providers have been mandated to report to the CIR all doses of vaccine administered to children <8 years of age. In 2005, the mandate was expanded to include vaccines given to patients through 18 years of age. We estimate that nearly all pediatric care facilities in NYC are registered with the CIR, and 94% of these reported ≥1 immunization in the last 6 months of 2013. The adolescent population capture, which includes 11- to 17-year-olds, in the CIR is 96%, as defined by documentation of ≥2 vaccinations administered since 9 years of age in the CIR, making it a nearly complete data source.[13]

Using CIR data, we analyzed adolescent vaccinations in NYC to assess changes in vaccine uptake among 11-year-olds over time, quantify co-administration of MCV4 and HPV vaccine at the time of Tdap vaccine administration, and evaluate whether children who delayed vaccination at 11-years-old received these vaccines at a later age (ie, catch-up later in adolescence).

METHODS

This study was reviewed and approved as public health surveillance that is nonresearch by the Institutional Review Board at the NYC Department of Health and Mental Hygiene.

We conducted 3 separate analyses to assess adolescent immunization and vaccine co-administration over time. All evaluations were performed using SAS version 9.2 (SAS Institute Inc, Cary, NC). Our analyses did not distinguish between quadrivalent and bivalent (licensed in 2009)[14] HPV vaccine or between different formulations of meningococcal conjugate vaccine. For all analyses, Tdap and MCV4 vaccine uptake is presented for boys and girls, combined, whereas HPV vaccination coverage is reported separately, by gender. HPV vaccine uptake among boys was examined only from 2010 to 2013 because permissive use of quadrivalent HPV vaccine for boys was not recommended by the Advisory Committee on Immunization Practices until October 2009 and was extended to a routine recommendation for boys in 2011.[15]

Adolescent Vaccine Uptake Over Time

To measure vaccine uptake before and after the Tdap school entry requirement, we examined the number of Tdap, MCV4, and first HPV vaccine doses administered to 11-year-olds, by month, from January 2005 to December 2013.

Co-administration of Adolescent Vaccines

To evaluate changes in co-administration of adolescent vaccines in the post–Tdap school requirement years, we examined visits in which an 11-year-old received Tdap vaccine and was eligible for and received MCV4 or the first dose of HPV vaccine at the same visit. Co-administration with Tdap vaccine was examined from 2007 to 2013. We assessed trends in proportions of co-administration over the study period for MCV4 and HPV vaccine using the Cochran–Armitage trend test. We calculated differences in the proportions of co-administration by using the χ^2 test at a significance level of .05.

Catch-up Vaccination Coverage

To determine catch-up vaccination coverage over time, we examined the age at which 5 separate birth cohorts of adolescents received Tdap, MCV4, and the first and third doses of HPV vaccine. Data included vaccines administered to patients 9 to 18 years of age and received through December 2013. To calculate coverage over time, we included in our numerator the cumulative number of patients vaccinated each month, excluding patients who died, patients who did not reside in NYC, and patients reported to have moved out of NYC during the follow-up period (2007–2013). Our denominator was the age-appropriate population for each birth cohort, as estimated by 2010 US Census data for NYC. We used census estimates as our denominator instead of total adolescents enrolled in the CIR because the CIR contains fragmented, duplicate patient records and because the CIR is only partially able to remove patients who have moved out of the jurisdiction. Both factors inflate the denominators and can lead to underestimating coverage. Our use of census-based denominators is a common method for estimating coverage in an IIS.[16–18]

The oldest cohort consists of adolescents born in 1996 who reached 11 years of age in 2007, the first group for whom the Tdap school requirement was applicable. This cohort was tracked from age 11 (as of December 2007) to age 17 (as of December 2013) for 7 years of follow-up data. The youngest cohort included adolescents born in 2000, which provided 3 years of follow-up data from 11 to 13 years of age. We assessed differences in vaccination coverage by using the χ^2 test at a significance level of .05. We also assessed whether age-specific coverage increased with each successive birth cohort year by the Cochran–Armitage trend test.

RESULTS

Adolescent Vaccine Uptake Over Time

A large increase in Tdap vaccine administration occurred in the first year of the Tdap requirement, especially during late summer and early fall of 2007, at the beginning of the school year (Fig 1). Tdap vaccine uptake peaked in August 2007, with 10 662 doses administered to 11-year-olds, an increase of 305.9% from August 2006 (n = 2627). Increases in administration of MCV4 and first dose of HPV vaccine were also observed during the same period. Tdap and MCV4 uptake were similar by gender (data not shown). Administration of all vaccines peaked each year during the back-to-school months of August through October. In nearly all months observed, administration was highest for Tdap vaccine.

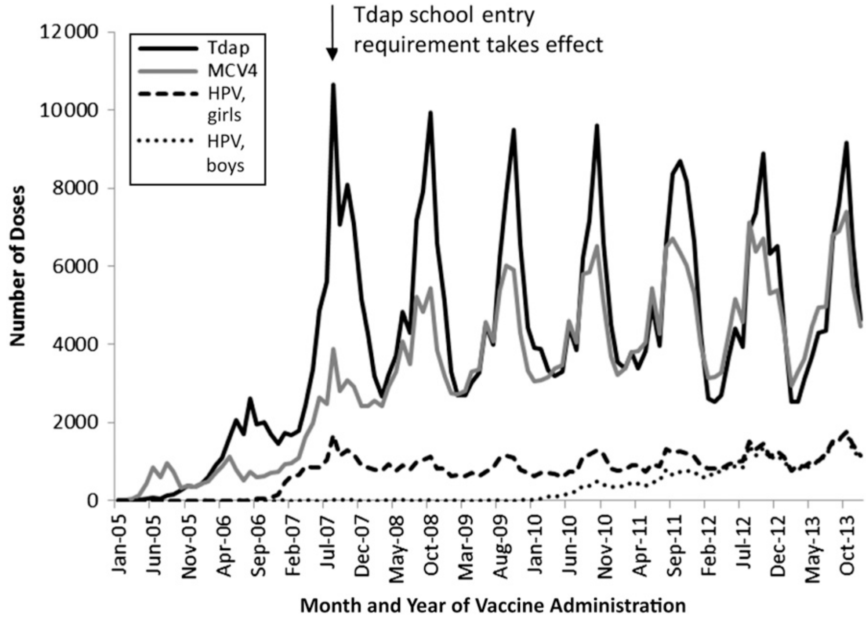

FIGURE 1
Tdap, MCV4, and first HPV vaccine doses administered to 11-year-olds each month from January 2005 to December 2013. Tdap vaccine and MCV4 doses are shown for boys and girls combined. HPV vaccine doses are reported separately for boys and girls.

Although doses of MCV4 administered increased substantially each year, peaking at 3895 doses in August 2007 and 7383 doses in October 2013 (89.6% increase), HPV vaccine uptake among girls stagnated. After an initial rise to 1680 doses administered in August 2007, peak administration in subsequent years ranged from 1135 to 1765 doses. HPV vaccine uptake among boys increased rapidly beginning in January 2010 and continued to rise, demonstrating uptake patterns similar to those of girls and reaching a comparable number of doses administered by mid-2012. In 2013, HPV vaccine uptake peaked in October with 1765 and 1768 doses administered to boys and girls, respectively.

Co-administration of Adolescent Vaccines

Co-administration of MCV4, similar by gender (data not shown), increased over the Tdap postrequirement years from 29.0% (95% confidence interval [CI], 28.6–29.3) in 2007 to 65.4% (95% CI, 65.0–65.8) in 2013, a 36.4 percentage point increase ($P < .001$) (Table 1). Among girls, co-administration of the

TABLE 1 Co-administration of MCV4 and First Dose of HPV Vaccine at Time of Tdap Vaccination Visit Among 11-year-olds Eligible for Either Vaccine from 2007 to 2013

Year	MCV4[a,b]		HPV, Girls[a]		HPV, Boys[a]	
	Eligible	Received	Eligible	Received	Eligible	Received
	n	%	n	%	n	%
2007	58 370	29.0	28 065	21.2	—[c]	—[c]
2008	60 708	44.6	28 310	19.5	—[c]	—[c]
2009	55 618	54.0	26 132	18.8	—[c]	—[c]
2010	57 729	57.2	27 388	20.1	30 321	4.6
2011	62 503	61.8	29 664	22.6	32 447	11.4
2012	57 675	64.2	27 462	25.2	29 502	20.4
2013	56 358	65.4	26 928	28.4	28 419	25.9

[a] Increasing trends in co-administration from 2007 to 2013 were statistically significant for both MCV4 and HPV vaccine ($P < .001$).
[b] MCV4 co-administration is shown for boys and girls combined.
[c] HPV vaccination among boys was only assessed from 2010 to 2013.

first dose of HPV vaccine with Tdap vaccine increased 7.2 percentage points ($P < .001$) from 21.2% (95% CI, 20.7–21.7) to 28.4% (95% CI, 27.8–28.9) during these same years. For boys in 2013, co-administration of HPV vaccine with Tdap vaccine occurred among 25.9% (95% CI, 25.4–26.4) of those eligible, similar to that seen among girls. The proportion of Tdap vaccination visits with co-administration of MCV4 was greater than the those with co-administration of first dose of HPV vaccine for every year analyzed ($P < .001$).

Catch-up Vaccination Coverage

In the 1996 birth cohort (n = 96 954), at age 11 years, 52.8% (95% CI, 52.5–53.1) and 19.3% (95% CI, 19.1–19.6) received Tdap vaccine and MCV4, respectively, by December 2007; by the end of 2013 at age 17 years, coverage increased to 97.5% (95% CI, 97.4–97.6) and 92.8% (95% CI, 92.6–92.9) for Tdap and MCV4, respectively (Fig 2). Despite similar coverage at 11 years of age, by age 17 years, MCV4 coverage was 15.3 percentage points higher than coverage among girls for ≥1 dose of HPV vaccine ($P < .001$). Among girls born in 1996, by age 17 years, 77.5% (95% CI, 77.1–77.9) and 53.1% (95% CI, 52.6–53.5) received ≥1 dose and 3 doses of HPV vaccine, respectively. HPV vaccination coverage among boys reached 49.3% (95% CI, 48.9–49.8) for ≥1 dose and 21.6% (95% CI, 21.3–22.0) for 3 doses by 17 years of age.

Vaccination coverage by age is higher in more recent birth cohorts for all vaccines (Table 2). Comparing coverage levels by 13 years of age in the 1996 and 2000 cohorts, Tdap vaccination coverage increased from 83.4% (95% CI, 83.2–83.7) to 98.4% (95% CI, 98.4–98.5) ($P < .001$), and MCV4 coverage increased from 64.2% (95% CI, 63.9–64.5) to 85.0% (95% CI, 84.8–85.2) ($P < .001$). HPV catch-up vaccination by 13 years of age among girls showed less change, rising from 46.8% (95% CI, 46.4–47.3) to 57.4% (95% CI, 57.0–57.9) for ≥1-dose coverage ($P < .001$) and 23.3% (95% CI, 23.0–23.7) to 29.6% (95% CI, 29.2–30.1) for 3-dose coverage ($P < .001$). Among boys in the most recent birth cohort, ≥1-dose and 3-dose HPV vaccination coverage reached 45.0% (95% CI, 44.5–45.4) and 18.8% (95% CI, 18.4–19.1), respectively, by 13 years of age.

DISCUSSION

Coverage for Tdap vaccine among NYC's adolescents increased after the 2007 Tdap school entry requirement, consistent with previous studies assessing the effectiveness of school entry requirements in promotion of vaccine uptake.[19] Furthermore, the results suggest that

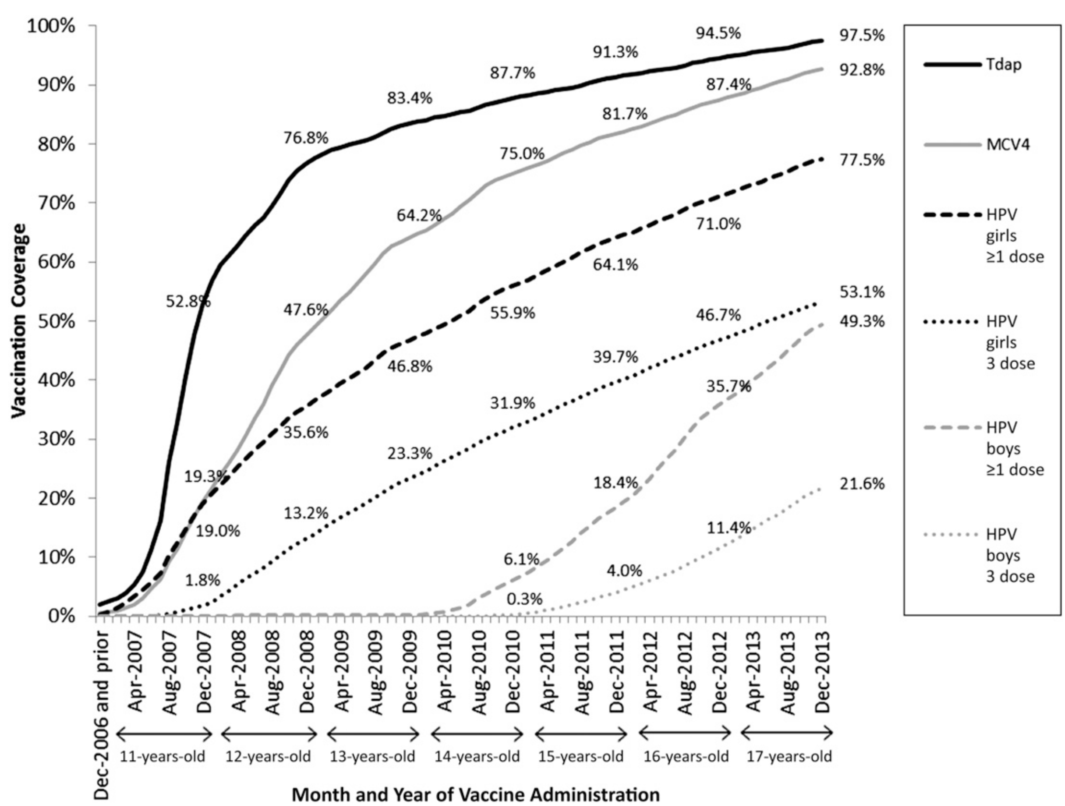

FIGURE 2

Coverage with Tdap, MCV4, and HPV vaccines among adolescents born in 1996 (n = 96 954). Percentage coverage by December of each year is indicated. Tdap and MCV4 vaccination coverage are shown for boys and girls combined. Male HPV vaccination coverage from 2010 to 2013 is included.

TABLE 2 Catch-up Vaccination Coverage From December 2007 to December 2013 for Tdap, MCV4, and HPV Vaccines, by Birth Cohort[a,b]

Vaccine	Age (y)	Year of Birth				
		1996 (n = 96 954)	1997 (n = 93 920)	1998 (n = 91 964)	1999 (n = 91 508)	2000 (n = 93 808)
Tdap[c]	11	52.8	65.5	67.9	70.1	77.7
	12	76.8	83.7	88.9	91.5	94.2
	13	83.4	88.9	94.3	96.1	98.4
	14	87.7	93.0	97.7	99.3	—[d]
	15	91.3	96.0	>99.9	—[d]	—[d]
	16	94.5	98.9	—[d]	—[d]	—[d]
	17	97.5	—[d]	—[d]	—[d]	—[d]
MCV4[c]	11	19.3	32.8	39.4	42.4	48.5
	12	47.6	59.5	66.7	71.4	74.9
	13	64.2	72.0	79.2	82.4	85.0
	14	75.0	81.5	87.5	89.6	—[d]
	15	81.7	87.1	92.7	—[d]	—[d]
	16	87.4	92.6	—[d]	—[d]	—[d]
	17	92.8	—[d]	—[d]	—[d]	—[d]
Vaccine	Age (y)	Year of Birth				
		1996 (n = 47 358)	1997 (n = 46 281)	1998 (n = 45 083)	1999 (n = 45 055)	2000 (n = 45 781)
HPV girls, ≥1 dose	11	19.0	23.2	23.5	23.5	26.2
	12	35.6	37.5	38.4	40.2	43.6
	13	46.8	47.9	50.5	52.5	57.4
	14	55.9	58.6	61.9	64.6	—[d]
	15	64.1	67.1	71.1	—[d]	—[d]
	16	71.0	74.9	—[d]	—[d]	—[d]
	17	77.5	—[d]	—[d]	—[d]	—[d]
HPV girls, 3 doses	11	1.8	5.5	5.9	4.7	5.3
	12	13.2	15.7	15.6	15.8	17.2
	13	23.3	24.8	25.6	26.9	29.6
	14	31.9	33.8	35.9	37.9	—[d]
	15	39.7	42.3	45.0	—[d]	—[d]
	16	46.7	50.1	—[d]	—[d]	—[d]
	17	53.1	—[d]	—[d]	—[d]	—[d]
Vaccine	Age (y)	Year of Birth				
		1996 (n = 49 596)	1997 (n = 47 639)	1998 (n = 46 881)	1999 (n = 46 453)	2000 (n = 48 027)
HPV boys, ≥1 dose[e]	11	—[e]	—[e]	—[e]	5.0	12.1
	12	—[e]	—[e]	5.5	15.8	28.9
	13	—[e]	5.6	17.0	32.7	45.0
	14	6.1	18.2	36.1	49.4	—[d]
	15	18.4	36.1	51.6	—[d]	—[d]
	16	35.7	50.8	—[d]	—[d]	—[d]
	17	49.3	—[d]	—[d]	—[d]	—[d]
HPV boys, 3 doses[e]	11	—[e]	—[e]	—[e]	0.2	1.5
	12	—[e]	—[e]	0.3	3.6	8.2
	13	—[e]	0.3	4.0	10.9	18.8
	14	0.3	4.1	11.7	22.2	—[d]
	15	4.0	11.9	23.3	—[d]	—[d]
	16	11.4	22.7	—[d]	—[d]	—[d]
	17	21.6	—[d]	—[d]	—[d]	—[d]

a Percentage coverage by December of each year, corresponding to age at vaccination, is reported for each birth cohort.

b Age-specific vaccination coverage showed a significant positive trend ($P < .001$) with each successive birth cohort (1996–2000), with the exception of coverage at age 17, for which data were available only for the 1996 cohort.

c Vaccination coverage among boys and girls combined.

d Vaccination coverage is not available as follow-up only extended through 2013.

e Analysis of HPV vaccination coverage among boys was limited to years 2010 to 2013, so coverage at certain earlier ages are not reported for the 1996 through 1998 birth cohorts.

the effect of the Tdap requirement extended to uptake of the other adolescent vaccines, particularly of MCV4. These results differ from those of Kharbanda et al,[20] who did not attribute general increases in MCV4 uptake from 2006 to 2008 to the requirement, because co-administration with Tdap remained low. However, our analysis with more years of postrequirement follow-up shows that co-administration of MCV4 at the time of Tdap vaccination continued to increase after 2008, with nearly two-thirds of Tdap vaccination visits including co-administration of MCV4 in 2013.

Improvements in Tdap and MCV4 vaccination coverage did not extend to HPV vaccine, for which co-administration with Tdap vaccine remained low, demonstrating minimal change over the observation period, although it was still statistically significant given our large sample size. By 2013, just over one-fourth of boys and girls eligible for HPV vaccine at their Tdap visit received the vaccine. Our findings agree with NIS-Teen's high estimates among girls for lack of co-administration of HPV vaccine at a health encounter where another vaccine was administered.[21]

Moreover, our analysis of catch-up coverage (Table 2) suggests that, compared with the high coverage levels seen for Tdap and MCV4 vaccine, many remained unvaccinated against HPV throughout adolescence; by 17 years of age, >20% of girls and 50% of boys did not receive any HPV vaccine dose, and nearly half of girls and 80% of boys did not complete the series. The lower HPV vaccination coverage among boys by age 17 in the 1996 birth cohort was not surprising because it includes only catch-up vaccinations received from 14 years of age on, given our analysis of 2010 to 2013 data, after the permissive use recommendation.

To our knowledge, no other study has used a large, population-based IIS to examine co-administration of adolescent vaccines over time. NYC's CIR is a well-validated, complete data source with many years of immunization data, up-to-date records, and a high adolescent population capture. It is also 1 of 6 2013 to 2017 IIS Sentinel Sites competitively selected by the CDC on the basis of high data quality standards.[22] Although previous studies have used immunization registries to evaluate missed opportunities for vaccination,[20,23,24] these studies did not evaluate all 3 adolescent vaccines, as we did in this study. Most similar to our study, Kharbanda et al[20] used a large hospital-based registry to assess co-administration of Tdap vaccine and MCV4. However, the study did not include HPV vaccination and limited the intake assessment to the years 2006 to 2008. By examining HPV vaccine uptake and extending follow-up to 2013, our findings highlight the difference in HPV vaccination coverage compared with Tdap vaccine and MCV4 and provide a novel examination of male HPV vaccination coverage over time.

Although the CIR offered several years of reliable data, our findings are limited to a single city. Furthermore, use of CIR data also presented study limitations common to analyses relying on registry data. As with most IISs, a certain percentage of vaccinations administered are not reported, decreasing observed coverage. However, comparison of adolescent vaccination coverage estimates among 13- to 17-year-olds using CIR versus NIS-Teen data[25] confirm that CIR findings are within the NIS-Teen confidence intervals; for example, in 2013, ≥1-dose HPV vaccination coverage in the CIR was 63.2% among girls (2013 NIS-Teen, NYC: 64.2% [95% CI, ± 9.0]) and 45.1% among boys (2013 NIS-Teen, NYC: 46.2% [95% CI, ± 9.6]), suggesting that any potential effect of underreporting was minimal. We could not assess racial or ethnic disparities in coverage because of limited capture of these demographics in the CIR. We also used age as a proxy for grade level in our assessment of timely vaccine uptake. However, because children in NYC begin kindergarten at 5 years of age, the majority are at least 11-years-old when they enter sixth grade; thus, we are capturing the majority of Tdap vaccination visits in our co-administration analysis.

Our study results suggest challenges specific to HPV vaccination, which must be addressed to increase coverage. A survey conducted by the NYC Health Department in 2007 among NYC providers identified a combination of financial, insurance, and parental concerns as barriers to HPV vaccination.[26] Parental concerns included vaccine safety, duration of protection, and fears that vaccination encourages early sexual activity. Despite the safety and effectiveness of the HPV vaccine,[27–30] the literature suggests that parents lack knowledge and accurate information about HPV vaccines, dissuading them from immunizing their children.[31]

Providers play a crucial role in decreasing the HPV vaccine knowledge gap among parents and emphasizing the benefits of timely vaccination. Several studies found that physicians' recommendations and HPV discussions with parents are associated with greater vaccine acceptance.[32–35] Unfortunately, parents consistently cite lack of recommendation by a health care professional for the HPV vaccine as a main reason for not vaccinating their children.[32] According to a 2008 nationwide provider survey,[36] fewer physicians strongly recommended HPV vaccine for 11- to 12-year-old girls than for 13- to 15-year-old girls. This delay leaves adolescents at risk for HPV infection from sexual activity,[37,38] many of whom, as our findings indicate, are not fully vaccinated through adolescence.

Our study results reinforce the need to improve timely HPV vaccination at the recommended age of 11 to 12 years. Public health efforts should focus on early vaccination and co-administration at the Tdap vaccination visit, emphasizing messages about protection against HPV-related cancers and disassociating the vaccine from sexual transmission and activity. The NYC Health Department has undertaken several efforts to emphasize the importance of strong provider recommendation of the HPV vaccine and encourages parents of adolescents to vaccinate their preteens and teens against HPV. Provider-focused interventions have involved various communications with providers, including letters encouraging co-administration of MCV4 and HPV vaccine at the time of Tdap vaccination and quarterly coverage reports to providers highlighting the proportion of patients in their practices not up to date for adolescent vaccines. The Health Department has also created several informational resources and promotional materials to educate parents about the benefits of timely HPV vaccination.

CONCLUSIONS

Our findings highlight the importance of promoting co-administration of all adolescent vaccines during the 11-year-old Tdap vaccination visit required for school entry in NYC. Increasing the number of adolescents who receive the HPV vaccine at this health care encounter can help reduce the number of adolescents unprotected in their late teens and early 20s, when nearly half of new annual HPV infections occur.[39] The NYC Health Department will continue parental and provider outreach efforts to improve HPV vaccination coverage by increasing public awareness of the HPV vaccine and reinforcing best practices for HPV vaccination by providers.

ACKNOWLEDGMENTS

We thank Amy Metroka, MSW, MPH, for her comments and feedback on article content.

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(Continued from first page)

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: This work was supported by Centers for Disease Control and Prevention grant CDC-RFA-IP13-1301 and Prevention and Public Health Fund grant CDC-RFA-IP12-1206PPHF12.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

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Pediatrics 2014;134;e1576
DOI: 10.1542/peds.2014-1452 originally published online November 10, 2014;