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Impact of Provider Recommendation on Tdap Vaccination of Adolescents Aged 13–17 Years

Peng-jun Lu, MD, PhD¹, David Yankey, MS¹, Jenny Jeyarajah, MS¹, Alissa O'Halloran, MSPH¹, Sarah A. Meyer, MD, MPH², Laurie D. Elam-Evans, PhD, MPH¹, and Sarah Reagan-Steiner, MD, MPH¹

¹Immunization Services Division, Centers for Disease Control and Prevention, Atlanta, Georgia

²Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

Abstract

Introduction—Tetanus, diphtheria, and acellular pertussis (Tdap) vaccination has been recommended for adolescents in the U.S. since 2006. Information on Tdap vaccination by provider recommendation is limited. The purpose of this study is to assess recent Tdap vaccination by provider recommendation status among adolescents aged 13–17 years.

Methods—The 2013 National Immunization Survey-Teen data (N=18,948) were analyzed in 2016 to assess national and state-specific Tdap vaccination coverage disparities among adolescents by provider recommendation status, and other demographic and access to care variables. Multivariable logistic regression analysis and predictive marginal modeling evaluated associations between Tdap vaccination and provider recommendation status and other factors among adolescents aged 13–17 years.

Results—Overall, only 56.9% of adolescents aged 13–17 years received a provider recommendation for Tdap. Coverage was significantly higher among adolescents with a provider recommendation (88.6%) compared with those without a provider recommendation (80.5%) ($p < 0.05$). Multivariable logistic regression showed that characteristics independently associated with a higher likelihood of Tdap vaccination included receiving a provider recommendation, Hispanic ethnicity, having two to three physician contacts in the past 12 months, having one or two vaccination providers, and receiving vaccinations from more than one type of facility ($p < 0.05$).

Conclusions—Provider recommendations were significantly associated with Tdap vaccination among adolescents aged 13–17 years. However, 43% of parents of adolescents did not receive a provider recommendation. Evidence-based strategies such as standing orders and provider reminders alone or health systems interventions in combination should be taken to improve provider recommendation and Tdap vaccination coverage.

Address correspondence to: Peng-jun Lu, MD, PhD, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, 1600 Clifton Road, NE, Mail Stop A-19, Atlanta GA 30333. lhp8@cdc.gov.

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INTRODUCTION

Pertussis, a respiratory illness caused by the bacteria *Bordetella pertussis*, remains endemic in the U.S. despite longstanding routine childhood pertussis vaccination. Since the 1980s, the number of reported pertussis cases has steadily increased, especially among adolescents and adults, likely due, in part, to waning immunity from the childhood vaccination series.¹⁻⁴ Overall, there were 32,971 reported cases of pertussis during 2014 compared with 25,824 cases reported during 2004.² The number of pertussis cases is likely under-reported because individuals with pertussis, particularly adolescents and adults, can have nonspecific symptoms, with pertussis often going undiagnosed.^{1,3,4} To protect adolescents from pertussis infection, the Advisory Committee on Immunization Practices recommended the tetanus, diphtheria, and acellular pertussis vaccine (Tdap) in 2005 as a routine booster vaccination for all adolescents aged 11–18 years, with a preferred age of administration at 11–12 years.^{3,4} Overall, by 2013, Tdap vaccination coverage was 84.7% among adolescents aged 13–17 years.⁵

Provider recommendations are strongly associated with vaccination.⁶⁻⁹ Overall Tdap vaccination has been assessed previously, but comprehensive assessment of the impact of provider recommendation on Tdap vaccination coverage and prevalence of provider recommendation among adolescents at the national and state levels have not been reported previously.⁵ The purpose of this study is to use data from the 2013 National Immunization Survey-Teen (NIS-Teen) to assess (1) Tdap vaccination and prevalence of provider recommendation of the vaccine; (2) provider recommendation and other factors associated with Tdap vaccination; and (3) coverage disparities among adolescents with and without a provider recommendation at the national and state levels. Such information is useful to develop tailored strategies to improve provider recommendation and Tdap vaccination coverage among adolescents.

METHODS

The 2013 NIS-Teen data were analyzed in 2016. NIS-Teen is a national, random-digit-dial telephone survey conducted by the Centers for Disease Control and Prevention (CDC). The objective of the NIS-Teen is to provide timely, detailed information regarding vaccination coverage among adolescents aged 13–17 years. Data are collected in the NIS-Teen in two phases. In the first phase, a random-digit-dial telephone interview is conducted to identify households with age-eligible adolescents (aged 13–17 years at the time of interview) and to collect demographic information from the parent or guardian on adolescent, maternal, and household characteristics. Also, the interview includes questions on the adolescent's reported vaccination history. After completing the interview, consent is requested to contact the vaccination provider(s). If consent is obtained, the adolescent's vaccination providers are mailed a questionnaire to collect provider-reported vaccination histories for each recommended adolescent vaccine and selected childhood vaccines.^{5,10}

In 2013, the NIS-Teen sampling plan included independent samples of households with a landline and also households with a cell phone.^{5,10} In total, there were 18,948 adolescents with adequate provider data from landline (representing 62.0% of all adolescents from the

landline sample with completed household interviews) and cell samples (representing 56.4% of all adolescents from the cell phone sample with completed household interviews) combined excluding the U.S. Virgin Islands and Guam. The Council of American Survey Research Organizations response rates were 51.1% for landline and 23.3% for cell phone.^{5,10,11}

Provider recommendation status was assessed by asking parents/guardians whether they have received a provider recommendation of the vaccine. Tdap vaccination was assessed by provider recommendation and controlled covariates that may be associated with vaccination coverage empirically or based on previous studies,^{6–8} which included age group; gender; race/ethnicity; mother's educational level; mother's marital status; mother's age; birth country; poverty level; type of health insurance and vaccine finance; number of physician contacts within the past 12 months; provider-reported healthcare visit at age 11–12 years; number of vaccination providers reported by parents; vaccination facility type (public, private, hospital, sexually transmitted disease/school/teen clinics, mixed [including facilities in more than one category such as private, public, hospital, sexually transmitted disease/school/teen clinics], and others [such as military, Special Supplemental Nutrition Program for Women, Infants, and Children clinics, and pharmacies]); metropolitan statistical area; and U.S. Census region. Prevalence of provider recommendation and vaccination coverage at the state level were assessed. Vaccination by middle school entry requirement, which was in effect as of 2013 based on information from immunization.org, was also evaluated.¹²

The authors used SUDAAN, version 11.0.1, to calculate point estimates and 95% CIs adjusted for the complex sample design of NIS-Teen. All analyses account for the complex sampling plan of NIS-Teen and the survey sampling weights.^{5,6} Chi-square tests were used to examine differences in population distribution between those with and without a provider recommendation. The study used *t*-tests to examine prevalence of provider recommendation and vaccination coverage compared with the reference group within each variable, as well as national and state-specific vaccination coverage differences between those with and without a provider recommendation. All tests were conducted with the significance level set at $\alpha < 0.05$. Multivariable logistic regression and predictive marginal modeling were conducted to derive the adjusted prevalence ratio (PR). NIS-Teen was approved by CDC, National Center for Health Statistics Research Ethics Review Board, and the NORC at the University of Chicago IRB.

RESULTS

Table 1 shows the demographic characteristics of the study population. Overall, a majority of adolescents were non-Hispanic white (55.0%); had mothers with more than a high school education (62.1%); had mothers who are currently married (66.1%); were born in the U.S. (95.5%); were living in a household with an income >133% of the federal poverty level (66.9%); had one vaccination provider (50.6%); had at least one physician contact within the past year (83.6%); and received all reported vaccination from providers in a private facility (50.4%).

Overall, only 56.9% of adolescents aged 13–17 years received a provider recommendation for Tdap (Table 1). Number of physician contacts in the past year and well-child visit at age 11–12 years were significantly associated with prevalence of provider recommendation for Tdap vaccine; this is particularly important because physician contacts and well-child visits might provide chances for providers to recommend vaccines to their patients. Prevalence of provider recommendation was significantly higher among those with one (56.5%); two to three (60.4%); and four or more (58.8%) physician contacts compared with those without a physician contact within the past year (47.5%). Prevalence of provider recommendation was significantly higher among those who had a well-child visit at age 11–12 years (63.9%) compared with those who did not (48.4%). Other variables that were significantly associated with prevalence of provider recommendation included race/ethnicity, mother's educational level, mother's marital status, mother's age, adolescent's birth county, poverty level, medical insurance, number of vaccination providers, metropolitan statistical area, region, and vaccination facility type. Additionally, prevalence of provider recommendation was the lowest among adolescents with mothers having less than high school education (34.4%), then born outside the U.S. (36.6%), and highest among those with mother's education beyond college graduation (70.4%) (Table 1).

Overall, Tdap vaccination coverage was 84.7% among adolescents aged 13–17 years. Coverage was significantly higher among adolescents with a provider recommendation (88.6%) compared with those without a provider recommendation (80.5%) ($p < 0.05$) (Table 2). Coverage was significantly higher among adolescents aged 13–15 years (86.3%) compared with those aged 16–17 years (82.3%) ($p < 0.05$) (Table 2). In multivariable analyses, characteristics independently associated with a higher likelihood of Tdap vaccination included receiving a provider recommendation (PR=1.06); being of Hispanic ethnicity (PR=1.05); having two three physician contacts in the past 12 months (PR=1.05); having one or two vaccination providers (PR=1.07, and PR=1.06, respectively); and receiving vaccinations from more than one type of facility (PR=1.09) ($p < 0.05$) (Table 3). Adolescents aged 16–17 years (PR=0.97); those not having a well-child visit at age 11–12 years (PR=0.88); and those living in the South (PR=0.95) had a lower likelihood of Tdap vaccination ($p < 0.05$) (Table 3). Coverage among adolescents with a provider recommendation was significantly higher across the majority of demographic and access to care characteristics compared with those without a provider recommendation (Table 2).

By state, prevalence of provider recommendation for Tdap among all adolescents aged 13–17 years ranged from 36.6% in Mississippi to 77.9% in Maine with a median of 57.6% (Table 4). Tdap vaccination coverage among all adolescents aged 13–17 years ranged from 59.3% in Mississippi to 95.5% in Rhode Island with a median of 84.2%. Tdap coverage among those with a provider recommendation ranged from 72.1% in Mississippi to 97.5% in North Dakota with a median of 88.6% compared with those without a provider recommendation (ranging from 52.9% in Mississippi to 96.4% in Rhode Island with a median of 81.2%) (Table 4). Point estimates of Tdap vaccination coverage were statistically significantly higher among adolescents with a provider recommendation compared with adolescents without a provider recommendation in 17 states (Table 4). Coverage differences ranged from –2.1% in Virginia to 26.2% in Maryland with a median of 7.2%. State prevalence of receiving provider recommendation also correlated positively with overall

state Tdap vaccination coverage ($r=0.50$, $p < 0.01$). Among 11 states without a middle school vaccination requirement as of 2013, eight states had lower Tdap vaccination coverage than national coverage though only coverage in South Dakota was significantly lower than the national coverage (Table 4).

DISCUSSION

The findings indicate that Tdap coverage was significantly higher among adolescents with a provider recommendation compared with those without a provider recommendation. Provider recommendation was associated with higher Tdap coverage across many demographic and access to care factors and 17 states. To the authors' knowledge, this is the first study to examine the association between provider recommendation and Tdap vaccination among adolescents. Although the impact of provider recommendation on Tdap vaccination was not reported previously, the impact of provider recommendation on other vaccinations was documented. One study showed that hepatitis A vaccination coverage was 86.9% among adolescents with a provider recommendation compared with those without a provider recommendation (65.5%).⁶ Another study indicated that human papillomavirus vaccination coverage (one or more doses) was 58.3% among adolescents with a provider recommendation compared with those without a provider recommendation (20.7%).¹³ Recommendations from providers increase parental acceptance of vaccination, and parents change their minds about delaying and refusing vaccines because of information or assurances from healthcare providers.^{14,15}

Provider recommendations for vaccination are strongly associated with a patient's decision to get vaccinated. Studies have consistently shown that provider recommendation is the strongest predictor of vaccination.⁶⁻⁹ However, the present study showed that about 43% of parents of adolescents reported not receiving a provider recommendation for the vaccine. Providers should strongly recommend vaccines to parents and adolescents. Parents usually trust physicians' opinions more than anyone else's when it comes to vaccinations.⁹ Providers should use every opportunity to vaccinate adolescent patients; review medical records to assess vaccination status when they see adolescents for sick visits and sports physicals; use patient reminder and recall systems (such as automated postcards, phone calls, and text messages); educate parents about the diseases that can be prevented by adolescent vaccines as parents may know very little about pertussis; and implement policies for standing orders so that patients can receive vaccines without a physician examination or individual physician order.^{9,16-18} Additionally, high coverage can be achieved even without provider recommendation: Overall, coverage is 80% among adolescents without a provider recommendation. Several reasons that may partially account for why coverage is relatively high among those without a provider recommendation included the following: the parent forgot about recommendation; vaccination was recommended and offered but the parent did not interpret the interaction as a recommendation; and the parent asked for the vaccine (e.g., to comply with state immunization pre-matriculation requirements) so a provider recommendation was not needed.

This study showed that having more physician contacts in the past 12 months and having a well-child visit at age 11-12 years were independently associated with a higher level of

Tdap vaccination. People who have more physician contacts may have more opportunities to discuss their vaccination status and receive vaccination. But, for many adolescents, the provider visits in the last 12 months might not be the times they would have received Tdap vaccination (which probably occurred at age 11 or 12 years, whereas the sample was adolescents aged 13–17 years). The Advisory Committee on Immunization Practices and partner organizations, including the American Academy of Pediatrics, American Medical Association, and Society for Adolescent Medicine, recommend a well-child visit for children aged 11–12 years to receive recommended vaccinations and indicated preventive services such as vaccinations required to attend middle school.^{7,19,20} Even though the well-child visit for children aged 11–12 years provides a good opportunity to discuss vaccination status and receive vaccinations, based on this study, only 40.2% of adolescents had a well-child visit at age 11–12 years. Efforts are needed to increase preventive healthcare utilization, especially at age 11–12 years, so that preteens can receive recommended vaccinations and other preventive services. In addition, providers should be encouraged to review and, if necessary, administer recommended adolescent vaccinations at all healthcare visits, in addition to the preteen visit at age 11–12 years, to prevent missed opportunities for vaccination.

Overall, Tdap vaccination coverage among adolescents aged 13–17 years in 2013 was 84.9%. Tdap vaccination coverage among adolescents aged 13–17 years has substantially increased since vaccination coverage was first assessed by NIS-Teen in 2006 (10.8%).²¹ Tdap vaccination coverage then increased from 30.4% in 2007 to 84.9% in 2013.^{16–19} Tdap vaccination coverage among adolescents could be compared with that of other vaccines that have also been recommended for adolescents since 2005–2006. Human papillomavirus vaccination coverage among female adolescents increased from 25.1% in 2007 to 57.3% in 2013,^{21–24} and prevalence of provider recommendation for human papillomavirus vaccination among female adolescents was 68.9% in 2013 (CDC unpublished data). Quadrivalent meningococcal conjugate vaccine coverage increased from 22.4% in 2007 to 77.8% in 2013,^{21–24} and prevalence of provider recommendation for this vaccine was 36.1% in 2013 (CDC unpublished data). As the vaccination program becomes more mature, coverage could be increased further.^{21–24} The providers' role is important for improving vaccination coverage after Advisory Committee on Immunization Practices recommendations for adolescents are made. Providers should strongly recommend adolescent vaccines to their parents and use every opportunity to assess vaccination status and vaccinate adolescent patients.

Substantial differences in coverage among states and regions were observed for Tdap vaccination among adolescents. Variation in state coverage could be due to differing medical care delivery infrastructure, socioeconomic factors, state laws, effectiveness of state and local immunization programs, population attitudes toward vaccinations, immunization resources, reimbursement for vaccines, vaccine administration, variations in prevalence of receipt of provider recommendation for Tdap, and other factors.^{12,25–35} Assessing local, state, and national vaccination programs is necessary for evaluating progress. For example, state-level comparisons may aid in designing tailored intervention programs and sharing best practices. Some states achieved very high coverage, and states with low prevalence of provider recommendation and lower Tdap coverage may particularly benefit from provider-

based interventions such as provider assessment and feedback, provider reminders, and a standing orders program.

Forty states have middle school requirements for Tdap vaccination as of 2013.¹² Pertussis outbreaks may occur in middle and high schools and can be highly disruptive and costly to schools and health departments.³⁶ The findings from this study showed that among 11 states without a middle school vaccination requirement, eight states had lower Tdap vaccination coverage than national coverage though only coverage in South Dakota was significantly lower than national coverage. Previous studies also indicated that middle school entry requirements have helped increase coverage for some vaccinations.^{37–39}

Limitations

The findings of this study are subject to several limitations. First, household response rates were 51.1% (landline households) and 23.3% (cell phone households), respectively. Only 59.5% (landline) and 54.5% (cell phone) of completed household interviews also had adequate provider-reported vaccination data. Some bias may remain after weighting adjustments designed to mitigate potential bias from incomplete data from the sample frame and non-response.^{40–43} Second, some provider-reported vaccination histories might not include all received vaccinations (e.g., vaccinations administered in nontraditional settings such as emergency departments) and might have underestimated vaccination coverage. Finally, reporting of provider recommendation by parents is subject to recall bias if parents did not accurately remember whether or not a recommendation had occurred, particularly parents of older adolescents who had been vaccinated years earlier.

CONCLUSIONS

The current study indicated that Tdap coverage was significantly higher among adolescents with a provider recommendation (88.6%) compared with those without a provider recommendation (80.5%). However, 43% of parents of adolescents did not receive a provider recommendation. Higher coverage can be achieved given that very high coverage was observed in some states and subgroups. For example, Tdap vaccination coverage was >90% among six states and >93% among those with a well-child visit. To further improve Tdap vaccination coverage, vaccine education efforts should target healthcare providers to increase rates of provider recommendation for Tdap. Additionally, evidence-based strategies such as standing orders and provider reminders alone or health systems interventions in combination should be taken to further improve Tdap vaccination coverage. Providers and parents should use every healthcare visit, whether for health problems, well-checks, or physicals for sports, school, or camp, as an opportunity to review adolescents' vaccination histories and ensure that every adolescent receives Tdap and other recommended vaccines.^{44,45} Additionally, to increase Tdap coverage, intervention programs should be particularly targeted to the demographic and access to care groups where vaccination coverage was low based on this study. Provider-based interventions such as provider assessment and feedback, provider reminders, and standing orders programs should be enhanced for states with low prevalence of provider recommendation and lower Tdap coverage. State programs are encouraged by CDC to promote adolescent vaccinations within their communities by

increasing awareness about the importance and benefits of adolescent vaccination. Federal, state, and local governments and community partners should collaborate to further improve vaccination coverage among adolescents.

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Table 1

Sample Characteristics of Adolescents Aged 13–17 Years in the U.S.—NIS-Teen 2013

Characteristic	Sample	Weighted %	Prevalence of provider recommendation for vaccine, weighted %
Total	18,948	100.0	56.9
Age (years)			
13–15 ^a	11,651	60.7	56.7
16–17	7,297	39.3	57.1
Gender			
Male ^a	9,906	51.2	57.1
Female	9,042	48.8	56.6
Race/ethnicity			
Non-Hispanic white ^a	12,499	55.0	63.9
Non-Hispanic black	1,701	13.8	47.7^b
Hispanic	2,872	22.1	42.4^b
American Indian/Alaskan Native	289	1.0	57.7
Asian	586	3.4	67.0
Other	1,001	4.7	62.0
Mother's educational level			
<High school ^a	2,069	13.8	34.4
High school	3,298	24.2	48.8^b
Some college or college graduate	5,266	26.0	57.0^b
>College graduate	8,315	36.1	70.4^b
Mother's married status			
Married ^a	13,671	66.1	59.4
Widowed/divorced/separated	3,589	22.8	55.8^b
Never married	1,532	11.0	44.0^b
Mother's age (years)			
34 ^a	1,651	10.2	47.9
35–44	7,964	44.6	53.5^b
45	9,333	45.3	62.2^b
Adolescent's birth country			
Born in U.S. ^a	18,237	95.5	57.8
Born outside U.S.	654	4.5	36.6^b
Income to poverty ratio			
<133% ^a	4,650	33.1	41.7
133%–<322%	5,579	29.8	57.2^b

Characteristic	Sample	Weighted %	Prevalence of provider recommendation for vaccine, weighted %
322%–<503%	4,282	18.5	67.7^b
503%	4,437	18.6	72.4^b
Medical insurance and vaccine finance ^c			
Private insurance only ^a	8,815	43.2	67.7
VFC eligible–Medicaid/IHS/AIAN (All)	7,351	44.5	50.6^b
VFC eligible–uninsured	888	5.7	37.6^b
CHIP (public)	511	2.9	55.1^b
Military	566	2.7	58.6^b
Other	133	0.9	40.9^b
Physician contacts within past year			
None ^a	2,699	16.4	47.5
1	5,331	27.8	56.5^b
2–3	6,706	35.6	60.4^b
4	4,128	20.1	58.8^b
Well child visit at age 11–12 years ^d			
Yes ^a	7,963	40.2	63.9
No	5,063	24.7	48.4^b
Don't know	5,922	35.0	54.9^b
Number of vaccination providers			
1	9,267	50.6	58.2
2	5,630	29.0	54.7
3 ^a	4,024	20.3	56.7
Metropolitan statistical area (MSA)			
Urban area	7,240	38.9	52.7
Suburban area	7,430	47.8	61.6^b
Rural area ^a	4,278	13.3	52.3
Region			
Northeast	3,893	16.9	64.8^b
Midwest	4,297	21.7	59.0
South	6,246	37.5	52.8
West ^a	4,512	24.0	55.9
Vaccination facility type			
All private facilities ^a	8,719	50.4	63.0
All public facilities	2,795	15.4	37.6^b
All hospital facilities	1,942	9.0	60.5

Characteristic	Sample	Weighted %	Prevalence of provider recommendation for vaccine, weighted %
All STD/school/teen clinics or other facilities	320	1.8	39.9^b
Mixed ^e	4,774	21.9	56.5^b
Other ^f	287	1.5	57.8
Parental report of provider recommendation for vaccine			
Yes ^a	10,258	56.9	
No	6,690	43.1	

Note: Boldface indicates statistical significance ($p < 0.05$).

^aReference level.

^b $p < 0.05$ by t -test compared with reference group.

^cInsurance categories are mutually exclusive.

^dStatus of healthcare visit at age 11–12 years based on provider-reported data.

^eMixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, STD/school/teen clinics.

^fIncludes military, WIC clinics, and pharmacies.

AIAN, American Indian/Alaska Native; CHIP, Children's Health Insurance Program; IHS, Indian Health Service; NIS, National Immunization Survey; STD, sexually transmitted diseases; VFC, Vaccines for Children Program; WIC, the National Special Supplemental Nutrition Program for Women, Infants, and Children.

Table 2

Tdap Vaccination Coverage (1 Dose) Among Adolescents Aged 13–17 Years—NIS-Teen 2013

Characteristic	Tdap vaccination coverage		
	Overall, % (95% CI)	Parental report of provider recommendation for vaccine	
		Yes, % (95% CI)	No, % (95% CI)
Total	84.7 (83.7, 85.7)	88.6 (87.5, 89.7)	80.5 (78.6, 82.3)^a
Age (years)			
13–15 ^b	86.3 (85.1, 87.4)	89.8 (88.3, 91.0)	82.2 (80.0, 84.2)^a
16–17	82.3 (80.5, 84.0)^c	86.9 (85.0, 88.7)^c	77.8 (74.3, 81.0)^{a,c}
Gender			
Male ^b	84.4 (83.0, 85.8)	88.4 (86.7, 89.8)	80.1 (77.3, 82.7)^a
Female	85.0 (83.6, 86.3)	88.9 (87.3, 90.4)	80.9 (78.2, 83.3)^a
Race/ethnicity			
Non-Hispanic white ^b	84.8 (83.6, 85.9)	88.3 (86.9, 89.6)	79.4 (77.0, 81.6)^a
Non-Hispanic black	82.7 (79.4, 85.5)	86.0 (81.5, 89.6)	80.6 (75.1, 85.1)
Hispanic	84.9 (82.2, 87.3)	89.8 (86.6, 92.3)	81.7 (77.2, 85.4)^a
American Indian/Alaskan Native	84.8 (76.2, 90.7)	89.5 (79.0, 95.0)	84.5 (74.6, 91.0)
Asian	88.8 (84.7, 91.9)	93.2 (88.2, 96.1)	84.6 (75.1, 90.9)
Other	86.1 (81.9, 89.4)	91.1 (86.4, 94.3)	80.0 (71.2, 86.7)^a
Mother's educational level			
<High school ^b	83.6 (80.5, 86.4)	87.2 (82.8, 90.6)	82.8 (78.1, 86.6)
High school	81.8 (79.2, 84.1)	87.4 (84.1, 90.2)	76.8 (72.4, 80.8)^a
Some college or college graduate	83.9 (82.1, 85.6)	87.1 (84.7, 89.2)	80.9 (77.7, 83.7)^a
>College graduate	87.7 (86.4, 88.9)^c	90.3 (88.8, 91.6)	82.2 (78.9, 85.1)^a
Mother's married status			
Married ^b	85.7 (84.5, 86.8)	89.5 (88.2, 90.6)	80.8 (78.4, 83.1)^a
Widowed/divorced/separated	83.9 (81.8, 85.8)	86.7 (83.7, 89.2)	82.9 (79.6, 85.8)
Never married	81.9 (78.0, 85.3)^c	87.3 (82.3, 91.1)	77.2 (70.8, 82.6)^a

Characteristic	Tdap vaccination coverage		
	Overall, % (95% CI)	Parental report of provider recommendation for vaccine	
		Yes, % (95% CI)	No, % (95% CI)
Mother's age (years)			
34 ^b	81.9 (78.5, 84.9)	83.3 (77.6, 87.7)	80.7 (75.9, 84.7)
35–44	83.7 (82.0, 85.2)	88.4 (86.7, 89.9)^c	79.3 (76.0, 82.2)^a
45	86.4 (85.1, 87.6)^c	89.8 (88.1, 91.2)^c	81.9 (79.3, 84.2)^a
Adolescent's birth country			
Born in U.S. ^b	84.9 (83.9, 85.9)	88.7 (87.5, 89.7)	80.7 (78.7, 82.4)^a
Born outside U.S.	80.4 (73.0, 86.1)	87.8 (80.5, 92.6)	78.2 (66.6, 86.7)
Income to poverty ratio			
<133% ^b	83.2 (81.1, 85.1)	87.4 (84.7, 89.7)	80.7 (77.3, 83.6)^a
133%–<322%	82.6 (80.8, 84.3)	86.6 (84.3, 88.6)	78.6 (75.4, 81.5)^a
322%–<503%	87.1 (85.0, 88.8)^c	90.5 (88.3, 92.3)	82.1 (77.4, 86.0)^a
503%	88.5 (86.6, 90.1)^c	90.7 (88.6, 92.6)^c	82.4 (77.7, 86.3)^a
Medical insurance and vaccine finance ^d			
Private only ^b	88.2 (87.0, 89.3)	91.4 (90.0, 92.6)	83.1 (80.2, 85.6)^a
VFC eligible–Medicaid/IHS/AIAN (All)	85.4 (83.8, 86.8)^c	88.0 (86.0, 89.8)^c	82.8 (80.1, 85.2)^a
VFC eligible–uninsured	76.8 (71.6, 81.4)^c	82.7 (72.6, 89.6)^c	77.0 (70.0, 82.7)
CHIP (public)	84.3 (78.7, 88.7)	88.2 (79.0, 93.7)	81.4 (73.0, 87.6)
Military	86.2 (79.3, 91.1)	90.5 (80.4, 95.7)	80.2 (67.8, 88.7)
Other	74.5 (49.7, 89.6)	89.8 (79.0, 95.3)	68.4 (30.6, 91.4)
Physician contacts within past year			
None ^b	79.1 (75.8, 82.1)	86.0 (82.4, 89.1)	75.0 (69.2, 80.1)^a
1	84.0 (82.1, 85.8)^c	88.4 (86.0, 90.4)	79.5 (75.8, 82.7)^a
2–3	86.9 (85.4, 88.2)^c	89.9 (88.0, 91.5)^c	83.4 (80.8, 85.7)^{a,c}
4	86.3 (84.2, 88.1)^c	88.4 (86.0, 90.5)	82.3 (78.0, 85.9)^{a,c}

Characteristic	Tdap vaccination coverage		
	Overall, % (95% CI)	Parental report of provider recommendation for vaccine	
		Yes, % (95% CI)	No, % (95% CI)
Well-child visit at age 11–12 years ^e			
Yes ^b	93.0 (91.8, 94.0)	93.2 (91.5, 94.5)	92.0 (89.6, 93.9)
No	77.4 (75.2, 79.4)^c	83.4 (80.6, 85.9)^c	73.8 (70.2, 77.1)^{a,c}
Don't know	80.5 (78.5, 82.2)^c	85.8 (83.7, 87.8)^c	75.2 (71.5, 78.6)^{a,c}
Number of providers			
1	86.0 (84.7, 87.3)^c	89.5 (87.9, 90.9)^c	82.1 (79.4, 84.5)^{a,c}
2	85.4 (83.6, 86.9)^c	89.1 (86.9, 90.9)^c	81.2 (78.0, 84.0)^{a,c}
3 ^b	80.9 (78.2, 83.3)	85.8 (82.9, 88.3)	75.6 (70.5, 80.1)^a
Metropolitan statistical area (MSA)			
Urban area	84.8 (83.1, 86.3)^c	87.6 (85.6, 89.4)	81.6 (78.6, 84.3)^{a,c}
Suburban area	85.8 (84.3, 87.2)^c	89.8 (88.2, 91.3)^c	81.2 (77.9, 84.0)^{a,c}
Rural area ^b	80.6 (78.3, 82.7)	86.6 (83.7, 89.1)	75.3 (71.7, 78.7)^a
Region			
Northeast	89.3 (87.6, 90.8)^c	92.3 (90.3, 93.9)	84.5 (80.7, 87.7)^a
Midwest	84.1 (82.3, 85.6)	87.8 (85.7, 89.7)	80.2 (77.1, 83.1)^a
South	82.2 (80.5, 83.7)^c	85.8 (83.5, 87.8)^c	79.0 (76.4, 81.5)^a
West ^b	86.1 (83.3, 88.4)	90.7 (88.0, 92.8)	80.8 (74.9, 85.6)^a
Facility type			
All private facilities ^b	86.7 (85.4, 87.9)	89.6 (88.0, 90.9)	82.5 (79.8, 85.0)^a
All public facilities	78.5 (75.2, 81.4)^c	81.7 (77.1, 85.6)^c	76.3 (71.4, 80.6)^c
All hospital facilities	79.2 (75.0, 82.9)^c	84.6 (80.1, 88.2)^c	68.1 (59.2, 75.8)^{a,c}
All STD/school/teen clinics or other facilities	78.6 (70.2, 85.2)^c	78.2 (61.0, 89.2)^c	78.7 (67.5, 86.7)
Mixed ^f	88.9 (87.3, 90.3)^c	91.9 (89.8, 93.7)	86.0 (83.3, 88.4)^a
Other ^g	80.0 (68.0, 88.3)	87.5 (77.1, 93.6)	71.7 (48.0, 87.4)

Characteristic	Tdap vaccination coverage		
	Overall, % (95% CI)	Parental report of provider recommendation for vaccine	
		Yes, % (95% CI)	No, % (95% CI)
Parental report of provider recommendation for vaccine			
Yes ^b	88.6 (87.5, 89.7)		
No	80.5 (78.6, 82.3)^c		

Note: Boldface indicates statistical significance ($p < 0.05$).

^a $p < 0.05$ by t -test comparing provider recommendation versus no provider recommendation.

^b Reference level.

^c $p < 0.05$ by t -test comparing against reference level.

^d Insurance categories are mutually exclusive.

^e Status of healthcare visit at age 11–12 years based on provider-reported data.

^f Mixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, STD/school/teen clinics.

^g Includes military, WIC clinics, and pharmacies.

AIAN, American Indian/Alaska Native; CHIP, Children's Health Insurance Program; IHS, Indian Health Service; NIS, National Immunization Survey; STD, sexually transmitted diseases; Tdap, tetanus, diphtheria, and acellular pertussis; VFC, Vaccines for Children Program.

Table 3

Multivariable Logistic Regression and Predictive Marginal Analysis of Tdap Vaccination (1 Dose) Among Adolescents

Characteristic	Adjusted prevalence ratio ^a (95% CI)
Age (years)	
13–15 ^b	ref
16–17	0.97 (0.95, 0.99)^c
Race/ethnicity	
Non-Hispanic white ^b	ref
Non-Hispanic black	1.03 (0.99, 1.07)
Hispanic	1.05 (1.01, 1.08)^c
American Indian/Alaskan Native	1.05 (0.99, 1.12)
Asian	1.05 (1.00, 1.10)
Other	1.03 (0.98, 1.08)
Physician contacts within past year	
None ^b	ref
1	1.03 (0.99, 1.07)
2–3	1.05 (1.01, 1.09)^c
4	1.04 (1.00, 1.08)
Well-child visit at age 11–12 years ^d	
Yes ^b	ref
No	0.88 (0.86, 0.91)^c
Don't know	0.90 (0.88, 0.92)^c
Number of providers	
1	1.07 (1.03, 1.11)^c
2	1.06 (1.02, 1.10)^c
3 ^b	ref
Region	
Northeast	0.99 (0.96, 1.03)
Midwest	0.97 (0.94, 1.00)
South	0.95 (0.92, 0.98)^c
West ^b	ref
Facility type	
All private facilities ^b	ref
All public facilities	0.99 (0.95, 1.03)
All hospital facilities	0.96 (0.91, 1.00)
All STD/school/teen clinics or other facilities	0.99 (0.91, 1.07)

Characteristic	Adjusted prevalence ratio ^a (95% CI)
Mixed ^e	1.09 (1.06, 1.12)^c
Other ^f	1.06 (0.97, 1.16)
Parental report of provider recommendation for vaccine	
Yes	1.06 (1.04, 1.08)^c
No ^b	ref

Note: Boldface indicates statistical significance ($p < 0.05$).

^aPrevalence ratios were also adjusted by several variables that were not significant in the model, and those variables include gender, mother's educational level, mother's marital status, mother's age, birth country, poverty level, type of health insurance and vaccine finance, and metropolitan statistical area (MSA).

^bReference level.

^c $p < 0.05$ compared to reference level.

^dStatus of healthcare visit at age 11–12 years based on provider-reported data.

^eMixed indicates that the facility is identified to be in more than one of the facility categories such as private, public, hospital, STD/school/teen clinics.

^fIncludes military, WIC clinics, and pharmacies.

STD, sexually transmitted diseases; Tdap, Tetanus, diphtheria, and acellular pertussis; WIC, the National Special Supplemental Nutrition Program for Women, Infants, and Children.

Table 4
Tdap Vaccination Coverage Among Adolescents, by State and Provider Recommendation for Tdap Vaccination

	Sample size, N	Prevalence of provider recommendation		Tdap vaccination coverage			Coverage difference, ^d % (95% CI)
		for Tdap, % (95% CI)	Overall, % (95% CI)	With provider recommendation, % (95% CI)	Without provider recommendation, % (95% CI)		
National	18,948	56.9 (55.5, 58.3)	84.7 (83.7, 85.7)	88.6 (87.5, 89.7)	80.5 (78.6, 82.3)	8.2 (6.0, 10.3) ^b	
Alabama	324	59.5 (52.9, 66.0)	86.4 (81.2, 90.4)	88.6 (81.2, 93.4)	86.2 (77.4, 91.9)	2.5 (-6.8, 11.8)	
Alaska	338	53.7 (46.9, 60.4)	70.8 (64.4, 76.5)	79.6 (71.6, 85.8)	61.7 (51.1, 71.4)	17.9 (5.4, 30.3) ^b	
Arizona	391	46.5 (39.8, 53.1)	83.7 (78.2, 88.0)	87.2 (78.9, 92.6)	82.2 (73.0, 88.8)	5.0 (-5.3, 15.3)	
Arkansas ^c	323	38.6 (32.1, 45.2)	75.6 (69.7, 80.7)	80.9 (71.3, 87.9)	72.8 (64.6, 79.8)	8.1 (-3.1, 19.4)	
California	338	54.4 (47.4, 61.4)	87.9 (82.5, 91.8)	92.9 (87.4, 96.1)	81.2 (69.8, 88.9)	11.8 (1.4, 22.1) ^b	
Colorado	345	64.9 (58.8, 71.1)	86.5 (81.4, 90.4)	89.2 (82.2, 93.7)	80.2 (70.0, 87.6)	9.0 (-1.4, 19.4)	
Connecticut	332	66.9 (60.0, 73.8)	90.4 (85.2, 93.8)	93.8 (89.0, 96.6)	80.4 (65.5, 89.9)	13.4 (0.7, 26.1) ^b	
Delaware ^c	353	61.9 (55.3, 68.6)	83.9 (78.8, 88.0)	86.5 (80.3, 91.0)	76.3 (65.0, 84.8)	10.2 (-1.0, 21.4)	
District of Columbia	195	49.4 (38.1, 60.7)	80.8 (70.5, 88.1)	82.7 (65.5, 92.3)	74.8 (57.1, 86.9)	7.9 (-12.2, 27.9)	
Florida	330	52.3 (44.8, 59.8)	84.2 (77.9, 88.9)	85.6 (75.0, 92.2)	82.2 (72.0, 89.2)	3.4 (-8.6, 15.4)	
Georgia ^c	258	55.8 (47.4, 64.2)	81.1 (73.5, 87.0)	81.7 (69.9, 89.6)	83.2 (70.6, 91.1)	-1.5 (-15.6, 12.6)	
Hawaii ^c	323	62.6 (55.2, 69.9)	79.7 (73.9, 84.4)	88.9 (83.4, 92.8)	64.2 (51.1, 75.5)	24.7 (11.4, 38.0) ^b	
Idaho	288	54.6 (46.9, 62.3)	73.4 (66.3, 79.5)	74.3 (63.6, 82.6)	71.9 (60.6, 81.0)	2.3 (-11.7, 16.4)	
Illinois	572	56.7 (51.1, 62.4)	84.2 (79.4, 88.1)	90.5 (84.5, 94.4)	78.7 (70.0, 85.4)	11.9 (2.8, 20.9) ^b	
Indiana	385	54.0 (47.7, 60.3)	89.7 (85.7, 92.7)	91.4 (85.8, 94.9)	86.9 (79.2, 92.0)	4.5 (-3.2, 12.2)	
Iowa	389	68.2 (62.1, 74.2)	78.7 (73.1, 83.3)	83.4 (76.9, 88.3)	70.7 (58.9, 80.3)	12.6 (0.4, 24.8) ^b	
Kansas	309	57.6 (50.7, 64.4)	83.3 (77.8, 87.6)	86.1 (79.2, 90.9)	79.7 (68.9, 87.4)	6.4 (-4.5, 17.3)	
Kentucky	299	49.2 (42.0, 56.4)	83.6 (77.9, 88.0)	87.3 (78.5, 92.8)	80.4 (71.4, 87.1)	6.9 (-3.6, 17.4)	
Louisiana	301	58.9 (52.0, 65.7)	87.4 (82.2, 91.2)	90.1 (82.8, 94.5)	86.3 (76.2, 92.5)	3.8 (-6.0, 13.6)	
Maine ^c	350	71.9 (72.6, 83.2)	82.3 (77.3, 86.5)	87.7 (82.1, 91.7)	64.1 (50.9, 75.5)	23.5 (10.1, 37.0) ^b	
Maryland ^c	328	55.4 (47.1, 63.7)	82.5 (75.5, 87.8)	93.1 (84.2, 97.2)	67.0 (53.3, 78.3)	26.2 (12.1, 40.2) ^b	

	Sample size, N	Prevalence of provider recommendation for Tdap, % (95% CI)		Tdap vaccination coverage			Coverage difference, ^a % (95% CI)
		With provider recommendation, % (95% CI)	Without provider recommendation, % (95% CI)	Overall, % (95% CI)	With provider recommendation, % (95% CI)	Without provider recommendation, % (95% CI)	
Massachusetts	396	69.9 (63.8, 76.0)	94.9 (91.5, 96.9)	94.8 (89.3, 97.5)	96.1 (91.1, 98.4)	-1.3 (-6.4, 3.7)	
Michigan	316	59.4 (52.6, 66.2)	80.1 (74.4, 84.8)	84.2 (76.9, 89.6)	76.7 (66.1, 84.7)	7.6 (-3.7, 18.9)	
Minnesota ^c	386	65.1 (58.6, 71.6)	90.4 (85.7, 93.7)	95.4 (90.1, 97.9)	84.6 (72.7, 91.9)	10.8 (0.7, 20.9)^b	
Mississippi	295	36.6 (29.9, 43.3)	59.3 (52.6, 65.7)	72.1 (61.2, 80.9)	52.9 (43.9, 61.8)	19.2 (5.8, 32.5)^b	
Missouri	297	51.2 (43.6, 58.9)	80.9 (75.0, 85.7)	82.7 (73.4, 89.2)	82.0 (73.0, 88.5)	0.6 (-10.4, 11.7)	
Montana ^c	333	59.6 (52.9, 66.2)	84.3 (78.8, 88.6)	87.2 (79.8, 92.2)	82.4 (73.0, 89.0)	4.8 (-5.3, 14.9)	
Nebraska	310	59.1 (52.4, 65.7)	85.2 (79.7, 89.4)	89.5 (82.0, 94.1)	82.1 (72.0, 89.1)	7.4 (-2.9, 17.8)	
Nevada	352	45.3 (38.8, 51.8)	86.3 (81.4, 90.0)	89.2 (82.9, 93.4)	83.9 (75.6, 89.8)	5.3 (-3.4, 14.0)	
New Hampshire	348	70.3 (64.3, 76.3)	94.5 (90.8, 96.8)	95.0 (90.8, 97.3)	92.9 (81.7, 97.5)	2.1 (-5.7, 9.9)	
New Jersey	330	59.9 (52.9, 67.0)	84.4 (78.3, 88.9)	85.7 (76.5, 91.7)	84.1 (74.5, 90.5)	1.6 (-9.3, 12.6)	
New Mexico	377	56.1 (49.8, 62.5)	85.4 (80.5, 89.3)	86.8 (80.0, 91.6)	84.2 (75.6, 90.2)	2.6 (-6.6, 11.8)	
New York	723	62.1 (57.4, 66.9)	89.1 (85.8, 91.6)	93.7 (90.3, 96.0)	82.5 (75.0, 88.1)	11.2 (4.1, 18.2)^b	
North Carolina ^c	323	61.3 (54.6, 68.0)	87.9 (83.1, 91.4)	89.1 (82.0, 93.6)	84.6 (76.0, 90.5)	4.5 (-4.6, 13.6)	
North Dakota ^c	351	60.2 (53.3, 67.2)	94.3 (90.5, 96.6)	97.5 (93.8, 99.0)	91.2 (81.2, 96.1)	6.3 (-1.1, 13.6)	
Ohio	337	59.6 (53.0, 66.2)	82.2 (76.6, 86.8)	84.9 (77.0, 90.5)	78.2 (68.0, 85.8)	6.7 (-4.4, 17.9)	
Oklahoma	439	49.3 (43.4, 55.1)	76.4 (71.1, 81.0)	79.2 (71.4, 85.3)	74.3 (66.3, 81.0)	4.9 (-5.3, 15.0)	
Oregon	384	66.1 (60.1, 72.0)	84.9 (79.8, 88.8)	89.1 (83.4, 93.0)	76.2 (65.0, 84.7)	12.9 (1.9, 23.9)^b	
Pennsylvania	764	66.0 (60.2, 71.9)	89.8 (85.8, 92.8)	93.0 (88.9, 95.6)	84.0 (73.9, 90.7)	9.0 (0.1, 17.9)^b	
Rhode Island	317	71.7 (65.4, 77.9)	95.5 (91.6, 97.6)	94.5 (88.8, 97.4)	96.4 (88.2, 99.0)	-1.9 (-7.8, 4.1)	
South Carolina	316	51.6 (44.1, 59.1)	71.0 (64.1, 77.0)	76.1 (66.3, 83.8)	67.7 (56.9, 76.9)	8.4 (-5.0, 21.8)	
South Dakota ^c	307	56.8 (49.9, 63.7)	69.4 (62.8, 75.3)	76.4 (67.4, 83.5)	59.4 (48.6, 69.4)	17.0 (3.7, 30.3)^b	
Tennessee	313	57.0 (50.1, 63.8)	78.7 (72.9, 83.6)	80.3 (71.9, 86.6)	75.7 (65.0, 83.9)	4.6 (-7.4, 16.5)	
Texas	1,202	48.5 (43.2, 53.7)	84.3 (80.4, 87.6)	90.0 (85.7, 93.1)	81.3 (74.9, 86.3)	8.8 (2.0, 15.5)	
Utah	330	51.5 (44.7, 58.3)	84.2 (78.5, 88.6)	92.3 (87.4, 95.4)	80.2 (69.9, 87.7)	12.1 (2.4, 21.7)^b	
Vermont	333	76.6 (70.5, 82.8)	91.6 (87.1, 94.6)	95.5 (90.8, 97.9)	81.1 (65.8, 90.6)	14.4 (1.6, 27.1)^b	

	Sample size, N	Prevalence of provider recommendation for Tdap, % (95% CI)	Tdap vaccination coverage			Coverage difference, ^d % (95% CI)
			Overall, % (95% CI)	With provider recommendation, % (95% CI)	Without provider recommendation, % (95% CI)	
Virginia	309	57.1 (48.0, 66.2)	82.4 (74.7, 88.1)	82.5 (70.6, 90.2)	84.5 (74.1, 91.3)	-2.1 (-14.9, 10.8)
Washington	382	68.6 (62.1, 75.1)	85.1 (79.5, 89.4)	90.0 (83.5, 94.2)	83.6 (70.3, 91.7)	6.4 (-5.4, 18.2)
West Virginia	338	54.4 (47.7, 61.2)	75.7 (69.6, 80.9)	78.5 (69.9, 85.1)	69.4 (59.2, 78.0)	9.1 (-3.1, 21.3)
Wisconsin	338	65.9 (59.4, 72.4)	89.1 (84.1, 92.6)	91.3 (85.3, 95.0)	87.3 (75.8, 93.7)	4.1 (-5.8, 14.0)
Wyoming	331	50.4 (43.8, 57.1)	91.4 (87.8, 94.1)	92.9 (88.0, 95.9)	92.7 (86.8, 96.1)	0.2 (-5.7, 6.1)
Median		57.6	84.2	88.6	81.2	7.2
Range		36.6, 77.9	59.3, 95.5	72.1, 97.5	52.9, 96.4	-2.1, 26.2

Note: Boldface indicates statistical significance ($p < 0.05$)

^d Coverage difference between with and without provider recommendation.

^b $p < 0.05$ comparing with and without provider recommendation.

^c States without middle school Tdap vaccination requirement as of 2013.

Tdap, tetanus, diphtheria, and acellular pertussis.