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Concordance of adolescent human papillomavirus vaccination parental report with provider report in the National Immunization Survey-Teen (2008–2013)

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Abstract

Objectives—To examine the accuracy of parental report of HPV vaccination through examination of concordance, with healthcare provider vaccination report as the comparison.

Methods—The 2008–2013 National Immunization Survey (NIS)-Teen was used to examine accuracy of parent reports of HPV vaccination for their female daughters aged 13–17 years, as compared with provider report of initiation and number of doses. Multivariable logistic regression models were used to examine associations related to concordance of parent and provider report.

Results—Of 51,746 adolescents, 84% concordance for HPV vaccine initiation and 70% concordance for number of doses was observed. Accuracy varied by race/ ethnicity, region, time, and income. The parent report of number of doses was more likely to be accurate among parents of 13 and 14 year old females than 17 year olds. Accuracy of initiation and number of doses were lower among Hispanic and black adolescents compared to white parents. The odds of over-report was higher among minorities compared to whites, but the odds of underreport was also markedly

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higher in these groups compared to parents of white teens. Accuracy of parental vaccine report decreased across time.

Conclusions—These findings are important for healthcare providers who need to ascertain the vaccination status of young adults. Strengthening existing immunization registries to improve data sharing capabilities and record completeness could improve vaccination rates, while avoiding costs associated with over-vaccination.

Keywords

accuracy of vaccine reporting; human papillomavirus vaccine; parental HPV vaccine report

Introduction

The HPV vaccine is an effective primary prevention tool to prevent genital warts and anogenital cancers, a benefit demonstrated both in randomized clinical trials and in population studies.^{1–5} Currently, the Advisory Committee on Immunization Practices (ACIP) recommends HPV vaccination for 11–12 year olds with catch-up vaccination up to 26 years of age for females, and 21 years for males, or for men who have sex with men up to 26 years old if not vaccinated previously.⁶ The ACIP recommends 3 doses of the HPV vaccine to be given at intervals of 0, 1–2, and 6 months, and it can be given as early as age 9.⁶ In 2014, 60% of 13–17 year old females and 42% of males had initiated the HPV vaccine series, according to the National Immunization Survey-Teen (NIS-Teen).⁷

The low levels of vaccination achieved since the vaccine was licensed for use in the U.S. make it critical that unvaccinated individuals be identified and vaccinated, while avoiding the cost of over-vaccination among those who already received the series. Thus, it is important that patient HPV vaccination histories are accurate, which may be difficult for families that change healthcare providers often. Accurate vaccination records are also important to help understand national trends in preventable diseases, and are a benchmark for providers serving patients eligible for vaccination. Although national vaccination rates are evaluated using provider-reported vaccination histories, some HPV vaccination population estimates rely on self-report or parental report, particularly in the clinic, but also in some state and national surveys.^{8–10}

The purpose of this study was to examine the accuracy of HPV vaccination report by parents among their adolescent female children (age 13–17 years old), as compared to health provider reports across time (2008–2013). We also examined characteristics associated with parental over-reporting and underreporting of both HPV vaccine initiation and number of doses received. The quadrivalent HPV vaccine was not licensed for use in males until late 2009. In 2011, the vaccine was recommended for adolescent males by the ACIP.¹¹ As a result, data has not been collected on males for very long in the NIS-Teen, and therefore, our study focused on parental report of female adolescent children.

Methods

For this study, we used the NIS-Teen,¹² a national telephone survey administered by the Centers for Disease Control and Prevention (CDC) that asks parents of U.S. adolescents 13–17 years old about their vaccination status. The survey is conducted via randomly selected landline and cell phone numbers. Children’s providers are also surveyed when parents give permission to contact them. We examined data collected annually between 2008 and 2013 from this nationally representative sample. Detailed information about NIS-Teen methodology is reported elsewhere.^{12,13} During the time period examined, the parents of 96,147 females were included in the survey, 88,135 had data on the HPV vaccine, and 59,385 had provider-verified HPV vaccination information. This study was exempted by the University of Texas Institutional Review Board.

Parents of female adolescents who had responded either “yes” or “no” to the question, “has your teen ever received any human papillomavirus shots?” were included in this study. Parents that responded, “don’t know” or “refused” were not included. We evaluated characteristics for all females who met those inclusion criteria to compare representativeness of the subsample of females that included information from their providers. For all other calculations, female adolescents were included if their provider had also provided information about their HPV vaccination status. Vaccination status was requested of all providers reported by parents. The final sample that included both parental and provider report was 51,702.

Age of each female adolescent was evaluated as a categorical variable, and ranged between 13 and 17 years. Race/ ethnicity included adolescents categorized as: non-Hispanic white, non-Hispanic black, Hispanic, or other ethnicity. Region included 4 Census regions: Northeast, Midwest, South, and West. The year of interview was included as a categorical variable, ranging from 2008 to 2013. Both age and year were included as categorical because a linear relationship could not be assumed. Income was categorized as: <\$20,000, \$20,001–\$50,000, \$50,001+, and Missing. We collapsed some income categories available in the data to more evenly distribute the sample in each category. Further, the high-income cutoff was \$50,001+ because associations did not differ in higher income categories. We included income rather than poverty measures because income may have been more responsive to the changing economics of interviewed parents. The missing category was included because a high proportion of respondents (9.2%) had a missing value. In addition to reporting initiation as a binary variable (0=not initiated, 1=1+ shots), we included the number of shots that the parent reported their teen receiving. Possible results ranged from 0 doses to 3+ doses of the HPV vaccine.

For analyses that assessed agreement, a binary variable was created, with 0=no agreement between parent and provider reports and 1=agreement between parent and provider reports. Binary variables for agreement were developed for initiation of the HPV vaccine series, as well as the number of doses that the adolescent received. To assess over-reporting and underreporting of HPV vaccine initiation and number of doses, we developed a 3-level variable, with 1=underreport, 0=agreement, and –1=over-report. All variables were developed using provider report as the gold standard.

Statistical analyses

We calculated frequencies for each variable, and reported the weighted proportions for each characteristic. All data was weighted for all analyses in order to account for sampling methods, with weights calculated according to NIS-Teen instructions for analyses that pool data across time for both landline and cell-phone interviews.¹² Provider weights were used for all calculations. Strata were also included in all calculations to account for telephone number sampling methods according to NIS-Teen instructions.¹² We evaluated parent and provider agreement of both vaccine initiation and number of doses by: age of the teen, race/ethnicity, region of the U.S., year, and income level. We then calculated the sensitivity, specificity, false positive, and false negative of parental report of HPV vaccine initiation compared to the standard of provider report.

Sensitivity is the proportion of parents who recalled their child being vaccinated among the total who were vaccinated. Specificity was calculated as the proportion of parents who recalled that their children were not vaccinated among the total who were not vaccinated. False negative was calculated as the proportion of parents who responded that their child had not initiated compared to the total of provider reports of HPV vaccine initiates. False positive was calculated as the proportion of parents who responded that their child had initiated compared to the total of provider reports of non-initiates. All prevalence estimates also included a 95% confidence interval. We also calculated the proportion of parents that over-reported and underreported the number of HPV vaccine doses. To calculate weighted frequency of over-vaccination, adolescents whose providers reported they received more than 3 doses were estimated, and multiplied the number of excess doses by the weighted frequency for 2013. We calculated the potential excess doses that could be received by multiplying the difference between provider report and parent report with weighted frequencies of those whose providers reported had received between 1 and 3 doses. We evaluated the characteristics that were associated with agreement between parent self-report and provider report of teen patients' HPV vaccine initiation and number of doses received using multivariable logistic regression models. Comparisons to evaluate odds of over- and underreport of HPV vaccination were conducted using logistic regression with the glogit link. Agreement between parent and provider report was used as the referent. Logistic regression models were conducted using the SURVEYLOGISTIC procedure. All variables associated with report of either HPV vaccine initiation or completion in bivariate analyses were included in multivariable models. All calculations were conducted using SAS 9.3® software (SAS Institute, Cary, NC).

Results

Sample characteristics

The sample which included both provider and parental report of HPV vaccination had an even distribution across age (Table 1). Sample characteristics are similar between the full sample of parent reported data and parent with provider data. A higher proportion of parents reported their children had not been vaccinated in the total sample compared to parents with provider report ($p<0.001$). Parents reported that 41.9% (95% CI: 41.1%–42.6%) of their children had initiated, while providers reported that 46.9% (95% CI: 46.1%–47.4%) had

initiated. The majority of the sample was non-Hispanic white, followed by Hispanic, and black. Among those that reported the number of HPV doses received, less than 20% had received all 3 doses. Agreement of HPV vaccine initiation between parental self-report and provider report did not differ by age group. However, a higher proportion of parents of younger teens' responses were concordant with providers for the number of doses. Significant differences in agreement between parental response and provider response varied for reports of vaccine initiation and number of doses by: race/ ethnicity, region, year of interview, and income.

Sensitivity, specificity, and accuracy of parental report

Overall sensitivity of parental report of HPV vaccine initiation in this sample was 78% (95% CI, 76%–79%) and specificity was 90% (95% CI, 89%–90%). Overall agreement between parental report and provider report for adolescent HPV vaccine initiation occurred in 84.0% (95% CI, 83.4%–84.6%) of parental reports. Overall agreement for the number of doses was 73.1% (95% CI, 72.3%–73.8%). Sensitivity of parental report varied by adolescent age, race/ethnicity, region, time, and income (Table 2). In general, specificity decreased across time. False positives remained stable across all characteristics, and did not exceed 7.1% for any single characteristic (range 4.3%–7.1%). False negatives were higher, and were highest among adolescents living in the West and lowest among families making \$50,001+ in household income. A high proportion of parents underreported the number of doses at 21.2%, although over-report was also high at 8.6% in the total sample. There were variations in the proportion of parents that over-reported and underreported the number of doses their daughters had received (Table 2). Over-report of number of doses increased with age ($p<0.001$), and was highest among parents of non-Hispanic black females ($p<0.001$). It was also higher in the South ($p<0.001$). In general, over-report increased across time ($p<0.001$), but decreased by income ($p<0.001$). Over-report and underreport were highest among parents who reported that their child had received 2 doses, but there were no significant differences between parents reporting 1 or 2 doses ($p>0.05$).

A weighted frequency of 8,852 adolescents had received more than 3 injections in 2013, according to providers. The number of excess injections received was 10,010, and at \$130 per dose, the estimated cost for over-vaccination of 13–17 year olds would have been \$1,301,300. A weighted frequency of 316,716 parents underreported HPV vaccination in 2013. The potential for over-vaccination was 528,362 doses, with potential costs of \$68,687,060 if all underreporting parents seek to get 3 doses for their children, and if providers based the decision to vaccinate on parental recall alone.

Concordance between parent and provider reports

Younger age was associated with a higher likelihood of agreement with initiation between parent and provider reports among 13 year olds in multivariable logistic regression analyses (Table 3). Compared to non-Hispanic white females, the parents of other races/ethnicities were less likely to report HPV vaccine initiation in agreement with providers. The likelihood of agreement was less likely among those from the West compared to the Northeast, but similar for other regions. Agreement was less likely among parents with a lower household income, and odds of agreement for HPV vaccine initiation was lower in 2010 and later.

Agreement between parent and provider report of the number of HPV vaccine doses was more likely among 13 and 14 year olds, and was similar across the older age groups compared to 17 year old adolescents (Table 3). Agreement for number of doses was less for racial/ ethnic minorities compared to non-Hispanic whites. Small but significantly elevated odds of agreement for number of doses was observed in the Midwest and South regions compared to the Northeast, and the Western region had lower likelihood of agreement. Decreasing income was associated with decreased odds of agreement, while increasing age was associated with decreasing odds of agreement between parent and provider report for the number of HPV vaccine doses.

Over- and underreport of HPV vaccination

Parental over-report of HPV vaccine initiation was less likely among 13 and 14 year old adolescents compared to 17 year olds (Table 4). Parents of black adolescents were more likely to over-report compared to white. Parents in the South were more likely to over-report initiation, and over-report was more likely in 2012 and 2013 compared to 2008. Underreport of vaccine initiation had different patterns. Parental underreport was more likely among all minority groups compared to white adolescents. Parents in the South were less likely to underreport than those in the Northeast, while those in the West were more likely to underreport. Underreport also varied by income, with those making <\$20,000 more than 2 times more likely to underreport initiation compared to the highest income group. Underreport also varied across time, with the greatest odds of underreport occurring in 2010.

Parental over-report of the number of HPV vaccine doses was lower among younger adolescents. Odds of over-report was greater among Hispanic and black adolescents. Parents who had lower income were more likely to over-report the number of doses their adolescent had received, and odds of over-report were increased after 2011. Underreport of the number of HPV vaccine doses was less among parents of 13 and 14 year olds. Adolescents from ethnic minority groups were more likely to have parents who underreported. Compared to the Northeast, the other 3 regions evaluated were less likely to underreport the number of doses. Lower income was associated with higher odds of parents underreporting the number of doses. Time was associated with an increase in the odds of parents underreporting the number of doses, with parents being 2.7 times more likely to underreport the number of doses their child had received in 2013 than those that reported in 2008.

Discussion

Overall, we found that the accuracy of parental recall of their child's HPV vaccination status varied according to characteristics and across time. Recall accuracy appeared to be affected by the passage of time, with highest recall accuracy in 2008. After 2010, recall accuracy leveled out, indicating that variations in the future may be due to random chance rather than due to length of time since vaccination. There are several possible reasons for this change. First, it is likely that parental recall is more accurate closer to the time of actual vaccination. Second, it is likely that it was easier for parents to remember whether their children were vaccinated and how many vaccines they received in the first few years after HPV vaccine licensure. In fact, it has been found that 2008 NIS-Teen HPV vaccine parental recall had

higher agreement with providers compared to several other vaccines administered in adolescence.¹⁴ These differences were attributed to media coverage and the advertising campaign for this specific vaccine.¹⁴ Additionally, sensitivity for self-report of vaccines that are given yearly in adulthood were high compared to vaccines that are typically administered as a one-time series, such as the Hepatitis A or B vaccines,¹⁵ illustrating that recall is more accurate when vaccination decisions occur closer to the time when patients are asked to recall compared to those that may have occurred longer ago. Combined, these studies demonstrate that time since vaccination may play a role in accuracy of recall, although it is unknown whether time since HPV vaccination would affect parent recall and self-recall accuracy differently. Further, it is unknown whether parental recall is equally accurate for all routine adolescent vaccines.

Sensitivity and specificity in our study was lower than that reported for the 2010 NIS-Teen data.¹⁶ That study found that recall that was aided by household immunization records had lower sensitivity and higher specificity than solely adult recall.¹⁶ We did not stratify our analyses by whether parents had used records to aid their recall, and it is likely that the differences between studies are due to methodological differences. Further, sensitivity and specificity varied across time. These variations may have contributed to the overall differences, as well.

Agreement between parent report and provider report of HPV vaccine initiation and number of doses received was particularly low among Hispanics. This observation has been made in other studies, including those that investigated recall of other types of vaccines.^{16,17} Sensitivity and specificity for self-report of pneumococcal and flu vaccines have also been found to vary by race/ethnicity, with Hispanics and blacks having lower agreement with provider records.¹⁵ In particular, we found that parents of Hispanic adolescents were more likely to underreport vaccine initiation and the number of doses received compared to whites. It is unknown why Hispanics would have differences in vaccine reporting accuracy for both self-report, as found in previous studies, as well as parental report as found in our study. However, variation in reporting accuracy is an important consideration when determining population vaccination levels according to racial/ ethnic characteristics.

It is particularly interesting that a high proportion of parents reported that their child had not initiated the HPV vaccine, when their provider had records of vaccination occurring. Variations in underreporting occurred according to geographical area and ethnicity of the adolescents, with parents in the West and parents of Hispanics having the highest rate of underreporting, even in fully adjusted models. We observed similar variations in underreporting for the number of HPV vaccine doses received. This should be taken into account when relying on parental report of adolescent HPV vaccination to avoid the costs of over-vaccinating. This topic has not received much attention. However, one report based on administrative billing records from a private health insurance company found that 1,153 females out of 271,976 vaccine initiators that were evaluated had received more than 3 doses of the HPV vaccine.¹⁸ Although representing a small fraction of the sample, in large populations, the cost could become quite large due to the high price per dose. We found the potential for high costs related to over-vaccination should all parents who underreported their child's vaccination status seek vaccination with all 3 doses. However, we expect that

the cost for over-vaccination would be lower than our estimate because only a portion of those will change providers or have incomplete immunization records, reducing the estimated number of excess doses that will be received.

Vaccine report concordance varied by household income, with parents from lower income households being less likely to agree with their daughters' providers for both initiation and the number of vaccine doses. This is in agreement with a prior report on parental recall of their children's HPV vaccination status.¹⁹ Thus, our findings suggest that the current system in the US of relying on parental recall when patients change providers may lead to over-vaccination in some groups, and under-vaccination in others. This can lead to higher costs, and development of new disparities in HPV-related diseases. Improving data completeness in state immunization registries and increasing linkage capabilities as well as provider accessibility are needed to avoid these issues. The research on vaccination registries that has been done indicates variability in quality of data. Washington state immunization registry had high validity, completeness, and accuracy, but may not be well-suited for research due to missing data in non-required fields.²⁰ In Arizona, 91% of children visiting an emergency room for care were included in their state vaccine registry, and accuracy was similar to parental recall.²¹ Accuracy of the data contained in vaccine registries needs to be assessed, and information required for linkage between states should be standardized.

Parents with lower household income and with adolescents from minority ethnic backgrounds were more likely to both over- and underreport their daughters' vaccination status. This has important implications for reducing disparities in HPV-related disease. Vaccines given to adolescents who are already fully vaccinated do not just add additional cost, but are then no longer available to patients who are not adequately vaccinated, and for whom finding a clinic, then scheduling and returning for vaccine appointments may be barriers to vaccination.²² Further, disparities in cervical cancer for racial minorities and women of lower socioeconomic status persist.^{23,24} Therefore, higher levels of over-report of vaccination in vulnerable groups of female adolescents can lead to a continuation of disparities in HPV-related disease because these young women will not be adequately protected.

There were some limitations in this study. One limitation was the possibility that providers did not provide complete data on their patients. Missing data from providers would have led to an increase in over-reporting estimates. Additionally, this study was limited to adolescents with adequate provider data on HPV vaccination which may have led to bias toward adolescents with better access to regular healthcare, and may therefore be a conservative estimate of the accuracy of parental vaccination report. We found that a lower proportion of the sample reported that their teens were vaccinated, indicating that underreport may be greater than the estimates in this paper. This study used the subset of parents with health providers who also completed a survey. This may have led to response bias, and agreement could be overestimated. Parents may not have provided all of their children's provider data, which could have led to a higher estimate of over-reporting. Weighting adjustments that accounted for nonresponse and response method were used in these analyses, but it is possible that response bias may still exist.

Overall, our study indicates that parent report may be an adequate method of determining population estimates for vaccination. However, these reports may not be as valid for healthcare providers who need to determine a new patient's vaccination status. Improving state registries by increasing quality of the data and improving linkage capabilities between state registries would help ensure that eligible adolescents receive the HPV vaccine, while reducing costs associated with over-vaccination.

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Table 1

Characteristics of NIS-Teen sample and agreement of parent and provider reports for HPV vaccine initiation and number of vaccine doses, 2008–2013

	Parent-report, with or without provider report (N=88,135)	Parent-report, with provider report (N=51,702)	Agreement of parent and provider report for HPV vaccine initiation	Agreement of parent and provider report for number of HPV vaccine doses
	n (w%)	n (w%)	w% (95% CI)	w% (95% CI)
Age				
13 years	17,348 (19.7)	10,547 (19.9)	85.4 (84.1–86.8)	77.1 (75.5–78.7)
14 years	18,087 (20.0)	10,744 (19.8)	84.5 (83.1–85.8)	74.5 (72.9–76.1)
15 years	17,915 (20.6)	10,554 (21.2)	83.4 (81.9–84.9)	71.7 (70.0–73.5)
16 years	18,204 (20.4)	10,511 (20.9)	83.1 (81.5–84.7)	71.6 (69.8–73.4)
17 years	16,581 (19.3)	9,346 (18.2)	83.7 (82.2–85.1)	70.4 (68.6–72.2)
			p=0.08	p<0.001
Race/ ethnicity				
Non-Hispanic white	58,954 (58.4)	35,399 (58.3)	87.3 (86.7–88.0)	77.9 (77.1–78.7)
Non-Hispanic black	9,898 (14.7)	5,390 (14.9)	80.7 (79.0–82.5)	68.6 (66.5–70.7)
Hispanic	11,854 (19.1)	6,622 (19.0)	77.9 (75.8–80.0)	63.6 (61.2–66.0)
Other	7,523 (7.8)	4,291 (7.8)	80.1 (77.4–82.7)	68.5 (65.5–71.5)
			p<0.001	p<0.001
Region				
Northeast	16,751 (17.2)	10,043 (17.0)	85.3 (84.2–86.4)	73.4 (72.0–74.8)
Midwest	19,324 (22.2)	11,842 (22.3)	86.5 (85.5–87.4)	75.8 (73.7–76.0)
South	32,463 (37.2)	18,520 (37.3)	84.8 (83.9–85.7)	74.8 (73.7–76.0)
West	19,691 (23.4)	11,297 (23.4)	79.4 (77.4–81.4)	67.4 (65.1–69.6)
			p<0.001	p<0.001
Year of interview				
2008	13,807 (17.3)	8,058 (17.3)	87.9 (86.2–89.5)	82.4 (80.6–84.2)
2009	15,443 (17.0)	8,887 (16.9)	87.3 (85.8–88.8)	79.4 (77.7–81.1)
2010	15,033 (17.3)	9,002 (17.4)	80.8 (79.3–82.4)	70.3 (68.6–72.0)
2011	17,123 (16.9)	10,281 (16.9)	83.3 (81.9–84.8)	69.3 (67.6–71.0)
2012	13,184 (15.6)	7,896 (15.6)	81.8 (80.2–83.5)	68.3 (66.3–70.2)
2013	13,639 (15.8)	7,578 (15.9)	82.6 (80.8–84.4)	67.4 (65.2–69.6)
			p<0.001	p<0.001
Income				
<\$20,000	10,095 (16.3)	6,258 (16.5)	76.1 (74.0–78.1)	61.5 (59.2–63.8)
\$20,001–\$50,000	19,200 (24.5)	11,545 (25.6)	83.5 (82.1–84.9)	71.6 (69.9–73.2)
50,001+	50,944 (50.0)	30,964 (51.0)	87.0 (86.2–87.7)	77.2 (76.3–78.2)
Missing	7,990 (9.2)	2,935 (6.9)	83.1 (80.6–85.5)	75.7 (72.9–78.4)

	Parent-report, with or without provider report (N=88,135)	Parent-report, with provider report (N=51,702)	Agreement of parent and provider report for HPV vaccine initiation	Agreement of parent and provider report for number of HPV vaccine doses
	n (w%)	n (w%)	w% (95% CI)	w% (95% CI)
			p<0.001	p<0.001
Initiation, parent report				
0 shots	53,443 (61.6)	29,546 (58.1)		
1+ shots	34,692 (38.4)	22,156 (41.9)		
Number of shots, self-report				
0	53,443 (64.1)	29,546 (60.6)		90.7 (90.0–91.4)
1	7,744 (9.5)	4,830 (10.3)		43.4 (40.6–46.3)
2	7,278 (8.5)	4,761 (9.4)		39.5 (36.8–42.2)
3+	16,030 (17.9)	10,377 (19.6)		59.4 (57.9–61.0)

Table 2

Evaluation of agreement between parental report and provider report for HPV vaccination, NIS-Teen data, 2008–2013 (N=51,702)

	Sensitivity for initiation w% (95% CI)	Specificity for initiation w% (95% CI)	False positive for initiation w% (95% CI)	False negative for initiation w% (95% CI)	Over-reported number of doses w% (95% CI)	Underreported number of doses w% (95% CI)
Age						
13 years	74.3 (71.6–77.0)	92.8 (91.7–93.9)	4.3 (3.6–5.0)	10.3 (9.0–11.5)	6.9 (6.0–7.7)	16.0 (14.6–17.5)
14 years	75.9 (73.4–78.4)	91.1 (89.8–92.3)	5.1 (4.3–5.8)	10.4 (9.2–11.6)	7.6 (6.7–8.4)	17.9 (16.4–19.4)
15 years	77.0 (74.4–79.5)	89.6 (88.1–91.2)	5.2 (4.4–6.1)	11.3 (10.0–12.7)	8.3 (7.2–9.3)	20.0 (18.4–21.6)
16 years	79.0 (76.5–81.5)	87.3 (85.5–89.2)	6.3 (5.3–7.2)	10.6 (9.2–12.0)	9.3 (8.2–10.4)	19.2 (17.5–20.8)
17 years	81.0 (78.8–83.1)	86.6 (84.7–88.4)	6.5 (5.6–7.4)	9.8 (8.6–11.0)	9.8 (8.7–10.9)	19.8 (18.2–21.4)
Race/ethnicity						
Non-Hispanic white	82.4 (81.2–83.6)	91.1 (90.4–91.8)	5.0 (4.6–5.4)	7.6 (7.1–8.2)	7.7 (7.2–8.2)	14.4 (13.6–15.1)
Non-Hispanic black	74.3 (71.5–77.1)	86.5 (84.3–88.7)	7.1 (5.9–8.3)	12.2 (10.8–13.6)	10.4 (9.0–11.8)	21.0 (19.2–22.8)
Hispanic	70.2 (67.1–73.3)	87.8 (85.6–90.0)	5.4 (4.4–6.4)	16.7 (14.7–18.6)	8.6 (7.4–9.8)	27.8 (25.5–30.0)
Other	72.1 (67.9–76.2)	88.1 (85.2–91.1)	5.9 (4.4–7.5)	14.0 (11.6–16.3)	8.4 (6.6–10.1)	23.1 (20.4–25.9)
Region						
Northeast	80.9 (79.2–82.6)	90.0 (88.6–91.3)	4.8 (4.2–5.5)	9.9 (8.9–10.8)	7.6 (6.8–8.5)	18.9 (17.6–20.1)
Midwest	80.5 (78.8–82.2)	91.1 (90.1–92.1)	5.0 (4.4–5.6)	8.5 (7.7–9.3)	7.7 (7.0–8.5)	16.4 (15.3–17.5)
South	79.6 (78.1–81.1)	88.8 (87.7–89.8)	6.4 (5.8–7.0)	8.8 (8.0–9.5)	9.2 (8.5–10.0)	15.9 (15.0–16.8)
West	70.2 (67.1–73.4)	89.7 (87.7–91.6)	4.9 (3.9–5.8)	15.7 (13.8–17.6)	7.9 (6.8–9.1)	24.7 (22.5–26.8)
Year of interview						
2008	79.3 (75.8–82.9)	92.5 (91.0–93.9)	4.9 (3.9–5.8)	7.2 (5.8–8.6)	7.1 (6.0–8.1)	10.5 (8.9–12.0)
2009	81.8 (78.8–84.8)	91.2 (89.9–92.4)	5.2 (4.4–5.9)	7.6 (6.2–8.9)	7.6 (6.7–8.5)	13.0 (11.4–14.6)
2010	70.1 (67.4–72.6)	91.1 (89.6–92.6)	4.6 (3.7–5.4)	14.6 (13.2–16.0)	7.3 (6.3–8.3)	22.4 (20.7–24.0)
2011	77.8 (75.4–80.1)	89.1 (87.6–90.6)	5.4 (4.6–6.1)	11.3 (10.0–12.6)	9.1 (8.0–10.1)	21.6 (20.0–23.2)
2012	77.5 (74.8–80.2)	86.5 (84.6–88.4)	6.6 (5.6–7.5)	11.6 (10.1–13.1)	10.2 (9.0–11.4)	21.6 (19.7–23.4)
2013	80.2 (77.6–82.7)	85.6 (83.2–88.0)	6.5 (5.3–7.6)	10.9 (9.4–12.4)	9.1 (7.7–10.4)	23.5 (21.4–25.5)
Income						
<\$20,000	68.5 (65.5–71.5)	86.1 (83.9–88.4)	5.9 (4.9–6.9)	18.0 (16.1–19.9)	9.4 (8.2–10.6)	29.1 (26.9–31.3)

	Sensitivity for initiation	Specificity for initiation	False positive for initiation	False negative for initiation	Over-reported number of doses	Underreported number of doses
	w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)
\$20,001–\$50,000	76.8 (74.3–79.3)	89.4 (88.0–90.8)	5.9 (4.9–6.9)	18.0 (16.1–19.9)	9.2 (8.2–10.1)	19.2 (17.7–20.8)
50,001+	82.5 (81.3–83.8)	90.4 (89.6–91.3)	5.6 (4.9–6.4)	10.9 (9.6–12.2)	7.9 (7.3–8.5)	14.8 (14.0–15.6)
Missing	72.3 (67.9–76.7)	91.7 (89.7–93.7)	4.6 (3.5–5.7)	12.3 (10.0–14.6)	5.7 (4.5–6.9)	18.6 (16.0–21.2)
Number of HPV vaccines reported by parent						
0 shots						18.1 (17.2–190.)
1 shot					23.1 (20.9–25.4)	37.2 (34.6–39.8)
2 shots					19.5 (17.6–21.4)	39.7 (37.2–42.2)
3+ shots					21.0 (19.5–22.4)	

Table 3

Multivariable binary logistic regression to evaluate odds of agreement with provider-reported vaccination by sample characteristics from NIS-Teen, 2008–2013 (N=51,702)^a

Characteristics	Agreement with initiation aOR (95% CI)	Agreement with number of vaccines aOR (95% CI)
Age		
13	1.18 (1.02–1.38)	1.51 (1.33–1.72)
14	1.08 (0.93–1.26)	1.27 (1.12–1.44)
15	1.01 (0.87–1.18)	1.11 (0.98–1.26)
16	0.97 (0.83–1.13)	1.09 (0.96–1.23)
17	Reference	Reference
Race/ Ethnicity		
Hispanic	0.66 (0.57–0.75)	0.61 (0.54–0.69)
White	Reference	Reference
Black	0.66 (0.58–0.76)	0.67 (0.59–0.75)
Other	0.66 (0.56–0.79)	0.70 (0.61–0.81)
Region		
Northeast	Reference	Reference
Midwest	1.08 (0.95–1.22)	1.12 (1.01–1.24)
South	1.06 (0.94–1.19)	1.20 (1.09–1.32)
West	0.73 (0.65–0.94)	0.83 (0.73–0.95)
Income		
<\$20,000	0.58 (0.50–0.66)	0.58 (0.51–0.65)
\$20,001– \$50,000	0.84 (0.74–0.95)	0.82 (0.74–0.91)
\$50,001+	Reference	Reference
Missing	0.78 (0.65–0.94)	0.97 (0.83–1.14)
Year of interview		
2008	Reference	Reference
2009	0.96 (0.78–1.17)	0.82 (0.70–0.97)
2010	0.59 (0.49–0.70)	0.50 (0.43–0.58)
2011	0.72 (0.60–0.87)	0.49 (0.42–0.57)
2012	0.65 (0.54–0.78)	0.47 (0.40–0.55)
2013	0.68 (0.56–0.83)	0.45 (0.38–0.53)

^aModels are adjusted for all variables shown in the table.

Table 4

Multivariable multinomial logistic regression to evaluate odds of underreport and over-report by sample characteristics from NIS-Teen, 2008–2013 (N=51,702)^a

Characteristics	Overreport initiation aOR (95% CI)	Underreport initiation aOR (95% CI)	Over-report number of vaccines aOR (95% CI)	Underreport number of vaccines aOR (95% CI)
Age				
13	0.63 (0.51–0.79)	0.99 (0.82–1.20)	0.61 (0.51–0.74)	0.68 (0.59–0.80)
14	0.76 (0.61–0.94)	1.04 (0.86–1.25)	0.68 (0.59–0.80)	0.82 (0.71–0.95)
15	0.80 (0.64–1.00)	1.12 (0.92–1.36)	0.81 (0.67–0.98)	0.95 (0.82–1.10)
16	0.95 (0.76–1.18)	1.09 (0.89–1.33)	0.91 (0.76–1.09)	0.93 (0.76–1.08)
17	Reference	Reference	Reference	Reference
Race/ Ethnicity				
Hispanic	1.16 (0.93–1.46)	1.72 (1.45–2.04)	1.26 (1.04–1.51)	1.82 (1.59–2.08)
White	Reference	Reference	Reference	Reference
Black	1.42 (1.16–1.74)	1.57 (1.33–1.85)	1.41 (1.18–1.68)	1.55 (1.36–1.77)
Other	1.25 (0.94–1.67)	1.67 (1.35–2.07)	1.16 (0.91–1.47)	1.57 (1.32–1.86)
Region				
Northeast	Reference	Reference	Reference	Reference
Midwest	1.03 (0.85–1.25)	0.88 (0.75–1.02)	0.98 (0.83–1.15)	0.86 (0.77–0.97)
South	1.27 (1.06–1.52)	0.79 (0.69–0.91)	1.10 (0.94–1.29)	0.73 (0.65–0.81)
West	1.07 (0.83–1.38)	1.51 (1.25–1.81)	1.10 (0.94–1.29)	0.73 (0.65–0.81)
Income				
<\$20,000	1.10 (0.88–1.37)	2.18 (1.85–2.56)	1.29 (1.08–1.54)	1.98 (1.73–2.26)
\$20,001– \$50,000	1.01 (0.85–1.20)	1.33 (1.13–1.57)	1.16 (1.01–1.34)	1.25 (1.10–1.42)
\$50,001+	Reference	Reference	Reference	Reference
Missing	0.88 (0.67–1.15)	1.56 (1.25–1.95)	0.71 (0.56–0.91)	1.20 (1.00–1.44)
Year of interview				
2008	Reference	Reference	Reference	Reference
2009	1.06 (0.82–1.37)	1.04 (0.78–1.38)	1.11 (0.90–1.38)	1.28 (1.03–1.60)
2010	1.02 (0.7–1.34)	2.18 (1.73–2.75)	1.23 (0.98–1.53)	2.52 (2.08–3.06)
2011	1.15 (0.89–1.48)	1.55 (1.22–1.97)	1.51 (1.23–1.86)	2.38 (1.96–2.88)
2012	1.43 (1.11–1.85)	1.62 (1.26–2.08)	1.73 (1.40–2.13)	2.42 (1.98–2.95)
2013	1.40 (1.06–1.84)	1.53 (1.17–1.98)	1.56 (1.23–1.97)	2.70 (2.20–3.31)

^aModels are adjusted for all variables shown in the table.