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Vaccination concordance and discordance between parents and provider-verified data of NIS-teen 2018

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Abstract Cover Page

Vaccination concordance and discordance between parents and provider-verified data of NIS-teen 2018

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B.S., University of Texas at Austin, 2019

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Abstract

Vaccination concordance and discordance between parents and provider-verified data of NIS-teen 2018

By Sean Huang

Background: Understanding concordance and discordance between parental self-report and provider-verified vaccination data is crucial for interpretation of more easily collected self-report data in the service of improving vaccine coverage. Limited research has investigated and compared vaccine concordance and discordance among adolescent vaccines evaluated in the National Immunization Survey-Teen.

Methods: This analysis examined reporting concordance and discordance for human papillomavirus (HPV), meningococcal disease (MenACWY), and tetanus, diphtheria, and pertussis (Tdap) vaccines by different sociodemographic variables. Sensitivity and specificity measures were measured for each vaccine to assess how well NIS-Teen capture true positive and true negative We computed adjusted estimates for individuals without adequate provider verified data, using the sensitivity and specificity estimates from individuals with both self-report and provider-verified data. Bivariate and multivariate Poisson regression analysis were performed to evaluate associations between sociodemographic characteristics and self-report concordance and discordance.

Results: For all vaccines, sensitivity of self-report was high (HPV 1+ shot: 90.4%, HPV 3+ shots: 85.5%, MenACWY: 90.8%, Tdap: 89.8%), with lower specificity (HPV 1+ shot: 57.4%, HPV 3+ shots: 58.4%, MenACWY: 26.3%, Tdap: 32.7%). Adjusted estimates were lower than the self-reported values (63.1% for 1+ HPV; 51.4% for 3+ HPV; 86.4% for MenACWY, 88.1% for Tdap), demonstrating the moderate accuracy of obtaining valid data from the method of self-reporting. For HPV and Tdap, Hispanic and non-Hispanic black were discovered to be more likely to under-report than non-Hispanic white, while mother with education level of less than 12 years and mother with education level of 12 years were more likely to under-report than mother with education level of college graduate. For MenACWY, region of Northeast was less likely to over-report than South.

Discussion: The sensitivity, specificity, adjusted estimates, and overall discordance stratums demonstrated that parental under-reporting was more likely to occur when utilizing self-reporting methods. The specific reason behind differences in and discordance within these sub-categories is unclear and merits further investigation. In addition, more studies need to be conducted to provider a better understanding of limitations of self-report. An alternative method may be preferred to capture more accurate immunization data in the future.

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Literature Review

Importance of adolescent vaccination

Three major vaccines recommended by CDC and Advisory Committee on Immunization Practices (ACIP) for adolescents to receive are HPV, MenACWY, and Tdap. These vaccines aid in prevention of diseases caused by a variety of pathogens including human papillomavirus, *Neisseria meningitidis*, *Clostridium tetani*, *Corynebacterium diphtheriae*, and *Bordetella pertussis*.

HPV

Human papillomavirus (HPV) is the leading sexually transmitted disease in the United States; it can cause a variety of conditions ranging from genital warts to cancer in different parts of the body[1]. One study, using data from 2013-2016 National Health and Nutrition Examination Survey (NHANES) estimated 42.5 million people aged 15-59 years old (23.4 million males and 19.2 million females) with at least one disease-associated HPV type in the United States. Among adolescents and adults of 15-24 years old, there were 9 million HPV infections (3.6 million males and 5.4 million females)[2]. Prevalence of genital HPV was found to be 42.5% in the United States from 2013-2014, with a higher prevalence among men (45.2%) compared to women (39.9%). Furthermore, the prevalence of oral HPV among adults aged 18 to 69 years old was 7.3% during the period of 2011-2014. Similar patterns were observed for both oral HPV and genital HPV: (1) Non-Hispanic Asian had the lowest prevalence; (2) Non-Hispanic blacks had the highest prevalence[1].

The first HPV vaccine, 4vHPV, was approved and recommended for use in the US in 2006, and within the first 6 years of vaccine administration, there was a 64% decrease in four types of HPV (HPV-6, 11, 16, 18) prevalence among females aged 14-19 years old. There was also a dramatic disparity in prevalence of these four types of HPV between vaccinated individuals (2.1%) and overall population before vaccine introduction (18.6%) [3]. 4vHPV was recommended for females in 2006, and it wasn't until 2011 that ACIP recommended the vaccine for males. 9vHPV was licensed in 2014 and

recommended for both males and females; it is effective against five additional HPV types (31, 33, 45, 52, and 58)[3].

HPV vaccination is advised by CDC and Advisory Committee on Immunization Practices (ACIP) to be acquired by people in the following categories: (1) All adolescents at 11 or 12 years of age (vaccination can start at 9 years old); (2) Everyone before the age of 26 if unvaccinated previously; (3) Adults of 27-45 years old after discussion with their clinicians. The HPV vaccination dose schedules are separated into two groups: (1) Adolescent before age 15 should receive two doses with 6-12 months in between. Anyone who receives the second dose with less than 5 months after the first dose is required to obtain a third dose; (2) Adults of age 15-26 years and/or immunocompromised individuals are advised to receive three doses, they should obtain the vaccines at 0, 1-2, and 6 months[4].

Meningococcal Disease

Although meningococcal disease is not widespread in United States, adolescents and young adults are known to be in higher risk. The most severe form of meningococcal disease is meningitis, which is an infection of lining of brain and spinal cord, and bloodstream infection. The disease can be fatal as 10-15 out of 100 people can die from it even if they received treatment. It is also known to cause long-term disabilities such as brain damage, nervous system impairment, and loss of limbs[5]. MenACWY was recommended for routine vaccination of adolescents in 2005 and the impact was drastic; the rates of meningococcal diseases among teens caused by type C, Y, and W decreased by more than 90%[6]. For MenACWY vaccine, CDC recommends all adolescents to receive it when they are 11 or 12 years of age, then the second booster shot at 16 years old. It is also recommended for certain groups including people traveling to or from meningococcal disease outbreak areas, immunocompromised individuals, and college freshmen living in residence halls[7].

Tetanus, Diphtheria, and Pertusiss

Tetanus is known to cause "lockjaw" in which the jaw muscles tighten, it can also cause muscle spasms, trouble swallowing, and muscle stiffness. Some cases would develop into severe illness including bone fractures, aspiration pneumonia, pulmonary embolism, and death[8]. The annual number of tetanus infections in the US before introduction of vaccination was 500-600 cases; the number of tetanus infections has been declining since introduction of the vaccine. Nowadays, tetanus infections are uncommon as only about 30 cases are reported annually in United States[9]. Diphtheria was a leading cause of child illness and mortality before 1920s, the United States alone recorded 206,000 cases and 15,520 deaths in 1921[9]. Frequent Diphtheria infection sites are respiratory tract and skin, in which it can cause sore throat and ulcers respectively. Complications are often associated with respiratory infection that led to myocarditis, paralysis, airway blockage, and even death[10]. Diphtheria vaccine helped reduced the rate of prevalence; only 3 cases has been reported in the United States since 2010[9]. Pertussis, also known as "whooping cough", can cause symptoms of violent coughing and vomiting that persist on for long periods of time[11]. Before the vaccine (DTwP) became available in the 1940s, United States reported 200,000 cases and 9,000 death in children annually[9]. Although DTwP, a whole cell vaccine, was effectively decreasing pertussis, it was also causing many adverse events including swelling and pain at the injection site. These safety concerns facilitated the development and licensure of DTaP in 1992. In contrast to DTwP, DTaP was an acellular vaccine that only contained part of the *Bordetella pertussis*. ACIP recommended children to receive DTaP at 2, 4, 6, and 15-18 months while getting the last booster between age 4-6 years old to complete the 5-dose series. Lastly, Tdap was introduced in 2006 to be administered to adolescents of 11-12 years old for boosting the waning immunity[12]. Tdap vaccine is recommended to be administered to every children, adolescent, and adult over 7 years old with a single dose. Adults should receive a booster dose of either Tdap or Td every 10 years[13]. Overall, the rate of prevalence for pertussis declined to the lowest in 1970s but started to increase again. Several reasons could explain the increase including: (1) better diagnostic tests; (2) waning immunity; (3) enhanced surveillance system. In addition, the bacteria that causes pertussis has a relatively higher mutation rate

that allows them to escape vaccine protection. However, pertussis vaccine still provides partial if not full protection from the disease[9].

Adolescents' vaccine coverage

Surveillance of adolescent vaccine coverage is conducted through the National Immunization Survey-Teen (NIS-Teen). NIS-Teen collects data on coverage of 3 main vaccinations among adolescents 13-17 years: (1) Tetanus, diphtheria, acellular pertussis (Tdap); (2) Meningococcal conjugate (MenACWY); (3) Human papillomavirus (HPV)[14].

Ever since the creation of National Immunization Survey in April of 1994 to assess childhood immunization coverage, the National Center for Immunization and Respiratory Diseases (NCIRD) of the Centers for Disease Control and Prevention (CDC) has been relying on the method of self-reporting to collect data on vaccination coverage among children and teens[14]. This method has been widely popular and commonly used in many studies due to its advantages including but not limited to: (1) Richness of information; (2) Sheer practicality; (3) Motivation to report; (4) Causal force; (5) Easy interpretability[15]. However, it also institute plenty of complications inducing inaccuracy and invalidity due to information biases of various reasons: (1) Long recall period; (2) Selective recalls; (3) Social desirability; (4) Question phrasing and answer alternatives; (5) Digit preference[16].

Since the mid-2000s, the NIS-Teen has assessed adolescent vaccine coverage, documenting increases in coverage levels over time for all 3 vaccines: (1) Tdap coverage initiated with 40.8% coverage nationally in 2008, and it doubled in 5 years and reached 86.0% in 2013. It eventually plateaued around high 80% with limited growth till it reached 90.2% in 2019[17]; (2) MenACWY followed a similar pattern as Tdap; it began at 41.8% in 2008 and increased incrementally every year to reach 88.9% in 2019[18]; (3) Overall, HPV vaccine coverage for 1+ shot initiated at 60.4% in 2016, then it gradually increased to 71.5% in 2019. For female adolescents, HPV vaccine coverage of 1+ shot started at 37.2% in 2008 and improved

slowly till arriving at 73.2% in 2019. Male adolescents did not have a sufficient sample size till 2010 in which they reported an abysmal 1.4% HPV vaccine coverage, while it grew to 69.8% in 2019[19].

Vaccine Hesitancy

Vaccine hesitancy continues to have a major impact on overall vaccine coverage. Several studies have investigated possible barriers that contribute to this phenomenon[20–23]. Parents reported major factors that contributed to the phenomenon of vaccine hesitancy: (1) No provider recommendation; (2) Lack of knowledge; (3) Vaccination not needed[20]. Additional factors that impacted parental decision on their children receiving vaccines were outlined in another study: (1) School requirement; (2) News coverage; (3) Family and friends; (4) Books, internet, and TV shows; (5) drug company advertisements[21].

Further, for HPV vaccine specifically, parents have reported "not sexually active" as a reason for not vaccinating their children. Distorted parental and provider views also contributed to low vaccination coverage for male adolescents as they perceive less risk and severity for males in association with HPV[22].

In other respects, one study demonstrated that access to health care also had a significant impact on vaccine coverage[23]. Adolescents who had continuous healthcare coverage since age 11 were more likely to be vaccinated. Up to date MenACWY vaccination was found to be significantly associated with coverage of Tdap and HPV, which indicated that parental vaccine hesitancy is not towards a specific vaccine[23].

Vaccine coverage discordance between verified and self-reported data

Oftentimes, studies utilized the method of self-report for data collection due to logistical and budgetary limitations. The method has many advantages as it is cheap and simple to implement. However, there are also disadvantages including various types of bias that could affect the validity of data and the legitimacy of the studies. Previous research have assessed the validity of self-reported data through obtaining consent to access of provider verified records; studies of pneumococcal vaccination and influenza vaccination have shown that the overall validity for self-reported method is adequate[24,25] A study demonstrated the

possible inaccuracy with self-reported data for HPV vaccination; several demographic variables were found to be associated with higher rate of inaccuracy including being parents of females and racial/ethnicity minority adolescents[26]. However, there has not been widespread research investigating into the validity of other vaccinations in NIS self-reported surveys.

Studies had suggested vaccine discordance could be caused by three crucial factors: (1) Inaccurate parental recall (2) Lack of household immunization records or shot cards[27–30]; (3) Incomplete or inaccurate provider report[27,30]. Inaccurate parental recall can occur for a variety of reasons including long recall time and parents misinterpreting the questions. Studies have shown that parents with household immunization records and/or shot cards were significantly more likely to provide the accurate response[27–30]. In addition, vaccine discordance could appear when there is incompleteness in provider verified data: (1) Parents may not have identified all of their adolescents' providers; (2) Providers may not have completed surveys; (3) there is a chance provider who returned complete surveys had errors that changed the outcome of the surveys[30]. The healthcare structure of United States provides opportunity for the creation of more errors as there is no one unified system; the provider report could have been lost or altered when parents change providers. Different state immunization registries indicate variabilities in data qualities, which could contribute to more vaccine discordance[27]. Furthermore, some studies have been performed to display the statistics of vaccine discordance with sensitivity and specificity values[31–36], but few had examined vaccine discordance across multiple NIS-teen vaccines.

Introduction/Background

Three major vaccines recommended by CDC and ACIP for adolescents to receive are HPV, MenACWY, and Tdap. These vaccines aid in prevention of various types of diseases including wart, cancer, meningitis, tetanus, diphtheria, and pertussis. Following each vaccine introduction, NIS-Teen has documented the increase of coverage levels over time for all 3 vaccines: (1) HPV 1+ shot coverage rose from 60.4% in 2016 to 71.5% in 2019[19]; (2) MenACWY coverage increased from 41.8% in 2008 to 88.9% in 2019[18]; (3) Tdap started at 40.8% in 2008 then escalated to 90.2% in 2019[17].

The National Immunization Survey (NIS) was created in 1994 with the purpose of examining vaccination coverage after several measles outbreaks, it was administered by National Center for Immunization and Respiratory Diseases (NCIRD) of the Centers for Disease Control and Prevention (CDC). Originally, the target population of the surveys was children of age 19-35 months. It was then expanded to NIS-Teen in 2006 with the purpose of assessing vaccination coverage among adolescents aged 13 to 17 years old[14]. This script focused on NIS-Teen with three main vaccinations: Human Papillomavirus (HPV), Meningococcal conjugate (MenACWY), and the combination booster shot of Tetanus, diphtheria, and acellular pertussis (Tdap).

Although the HPV vaccine coverage has been increasing, the overall coverage was unsatisfactory as it was not increasing at an anticipated rate. There was only a 6% increase from 2016 to 2017; from 43% to only about 49% of adolescents were up to date[37]. This could be because HPV vaccine is relatively new; it was first recommended by the Advisory Committee on Immunization Practices (ACIP) in 2006 to be included as a routine vaccination for females of age 11 and 12 years old, and of females aged 13 to 26 years old as catch-up vaccination[38]. Additionally, ACIP recommended a 2-dose regimen for people who started the HPV vaccine series before the age 15 years old, and a 3-dose regimen for anyone between the age 15 and 26 years old[4]. In comparison, MenACWY and Tdap had higher vaccine coverage; 85.1% and 88.7% respectively in 2017[39]. CDC recommended all preteens of 11 and 12 years old to receive

MenACWY vaccination, and a booster dose at 16 years old[5]. Tdap vaccines is suggested to adolescents and adults to acquire once every 10 years by CDC[13].

While provider-verified vaccine coverage is the gold standard for assessing vaccination uptake, this may not always be possible for research purposes. Self-reported surveys had been used in many studies due to its advantages of simplicity and cost-effectiveness, but it has major drawback as well such as uncertainty in reliability and validity. Response bias is one type of informational bias known to be associated with self-reported data; response bias occurred for numerous reasons: (1) participants misunderstanding the questions; (2) participants want to impress the interviewer (social-desirability bias); (3) incorrect recall (recall bias); (4) participants reacting differently based on interviewers' format/tone of questioning or personality (interviewer bias); (5) participants' respond differ after intervention due to change of references (response-shift bias)[40]. Many previous studies had inspected barriers to vaccination[22,29,41,42], but there has not been a comparison of three vaccines for concordance and discordance. This analysis sought to examine discordance in vaccine coverage reporting systems (e.g. self-report versus provider-verified) by investigating possible influencing sociodemographic factors that might contribute to concordance and discordance between parental report and provider verified data.

Methods

This analysis was conducted using publicly available datasets for the 2018 National Immunization Survey of Teen[43]. The methods for the NIS-Teen have been previously described[14]. Briefly, NIS-Teen is a national survey conducted by CDC utilizing the method of random digit dialing in a single-frame cell phone sampling design to collect data on vaccination status of adolescents from age 13 to 17. Households were called and screened for the presence of teens who fit the age criteria, then the adult who was the most knowledgeable about the teens' vaccination status would be interviewed. If there were multiple teens who fit the age criteria, only one would be chosen randomly for the data collection. At the end of the survey, interviewers would ask for permission to contact teens' vaccination providers for verification purposes[14].

The 2018 NIS-Teen contained 38,706 observations with completed interviews, with 18,700 observations having adequate provider data. The primary outcomes were parental self-report (for the full sample) and provider-verified vaccination status (for the subset with adequate provider data) for three vaccinations: Human papillomavirus vaccine (HPV), quadrivalent meningococcal conjugate vaccine (MenACWY), and tetanus, diphtheria and pertussis acellular vaccine (Tdap). Respondents who chose options of "Refused" or "don't know" to the parental recall questions for adolescent vaccination were excluded from the analysis for that vaccine, yielding effective sample sizes for HPV, MenACWY, and Tdap of 34,980, 28,849, and 35,520 respectively.

We categorized type of data available for NIS-Teen participants, based on consent for, and provision of, provider data into four levels: (1) those with parental consent and adequate provider data available; (2) those with parental consent given with inadequate provider data; (3) parental consent denied with inadequate provider data; and (4) missing consent with inadequate provider data. We conducted a sensitivity analysis with two additional classifications to represent hypothetical scenarios around missing consent. First, we assumed that all parents who did not finish the survey gave consent for provider data, and second, we assumed that all parents who did not finish the survey denied consent for provider data.

Each vaccination variable for parental and provider reported vaccination were assessed by consent/data availability as described above, and subsequently stratified by sociodemographic variables of interest including US census region, adolescent's age, race/ethnicity, sex, poverty status, and education level of the mother, using standard NIS-Teen categorizations. Percentages were measured along with 95% confidence intervals (CI). Poverty status was recoded into two categories to produce more meaningful comparisons: (1) household above poverty status; (2) household below poverty status.

Statistical Analysis

To measure concordance and discordance, we created a three-level variable for each vaccine, indicating (1) concordance between parental and provider report, (2) discordance with parental over-reporting (i.e.

parent indicated vaccine was received, with no provider verification of vaccination), and (3) discordance with parental under-reporting (i.e. parent indicated the vaccine was not received, with provider verified data showing vaccination) Vaccination receipt data was stratified by variables of interest, with estimation of frequencies and percentages within categories. All factors used provider report as the gold standard for measuring concordance and discordance.

The prevalence ratios (PR) with 95% CI for discordance were measured and compared between the sociodemographic variables. We encountered difficulties with estimation for some models under the log-binomial regression framework, therefore, an alternative modeling strategy of Poisson regression was utilized. Bivariate analysis was performed to identify contribution of each sociodemographic variables independently with crude PR, and multivariate analysis was used to estimate adjusted PR (aPR) while controlling for other factors. All models were conducted under Poisson framework to ensure consistency.

All analyses were weighted in accordance to standard methodology for use of NIS-Teen data[44]. Sensitivity and specificity of parental self-report were calculated for those with adequate provider data, and these estimates were used to model adjusted values for adolescents only having parental reported vaccination data. All analysis was conducted in SAS (v9.4, The SAS Institute, Cary NC).

Results

HPV

Sample characteristics

Among the full sample, 47.5% of adolescents had adequate provider data, 41.4% of adolescents had inadequate provider data where consent for provider verification was missing, 10.6% of adolescents had inadequate provider data with consent for provider verification given, and 0.5% of adolescents had inadequate provider data where consent was not provided.

Consistent distributions were observed across most groups stratified by the sociodemographic variables for parental report of HPV vaccination (Table 1). The few notable differences all occurred within the group of inadequate provider data with missing consent: (1) Hispanic (34.4%) vs. Other race/ethnicity (44.7%); (2) household below poverty (31.2%) vs. household above poverty (42.0%); (3) mother of education level of less than 12 years (29.6%) vs. mother of college graduate (43.4%). These groups frequently had the highest percentage in both adequate provider data and inadequate with consent given when compared within their own stratifications: Hispanic, households below poverty status, and mother with education level less than 12 years.

The hypothetical situations around missing consent allowed the distributions for the two groups of inadequate provider data (lev 2 and 3) to become more uniform (Table 2 & 3). The differences observed previously in Table 1 disappeared in Table 2, while they persisted in Table 3.

Both provider data of 1+ shot HPV vaccine and 3+ shots HPV vaccine shown even proportions when stratified by the sociodemographic variables (Table 4 & 5). The overall vaccine coverage was higher for 1+ shot than 3+ shots HPV vaccine (high 60% vs. ~50%). Striking differences were detected with the same groups for both 1+ shot and 3+ shots: (1) Hispanic vs. non-Hispanic whites; (2) household below poverty vs. household above poverty; (3) mother with education level of less than 12 years vs. mother with education of more than 12 years but non-college graduate. However, there were a few discrepancies as well: (1) adolescents of 16 years old (71.2%) vs. adolescents of 13 years old (62.6%) of 1+ shot in contrast to adolescents of 17 years old (58.5%) vs. adolescents of 13 years old (41.8%) of 3+ shots; (2) West (71.9%) vs. South (63.8%) of 1+ shot in contrast to Northeast (57.8%) vs. South (48.9%) of 3+ shots.

Notably, three groups stood out for having the highest vaccine coverage for both 1+ shot and 3+ shots HPV vaccine: Hispanic, households that were below poverty threshold and mothers who had less than 12 years of education.

Generally, there was a reverse relationship between parental reported data and provider verified data when stratified by adolescents' age; we observed a gradual decrease in percentages from age 13 to age 17 for parental reported data while a steady increase in percentages for provider verified data.

Concordance between parental and provider report

The rate of concordance was higher (~80% vs. ~70%) with respect to 1+ shot HPV vaccination comparing to 3+ shots HPV vaccination (Table 6 & 7). For both 1+ shot HPV vaccination and 3+ shots HPV vaccination, agreement between parental and provider report was consistent when stratified by region, age, and sex. In contrast, there were noticeable variations in both vaccination variables when concordance was stratified by race/ethnicity, poverty status, and education level of mother: (1) Hispanic vs. non-Hispanic white; (2) household below poverty vs. household above poverty; (3) mother of education level of less than 12 years vs. mother of education level of college graduate.

Furthermore, we observed decreasing concordance along with decreasing level of mother's education.

Discordance between parental and provider report (over- and under-reporting)

Overall, there was consistently higher numbers of under-reporting than over-reporting for 1+ shot HPV vaccination (Table 6). Parental over-reporting occurred uniformly when stratified by the sociodemographic variables. On contrary, parental under-reporting varied remarkably in some strata: (1) Hispanic (17.5%, aPR 1.87, 95% CI 1.51, 2.32) and non-Hispanic black (13.9%, aPR 1.86, 95% CI 1.47, 2.34) vs. non-Hispanic white (7.02%, referent); (2) mothers with education of less than 12 years (21.2%, aPR 2.32, 95% CI 1.77, 3.04) vs. mothers with education of college graduate (6.36%, referent) (Table 7). Although there seemed to be a difference of under-reporting for households below poverty (18.3%) and households above poverty (8.73%); the aPR demonstrated that this difference was insignificant (1.22, 95% CI 0.98, 1.51) (Table 8).

For 3+ shots HPV vaccination, reverse phenomenon was uncovered with higher numbers of over-reporting than under-reporting (Table 7). However, the trends were similar; distributions of over-reporting

were consistent in the corresponding categories while parental under-reporting followed an identical pattern: (1) Hispanic (12.7%, aPR 2.20, 95% CI 1.69, 2.86) and non-Hispanic black (8.07%, aPR 1.91, 95% CI 1.41, 2.58) vs. non-Hispanic white (4.27%, referent); (2) mothers with education of less than 12 years (15.4%, aPR 2.42, 95% CI 1.74, 3.37) vs. mothers with education of college graduate (4.02%, referent). The difference between household below poverty (12.3%, aPR 1.19, 95% CI 0.90, 1.58) and household above poverty (5.58%, referent) was found to be insignificant as well (Table 9).

Sensitivity and Specificity

Sensitivity was higher in HPV 1+ shot vaccination (90.4%) than 3+ shots (85.5%), while specificity was in reverse (57.4% vs. 58.4%) (Table 10). For those with inadequate provider data, the adjusted estimates were lower (HPV 1+ shot: 63.1%, HPV 3+ shots: 51.4%) with parental reported coverage of 42.9% and 22.5% for HPV 1+ shot and HPV 3+ shots respectively.

MenACWY

Sample characteristics

Parental report of MenACWY for the group of inadequate data with missing consent varied in these sub-categories: (1) Hispanic (34.3%) vs. Other (44.3%); (2) household below poverty (30.3%) vs. household above poverty (42.2%); (3) mother with education level of less than 12 years (27.4%) vs. mother with education level of college graduate (43.1%) (Table 11).

Two distinct disparities were detected in MenACWY for the other groups within the stratification of education level of mother: (1) less than 12 years (53.0%) vs. 12 years (44.9%) in the group of adequate provider data; (2) less than 12 years (18.9%) vs. college graduate (8.04%) in the group of inadequate data with consent given.

The re-allocation allowed the differences to disappear when we assumed all those with missing consent gave consent (Table 12), but it persisted within the same sociodemographic variables for the presumption when all those with missing consent denied consent (Table 13).

The distributions for provider verified data stratified by sociodemographic variables of MenACWY were higher and more consistent comparing to HPV (Table 14). The only visible discrepancy was between Northeast (94.3%) and South (84.5%). Notably, these groups had the highest MenACWY vaccine coverage: region of Northeast, adolescents of age 17 years old, Hispanic, and mother with education level of college graduate.

Concordance between parental and provider report

The concordance rates were steady among all sociodemographic variables other than age; there was a ~11% difference between adolescents of age 15 years old (71.7%) and adolescents of age 17 years old (82.7%). In addition, we observed a decrease of concordance rate as the education level of mother declined (Table 15).

Discordance between parental and provider report (over- and under-reporting)

Overall, there was a higher under-reporting rate than over-reporting rate for discordance (Table 15). Both had mostly uniform distributions across sociodemographic variables. The only noticeable difference for over-reporting was within region between South (9.08%) and Northeast (3.53%); the Northeast was less likely to over-report compared to the South (aPR 0.38, 95% CI 0.28, 0.52) (Table 16).

Meanwhile, adolescents of 15 years old (20.4%) was more likely to under-report than adolescents of 17 years old (11.2%) with an aPR of 1.81 (95% CI 1.47, 2.24). Although there appeared to be a negative relationship between education level of mother and under-reporting, there was no significant difference.

Sensitivity and Specificity

The measures of sensitivity and specificity concerning MenACWY vaccine concordance and discordance were the most polarized out of all three vaccines: with a high sensitivity of 90.8% and a low specificity of 26.3% (Table 10). The parental reported coverage of 74.5% combined with the sensitivity value from adequate provider data generated a lower adjusted estimate of 86.4% for the sensitivity of those without adequate provider data.

Tdap

Sample characteristics

Distributions for parental report of Tdap fluctuated the most in the group of inadequate data with missing consent: (1) Hispanic (34.3%) vs. non-Hispanic black (44.1%) and Other (44.1%); (2) household below poverty (30.4%) vs. household above poverty (42.1%); (3) mother with education level of less than 12 years (28.9%) vs. mother of college graduate (43.3%) (Table 17). In the group of inadequate data with consent, mother with education level of less than 12 years also had visible difference from mother of college graduate (18.0% vs. 7.81% respectively).

Similar to the hypothetical scenarios of reallocation for HPV and MenACWY, the striking differences observed had disappeared when we assumed all those of inadequate data with missing consent gave consent to provider verified data (Table 18), but the differences remained when we assumed the group denied consent (Table 19).

For provider verified data, Tdap vaccine coverage was high and uniformly distributed across all sociodemographic variables (Table 20). There appeared to be a positive relationship between vaccine coverage and age of adolescents; the coverage increased as the adolescents age increased. These groups had the highest Tdap vaccine coverage: region of Northeast, adolescents of age 17 years old, non-Hispanic white, and mother with education level of college graduate.

Concordance between parental and provider report

The only visible difference in the rate of concordance was within education level of mother between mother with education of less than 12 years (80.8%) and mother of college graduate (89.7%) (Table 21). We also observed positive relationships between concordance rate and education of mother and between concordance rate and age of adolescents; the concordance rate increased along with increase in education of mother and increase in age of adolescents.

Discordance between parental and provider report (over- and under-reporting)

Parental over-reporting was higher than under-reporting for Tdap vaccine with most of under-reporting ranging from 2-5% (Table 21). Overall, the stratification of parental over-reporting for Tdap was consistent across sociodemographic variables, and this was supported by the Poisson regression analysis as most of aPRs were found to be insignificant (Table 22).

In contrast, there existed a few discrepancies for parental under-reporting: (1) non-Hispanic black (6.16%) was approximately twice as likely as non-Hispanic white (2.22%) to under-report (aPR 2.17, 95% CI 1.49, 3.17); (2) mother with education level of less than 12 years (8.17%, aPR 4.42, 95% CI 2.98, 6.56) and mother with education level of 12 years (5.09%, aPR 2.84, 95% CI 1.98, 4.07) vs. mother of college graduate (1.67%, referent).

Despite the fact it looked as if there was a difference of under-reporting in household above poverty (2.85%) and household below poverty (5.88%); further analysis determined that the difference was insignificant (aPR 1.08, 95% CI 0.80, 1.47).

Sensitivity and Specificity

Tdap had a high sensitivity (89.8%) but a low specificity (32.7%) with regards to concordance and discordance (Table 10). The parental reported coverage of 92.6% in combination with sensitivity value from adequate provider data produced a lower adjusted estimate of 88.1% for those with inadequate provider data.

Discussion

We found a unique trend for all three vaccines; household below poverty status consistently had the highest percentages in two groups of people: (1) those who had adequate provider verification data; (2) those who had inadequate data with consent given, and it also had the lowest proportion of people who had inadequate data with missing consent. This indicated these households were more likely to be cooperative in participating. Furthermore, mother with education level of less than 12 years were perceived to be more cooperative than mother with college-level education for the same reason.

For HPV 1+ and 3+ shots, the trends observed above corresponded perfectly to the trends observed for breakdown of vaccine coverage by the same sociodemographic variables; Hispanics, household below poverty status, and mother with education level of less than 12 years all reported the highest vaccination coverage within their own stratification. This could provide a reason for why these groups were more cooperative, those without the proper vaccinations were more likely to provide incomplete data or refuse consent to provider verification data. On the other hand, we identified the lowest HPV vaccine coverage for both 1+ and 3+ shots tend to be non-Hispanic white male adolescents of age 13 years old from the South with mother's education level of more than 12 years but non-college graduate in a household above poverty status. The exact reason for differences in HPV vaccine coverage needs further investigation, other studies have also found similar outcome with lower initiation from white household[45,46]. One study suggested that it could be because they have a lower perceived risk of HPV due to better access to healthcare for routine checkup and cervical cancer examination[47]. Another study theorized household below poverty had higher HPV vaccination due to the effectiveness of Vaccines For Children (VFC) program, it provides vaccines to the uninsured and those who couldn't afford vaccination[48]. This could also explain how all of these vaccine coverages were highest in Hispanic other than Tdap.

Results from different studies indicated that male adolescents were less likely to be vaccinated because of attitudes toward HPV vaccine from healthcare professionals and parents: (1) they may not think it was worth the effort to vaccinate males; (2) they might be unaware of the need to vaccinate male adolescents;

(3) they could perceive HPV to have less severe effects on males[22]. Although some studies suggested black and Hispanic adolescents were less likely to complete the HPV vaccine series compared to white adolescents[22], this wasn't the case for NIS-Teen 2018 as they had the first and second highest coverage for HPV 3+ shots.

Different from HPV vaccination, females did not report higher vaccine coverage than males for MenACWY and Tdap. This could be attributed to the fact that parents would not think these diseases affect their children differently based on the gender, unlike the circumstances for HPV. Furthermore, both had the highest coverage in region of Northeast, households above poverty, and mothers of college graduate. An important consideration for vaccine coverage variation in regions is school policies, school entry requirement of vaccines was found to have a positive correlation with MenACWY vaccine coverage[23]. One study exhibited the most common reasons for not receiving MenACWY and Tdap vaccination to be no provider recommendation and lack of knowledge[20]. This could explain why households above poverty and mothers of college graduate had the highest vaccine coverage; they were more likely to receive vaccine recommendation due to better access and higher quality of healthcare, and they were more likely to know about these diseases from their education.

All vaccinations had the highest coverage in the group of adolescents of 17 years old, and there was a positive relationship as the coverage increased with age increased; this was reasonable since the older these teens were, the more time they had to complete their vaccination. In addition, providers would delay the recommendation of these vaccines as they perceive less risk for younger adolescents to acquire these diseases. For instance, providers would wait till later because they believe risk of meningococcal is higher after college entry[23]. For the specific case of HPV, another contributing factor was the presumption from both parents and provider that younger teens would not be sexually active[20].

Although Hispanics, household below poverty status, and mother with education level of less than 12 years had the highest vaccine coverage rate, they were found to have the lowest concordance between parental report and provider verified data for both HPV 1+ and 3+ vaccinations. We found Hispanics

were approximately twice as likely to under-report than non-Hispanic white (aPR of 1.87 for 1+ shot and aPR of 2.20 for 3+ shots). Upon further examination, the reason behind this phenomenon became clear; these sub-categories had the lowest concordance rate because they had the highest under-report rate. It complemented nicely with the fact that they have high vaccine coverage; the parents could have forgotten, or they could be unfamiliar with their children's vaccine records. In comparison, those of non-Hispanic white, household above poverty, and mother with college graduate education level had consistently low discordance rate for both over- and under-reporting, which suggests these parents might be more knowledgeable about their adolescents' vaccine status. The low concordance rate of Hispanics and household below poverty, and higher concordance rate of non-Hispanic white and household above poverty was seen in another study as well; in which it indicated improvements must be made to avoid over- or under-vaccination for the respective groups, in the meantime allowing the vaccination process to reduce disparities and become more cost-efficient[27].

Parental under-reporting did not vary a lot among the sociodemographic variables for MenACWY vaccine; most of them cross the null value of 1 with no significant difference. However, it was identified that parents of male adolescents were 0.79 times less likely to under-report comparing to parents of female adolescents. The exact reason behind this phenomenon needs further investigation.

Parental under-reporting for Tdap followed similar fashion as HPV 1+ and 3+ shots; household below poverty and mother with education level of less than 12 years had the highest under-reporting rate. However, unlike HPV 1+ and 3+ shots, they had the lowest Tdap vaccine coverage within the stratification. When stratified by race, non-Hispanic black was twice more likely to under-report than non-Hispanic white; they also had the highest under-reporting rate and lowest vaccine coverage.

For HPV 1+ shot vaccination, all of the parental over-reporting rates were relatively low. Parents from Midwest were found to be less likely to over-report than parents of South (aPR of 0.64). The rest of the parental over-reporting rates exhibited even distributions as most aPRs approached the null value of 1. In contrast, parental over-reporting was high across the sub-categories for HPV 3+ vaccination. It also had

steady distributions similar to HPV 1+ shot. This could be because parents were able to recall their children receiving the first dose of HPV vaccination, and they assumed the adolescents finished the vaccine series.

In correspondence, the trends of parental over-reporting for MenACWY and Tdap vaccines bore resemblance to HPV 1+ shot vaccination; the overall rates remained low while most of them displayed even distributions without significant differences. A particular noteworthy revelation came from MenACWY vaccine within different regions; parents of Northeast were 0.39 times than parents of South to over-report. Northeast was identified to be the region of highest MenACWY vaccine coverage in another study; it suggested school entry requirement was associated with vaccine coverage[23]. This could also be why there were less over-reporting in Northeast; parents were required to be more informed on their child's vaccination status.

In general, most of the adjusted PR from Poisson regression analysis gravitated toward the null value of 1 when compared to the crude PR estimates. This was because these aPRs were calculated with a multivariate analysis in which every sociodemographic variable was part of the model, the effect of one factor on discordance would be parcel disseminated into other variables.

HPV 1+ shot had a higher sensitivity but a slightly lower specificity for concordance/discordance in comparison with HPV 3+ shots. These values indicate there were a higher number of true positives captured in the 1+ shot vaccination in which more parents responded accurately when their children received vaccination. Concurrently, the 3+ shots vaccination was able to capture more true negatives; people who didn't receive the vaccination that answered truthfully. The sensitivity of MenACWY was calculated to be similar to HPV 1+ shot, but the specificity was the lowest among all three vaccines. Similarly, Tdap recorded high sensitivity measure with a low specificity value. The high sensitivity and low specificity suggested the capability of NIS-Teen in capturing the true positives, while it was ineffective in capturing the true negatives. It also indicated there was a higher degree of parental under-reporting among all three vaccines; more households were reporting their adolescents didn't receive

vaccination when provider verified report proved otherwise. Effective intervention methods such as providing and encouraging parents to retain the shot cards and immunization records could remedy the issue of inaccurate parental recall[27–30] These values from adequate provider data were used to derive adjusted estimate of sensitivity for those of inadequate provider data. The adjusted estimates were all lower than the values from adequate provider data because we used parental reported coverage of each vaccine to multiply the true sensitivity measure acquired from provider verified data. These adjusted estimates indicate the inability to capture accurate data from the self-reporting method.

There exist some limitations for this analysis: (1) selection bias in which the households that participated in NIS-Teen could be an over-representation of target population in factors such as access to healthcare and vaccination. However, the effect of this bias could be alleviated by the modification of sample weights[23]; (2) provider verified data were assumed to be the gold standard in measuring concordance and discordance, but there could be classification errors in these data. This would lead to inaccurate estimation of measures including concordance, discordance, sensitivity, and specificity[32]; (3) potential of response bias could lead to higher estimates of over-reporting because parents may not have provided complete documentations of their children's vaccination records[27]; (4) Recall bias and social desirability bias due to the nature of self-reported surveys could skewed the estimates; which may lead to imprecise calculation of prevalence ratios and significant differences.

Despite the limitations, the results of this analysis share resemblances with other studies and CDC statistics[17–19,23,26,27,37,42,46–48]; vaccine coverage, discordance, and measures of sensitivity and specificity were detected to be higher in similar groups or particular vaccine and lower in others. Although coverages were high in all three vaccines; there are potential for improvement, especially for HPV vaccine. We have identified groups with significantly higher rate of discordance that will require more focus and research in order to improve vaccine coverage in these specific groups. Furthermore, the sensitivity, specificity and adjusted estimates uncovered the limitation of self-reporting method; these measures demonstrated mediocre accuracy in capturing the data. There remain unanswered questions in regard to vaccine

discordance that merits further investigations; questions such as why certain groups are more likely or less likely to over-report or under-report, how we can overcome the issue of bias that accompanies self-reported survey, and how to improve vaccine coverage for NIS-Teen. An alternative method may be preferred to capture more accurate data in the future.

Tables

Table 1

Distributions of parental report for HPV vaccine in NIS-Teen 2018

HPVI_ANY stratified by different variables with LEV					
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)	Inadequate with missing consent (lev 4)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	0.53 (0.39, 0.68)	41.4 (40.5, 42.3)
		w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)
Region					
Northeast	16.2	47.4 (45.4, 49.4)	7.43 (6.47, 8.39)	0.36 (0.14, 0.59)	44.8 (42.8, 46.8)
Midwest	21.2	49.6 (48.0, 51.1)	9.52 (8.58, 10.4)	0.29 (0.12, 0.47)	40.6 (39.1, 21.1)
South	38.6	47.0 (45.6, 48.3)	10.8 (9.94, 11.6)	0.62 (0.39, 0.84)	41.7 (40.4, 43.0)
West	24.0	49.5 (46.7, 52.3)	10.9 (9.19, 12.7)	0.58 (0.18, 0.98)	38.9 (36.2, 41.7)
Age					
13 years	20.0	50.9 (48.7, 53.0)	9.61 (8.23, 11.0)	0.43 (0.14, 0.71)	39.1 (37.0, 41.1)
14 years	20.1	48.5 (46.4, 50.6)	8.77 (7.63, 9.91)	0.71 (0.26, 1.16)	42.0 (39.9, 44.1)
15 years	20.0	48.4 (46.3, 50.5)	10.7 (9.38, 12.1)	0.64 (0.30, 0.99)	40.3 (38.3, 42.3)
16 years	19.8	47.7 (45.5, 49.8)	9.43 (8.34, 10.5)	0.34 (0.14, 0.55)	42.6 (40.4, 44.7)
17 years	20.1	45.6 (43.5, 47.8)	11.4 (9.95, 12.9)	0.37 (0.18, 0.55)	42.6 (40.5, 44.7)
Race/Ethnicity					
Hispanic	24.2	49.4 (47.0, 51.8)	15.5 (13.8, 17.2)	0.68 (0.28, 1.07)	34.4 (32.2, 36.7)
Non-Hispanic white	52.0	49.3 (48.2, 50.5)	7.40 (6.81, 7.99)	0.35 (0.23, 0.48)	42.9 (41.8, 44.0)
Non-Hispanic black	13.5	42.9 (40.3, 45.6)	12.2 (10.5, 13.8)	0.65 (0.24, 1.07)	44.2 (41.5, 46.9)
Other	10.3	46.2 (43.0, 49.3)	8.44 (6.82, 10.1)	0.67 (0.07, 1.26)	44.7 (41.6, 47.9)
Sex					
Male	51.0	48.3 (46.9, 49.6)	9.77 (8.99, 10.5)	0.45 (0.28, 0.62)	41.5 (40.2, 42.9)
Female	49.0	48.1 (46.8, 49.5)	10.2 (9.37, 11.1)	0.55 (0.33, 0.76)	41.1 (39.8, 42.4)
Poverty Status					

Above Poverty	79.7	48.3 (47.2, 49.4)	9.14 (8.51, 9.76)	0.54 (0.37, 0.71)	42.0 (41.0, 43.1)
Below Poverty	20.3	54.0 (51.5, 56.5)	14.4 (12.7, 16.2)	0.31 (0.11, 0.51)	31.2 (28.9, 33.6)
Education Level of Mother					
Less than 12 years	12.3	51.8 (48.9, 54.8)	17.9 (15.6, 20.1)	0.66 (0.24, 1.08)	29.6 (27.0, 32.3)
12 years	21.9	46.4 (44.0, 48.7)	11.5 (10.2, 12.9)	0.70 (0.26, 1.13)	41.4 (39.1, 43.7)
More than 12 years, non-college graduate	24.2	47.9 (46.1, 49.8)	9.20 (8.05, 10.4)	0.36 (0.16, 0.56)	42.5 (40.7, 44.4)
College graduate	41.7	48.4 (47.0, 49.7)	7.77 (7.00, 8.53)	0.44 (0.26, 0.62)	43.4 (42.1, 44.8)

Table 2

Distributions of parental report for HPV vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all gave consent to provider data)

HPVI_ANY stratified by different variables with LEV_A				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	52.0 (51.1, 52.9)	0.53 (0.39, 0.68)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	47.4 (45.4, 49.4)	52.3 (50.3, 54.3)	0.36 (0.14, 0.59)
Midwest	21.2	49.6 (48.0, 51.1)	50.2 (48.6, 51.7)	0.29 (0.12, 0.47)
South	38.6	47.0 (45.6, 48.3)	52.4 (51.1, 53.8)	0.62 (0.39, 0.84)
West	24.0	49.5 (46.7, 52.3)	49.9 (47.1, 52.7)	0.58 (0.18, 0.98)
Age				
13 years	20.0	50.9 (48.7, 53.0)	48.7 (46.5, 50.8)	0.43 (0.14, 0.71)
14 years	20.1	48.5 (46.4, 50.6)	50.8 (48.7, 52.9)	0.71 (0.26, 1.16)
15 years	20.0	48.4 (46.3, 50.5)	51.0 (48.9, 53.1)	0.64 (0.30, 0.99)
16 years	19.8	47.7 (45.5, 49.8)	52.0 (49.8, 54.2)	0.34 (0.14, 0.55)
17 years	20.1	45.6 (43.5, 47.8)	54.0 (51.9, 56.1)	0.37 (0.18, 0.55)
Race/Ethnicity				
Hispanic	24.2	49.4 (47.0, 51.8)	49.9 (47.5, 52.3)	0.68 (0.28, 1.07)
Non-Hispanic white	52.0	49.3 (48.2, 50.5)	50.3 (49.2, 51.5)	0.35 (0.23, 0.48)

Non-Hispanic black	13.5	42.9 (40.3, 45.6)	56.4 (53.8, 59.1)	0.65 (0.24, 1.07)
Other	10.3	46.2 (43.0, 49.3)	53.2 (50.0, 56.3)	0.67 (0.07, 1.26)
Sex				
Male	51.0	48.3 (46.9, 49.6)	51.3 (49.9, 52.6)	0.45 (0.28, 0.62)
Female	49.0	48.1 (46.8, 49.5)	51.3 (50.0, 52.7)	0.55 (0.33, 0.76)
Poverty Status				
Above Poverty	79.7	48.3 (47.2, 49.4)	51.2 (50.1, 52.2)	0.54 (0.37, 0.71)
Below Poverty	20.3	54.0 (51.5, 56.5)	45.6 (43.2, 48.1)	0.31 (0.11, 0.51)
Education Level of Mother				
Less than 12 years	12.3	51.8 (48.9, 54.8)	47.5 (44.6, 50.5)	0.66 (0.24, 1.08)
12 years	21.9	46.4 (44.0, 48.7)	53.0 (50.6, 55.3)	0.70 (0.26, 1.13)
More than 12 years, non-college graduate	24.2	47.9 (46.1, 49.8)	51.7 (49.9, 53.6)	0.36 (0.16, 0.56)
College graduate	41.7	48.4 (47.0, 49.7)	51.2 (49.8, 52.6)	0.44 (0.26, 0.62)

Table 3

Distributions of parental report for HPV vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all denied consent to provider data)

HPVI_ANY stratified by different variables with LEV_B				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	41.9 (41.0, 42.8)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	47.4 (45.4, 49.4)	7.43 (6.47, 8.39)	45.2 (43.2, 47.2)
Midwest	21.2	49.6 (48.0, 51.1)	9.52 (8.58, 10.4)	40.9 (39.4, 42.4)
South	38.6	47.0 (45.6, 48.3)	10.8 (9.94, 11.6)	42.3 (41.0, 43.6)
West	24.0	49.5 (46.7, 52.3)	10.9 (9.19, 12.7)	39.5 (36.8, 42.3)
Age				
13 years	20.0	50.9 (48.7, 53.0)	9.61 (8.23, 11.0)	39.5 (37.4, 41.6)
14 years	20.1	48.5 (46.4, 50.6)	8.77 (7.63, 9.91)	42.7 (40.6, 44.8)
15 years	20.0	48.4 (46.3, 50.5)	10.7 (9.38, 12.1)	40.9 (38.9, 43.0)
16 years	19.8	47.7 (45.5, 49.8)	9.43 (8.34, 10.5)	42.9 (40.7, 45.1)
17 years	20.1	45.6 (43.5, 47.8)	11.4 (9.95, 12.9)	43.0 (40.8, 45.1)

Race/Ethnicity				
Hispanic	24.2	49.4 (47.0, 51.8)	15.5 (13.8, 17.2)	35.1 (32.8, 37.4)
Non-Hispanic white	52.0	49.3 (48.2, 50.5)	7.40 (6.81, 7.99)	43.3 (42.1, 44.4)
Non-Hispanic black	13.5	42.9 (40.3, 45.6)	12.2 (10.5, 13.8)	44.9 (44.2, 47.6)
Other	10.3	46.2 (43.0, 49.3)	8.44 (6.82, 10.1)	45.4 (42.2, 48.6)
Sex				
Male	51.0	48.3 (46.9, 49.6)	9.77 (8.99, 10.5)	42.0 (40.6, 43.3)
Female	49.0	48.1 (46.8, 49.5)	10.2 (9.37, 11.1)	41.7 (40.3, 43.0)
Poverty Status				
Above Poverty	79.7	48.3 (47.2, 49.4)	9.14 (8.51, 9.76)	42.6 (41.5, 43.6)
Below Poverty	20.3	54.0 (51.5, 56.5)	14.4 (12.7, 16.2)	31.5 (29.2, 33.9)
Education Level of Mother				
Less than 12 years	12.3	51.8 (48.9, 54.8)	17.9 (15.6, 20.1)	30.3 (27.6, 33.0)
12 years	21.9	46.4 (44.0, 48.7)	11.5 (10.2, 12.9)	42.1 (39.8, 44.4)
More than 12 years, non-college graduate	24.2	47.9 (46.1, 49.8)	9.20 (8.05, 10.4)	42.9 (41.0, 44.7)
College graduate	41.7	48.4 (47.0, 49.7)	7.77 (7.00, 8.53)	43.9 (42.5, 45.2)

Table 4

Distributions of provider report for HPV vaccine (1+ shot) in NIS-Teen 2018

P_UTDHPV stratified by different variables				
	Weighted percentage distribution (%)	UTD	Not UTD	Percentage of UTD from provider report HPV 1+ shot
		n	n	w% (95% CI)
Region				
Northeast	16.2	2601	836	71.1 (68.4, 73.7)
Midwest	21.2	2827	1267	69.3 (67.3, 71.2)
South	38.6	4643	2541	63.8 (62.0, 65.6)
West	24.0	2685	1300	71.9 (68.5, 75.3)
Age				
13 years	20.0	2460	1392	62.6 (59.7, 65.5)
14 years	20.1	2617	1258	66.9 (64.2, 69.7)
15 years	20.0	2611	1130	69.7 (67.0, 72.4)
16 years	19.8	2661	1090	71.2 (68.6, 73.9)
17 years	20.1	2407	1074	70.1 (67.3, 72.9)
Race/Ethnicity				

Hispanic	24.2	3041	981	75.5 (72.8, 78.3)
Non-Hispanic white	52.0	7164	3964	63.5 (62.0, 65.1)
Non-Hispanic black	13.5	1094	393	72.8 (69.5, 76.2)
Other	10.3	1457	606	67.1 (62.9, 71.4)
Sex				
Male	51.0	6446	3326	66.3 (64.6, 68.0)
Female	49.0	6310	2618	69.9 (68.1, 71.7)
Poverty Status				
Above Poverty	79.7	9784	4932	65.8 (64.4, 67.2)
Below Poverty	20.3	2499	828	76.2 (73.6, 78.8)
Education Level of Mother				
Less than 12 years	12.3	1811	555	77.6 (74.7, 80.4)
12 years	21.9	1965	964	67.9 (64.8, 70.9)
More than 12 years, non-college graduate	24.2	2995	1725	65.1 (62.8, 67.5)
College graduate	41.7	5985	2700	67.1 (65.2, 69.0)

Table 5

Distributions of provider report for HPV vaccine (3+ shots) in NIS-Teen 2018

P_UTDHPV_15 stratified by different variables				
	Weighted percentage distribution (%)	UTD	Not UTD	Percentage of UTD from provider report HPV 3+ shots
		n	n	w% (95% CI)
Region				
Northeast	16.2	2154	1283	57.8 (55.0, 60.7)
Midwest	21.2	2257	1837	55.2 (53.1, 57.3)
South	38.6	3588	3596	48.9 (47.1, 50.8)
West	24.0	2071	1914	56.6 (52.7, 60.4)
Age				
13 years	20.0	1692	2160	41.8 (38.8, 44.8)
14 years	20.1	2053	1822	52.8 (49.9, 55.7)
15 years	20.0	2180	1561	57.8 (54.9, 60.7)
16 years	19.8	2185	1566	57.1 (54.1, 60.1)
17 years	20.1	1960	1521	58.5 (55.5, 61.5)
Race/Ethnicity				
Hispanic	24.2	2444	1578	60.5 (57.4, 63.6)
Non-Hispanic white	52.0	5638	5490	49.8 (48.2, 51.4)
Non-Hispanic black	13.5	847	640	55.0 (51.2, 58.9)
Other	10.3	1141	922	54.0 (49.5, 58.4)
Sex				
Male	51.0	5015	4757	51.0 (49.1, 52.9)

Female	49.0	5055	3873	56.2 (54.3, 58.1)
Poverty Status				
Above Poverty	79.7	7726	6990	51.8 (50.3, 53.3)
Below Poverty	20.3	1982	1345	60.6 (57.5, 63.6)
Education Level of Mother				
Less than 12 years	12.3	1459	907	62.3 (58.7, 65.8)
12 years	21.9	1489	1440	53.0 (49.7, 56.3)
More than 12 years, non-college graduate	24.2	2332	2387	50.9 (48.3, 53.4)
College graduate	41.7	4790	3895	52.8 (50.9, 54.8)

Table 6

Distributions of concordance and discordance for HPV vaccine (1+ shot) in NIS-Teen 2018

HPV Concordance & Discordance stratified by different variables (HPVI_ANY vs. P_UTDHPV)					
	Weighted percentage distribution (%)	Agreement of parent and provider report for HPV vaccine	Disagreement of parent and provider report for HPV vaccine (% Over-reporting)	Disagreement of parent and provider report for HPV vaccine (% Under-reporting)	Missing
		w% (95% CI)	w% (95% CI)	w% (95% CI)	n
Region					
Northeast	16.2	83.8 (81.5, 86.1)	6.13 (4.60, 7.65)	10.1 (8.20, 11.9)	281
Midwest	21.2	85.3 (83.8, 86.9)	5.23 (4.32, 6.13)	9.44 (8.11, 10.8)	300
South	38.6	81.2 (79.7, 82.8)	8.44 (7.34, 9.54)	10.3 (9.06, 11.6)	602
West	24.0	81.2 (78.0, 84.4)	6.53 (4.44, 8.63)	12.3 (9.64, 14.9)	344
Age					
13 years	20.0	82.2 (79.8, 84.7)	6.46 (4.85, 8.08)	11.3 (9.32, 13.3)	332
14 years	20.1	82.4 (80.0, 84.7)	7.30 (5.57, 9.04)	10.3 (8.58, 12.1)	329
15 years	20.0	81.0 (78.4, 83.7)	7.81 (5.86, 9.77)	11.1 (9.03, 13.3)	302
16 years	19.8	82.9 (80.4, 85.4)	6.26 (4.89, 7.62)	10.9 (8.65, 13.1)	310
17 years	20.1	84.2 (82.0, 86.4)	6.81 (5.50, 8.12)	9.03 (7.16, 10.9)	254
Race/Ethnicity					
Hispanic	24.2	75.3 (72.2, 78.4)	7.19 (5.16, 9.21)	17.5 (14.8, 20.2)	541
Non-Hispanic white	52.0	86.7 (85.7, 87.8)	6.25 (5.48, 7.02)	7.02 (6.22, 7.81)	616
Non-Hispanic black	13.5	78.2 (74.8, 81.5)	7.91 (5.86, 9.96)	13.9 (11.0, 16.8)	157
Other	10.3	82.6 (79.5, 85.7)	8.64 (6.13, 11.1)	8.74 (6.73, 10.8)	213
Sex					
Male	51.0	81.6 (80.1, 83.0)	6.72 (5.86, 7.57)	11.7 (10.4, 13.0)	887
Female	49.0	83.5 (81.9, 85.1)	7.14 (5.97, 8.31)	9.33 (8.12, 10.6)	640

Poverty Status					
Above Poverty	79.7	84.2 (83.1, 85.4)	7.02 (6.18, 7.87)	8.73 (7.79, 9.66)	903
Below Poverty	20.3	74.8 (71.8, 77.8)	6.90 (5.30, 8.50)	18.3 (15.6, 21.0)	524
Education Level of Mother					
Less than 12 years	12.3	71.7 (67.9, 75.5)	7.16 (4.96, 9.36)	21.2 (17.7, 24.6)	486
12 years	21.9	78.4 (75.5, 81.3)	7.58 (5.72, 9.43)	14.0 (11.6, 16.4)	334
More than 12 years, non-college graduate	24.2	82.3 (80.2, 84.4)	7.34 (6.14, 8.55)	10.4 (8.55, 12.2)	260
College graduate	41.7	87.3 (85.9, 88.7)	6.31 (5.20, 7.41)	6.36 (5.43, 7.30)	447

Table 7

Distributions of concordance and discordance for HPV vaccine (3+ shots) in NIS-Teen 2018

HPV1 Concordance & Discordance by different variables (HPVI_ANY vs. P_UTDHPV_15)					
	Weighted percentage distribution (%)	Agreement of parent and provider report for HPV vaccine	Disagreement of parent and provider report for HPV vaccine (% Over-reporting)	Disagreement of parent and provider report for HPV vaccine (% Under-reporting)	Missing
		w% (95% CI)	w% (95% CI)	w% (95% CI)	n
Region					
Northeast	16.2	77.6 (75.1, 80.0)	15.8 (13.7, 18.0)	6.60 (5.13, 8.07)	281
Midwest	21.2	77.7 (75.8, 79.5)	16.1 (14.5, 17.7)	6.26 (5.14, 7.38)	300
South	38.6	74.3 (72.6, 76.0)	19.4 (17.9, 20.9)	6.31 (5.36, 7.27)	602
West	24.0	74.1 (70.5, 77.7)	17.5 (14.4, 20.6)	8.40 (6.04, 10.8)	344
Age					
13 years	20.0	72.3 (69.5, 75.2)	21.9 (19.3, 24.6)	5.70 (4.23, 7.18)	332
14 years	20.1	75.1 (72.5, 77.8)	17.7 (15.4, 20.1)	7.14 (5.60, 8.67)	329
15 years	20.0	75.7 (72.9, 78.5)	16.3 (13.9, 18.7)	8.01 (6.12, 9.90)	302
16 years	19.8	75.7 (72.9, 78.5)	16.8 (14.4, 19.2)	7.51 (5.58, 9.45)	310
17 years	20.1	78.8 (76.4, 81.2)	15.4 (13.4, 17.4)	5.83 (4.36, 7.30)	254
Race/Ethnicity					
Hispanic	24.2	70.4 (67.1, 73.8)	16.9 (14.1, 19.7)	12.7 (10.2, 15.2)	541
Non-Hispanic white	52.0	78.6 (77.3, 79.9)	17.1 (15.9, 18.4)	4.27 (3.66, 4.88)	616
Non-Hispanic black	13.5	72.0 (68.4, 75.5)	20.0 (16.8, 23.1)	8.07 (5.92, 10.2)	157
Other	10.3	75.3 (71.7, 78.9)	19.3 (16.0, 22.6)	5.42 (3.78, 7.06)	213
Sex					

Male	51.0	74.5 (72.7, 76.2)	18.0 (16.5, 19.5)	7.56 (6.49, 8.63)	887
Female	49.0	76.5 (74.8, 78.3)	17.3 (15.8, 18.9)	6.11 (5.06, 7.16)	640
Poverty Status					
Above Poverty	79.7	76.5 (75.1, 77.8)	17.9 (16.7, 19.1)	5.58 (4.80, 6.37)	903
Below Poverty	20.3	71.5 (68.3, 74.6)	16.3 (13.8, 18.7)	12.3 (9.97, 14.6)	524
Education Level of Mother					
Less than 12 years	12.3	67.8 (63.7, 71.9)	16.8 (13.4, 20.3)	15.4 (12.3, 18.5)	486
12 years	21.9	73.7 (70.6, 76.8)	17.4 (14.8, 20.0)	8.88 (6.80, 11.0)	334
More than 12 years, non-college graduate	24.2	75.9 (73.6, 78.2)	17.7 (15.8, 19.7)	6.41 (4.83, 7.99)	260
College graduate	41.7	78.0 (76.3, 79.7)	18.0 (16.4, 19.6)	4.02 (3.32, 4.72)	447

Table 8

Bivariate and Multivariate Poisson regression analysis of over- and under-reporting for HPV 1+ shot

Bivariate and Multivariate Poisson regression analysis to estimate Prevalence Ratio of over- and under-reporting by sociodemographic variables (HPV 1+ shot)				
	Over-report Bivariate Analysis	Over-report Multivariate Analysis	Under-report Bivariate Analysis	Under-report Multivariate Analysis
	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)
Region				
Northeast	0.72 (0.55, 0.95)	0.76 (0.57, 1.00)	0.93 (0.75, 1.15)	1.04 (0.85, 1.28)
Midwest	0.64 (0.52, 0.80)	0.67 (0.54, 0.84)	0.90 (0.75, 1.07)	1.05 (0.88, 1.26)
South	Referent	Referent	Referent	Referent
West	0.85 (0.60, 1.22)	0.83 (0.60, 1.14)	1.18 (0.93, 1.51)	1.11 (0.88, 1.40)
Age				
13 years	0.99 (0.72, 1.35)	0.98 (0.71, 1.34)	1.26 (0.96, 1.65)	1.21 (0.92, 1.58)
14 years	1.09 (0.80, 1.48)	1.06 (0.78, 1.44)	1.14 (0.88, 1.48)	1.08 (0.83, 1.41)
15 years	1.17 (0.83, 1.65)	1.17 (0.84, 1.64)	1.21 (0.92, 1.61)	1.20 (0.92, 1.58)
16 years	0.88 (0.66, 1.18)	0.88 (0.66, 1.17)	1.19 (0.88, 1.61)	1.17 (0.87, 1.57)
17 years	Referent	Referent	Referent	Referent
Race/Ethnicity				
Hispanic	1.40 (1.02, 1.93)	1.26 (0.90, 1.76)	2.63 (2.17, 3.18)	1.87 (1.51, 2.32)
Non-Hispanic white	Referent	Referent	Referent	Referent

Non-Hispanic black	1.39 (1.04, 1.85)	1.27 (0.95, 1.70)	2.10 (1.67, 2.63)	1.86 (1.47, 2.34)
Other	1.41 (1.03, 1.94)	1.41 (1.03, 1.91)	1.21 (0.94, 1.56)	1.15 (0.89, 1.49)
Sex				
Male	0.94 (0.76, 1.17)	0.95 (0.77, 1.17)	1.25 (1.05, 1.48)	1.26 (1.07, 1.49)
Female	Referent	Referent	Referent	Referent
Poverty Status				
Above Poverty	Referent	Referent	Referent	Referent
Below Poverty	1.19 (0.91, 1.55)	0.98 (0.72, 1.35)	2.08 (1.75, 2.48)	1.22 (0.98, 1.51)
Education Level of Mother				
Less than 12 years	1.41 (0.99, 2.01)	1.28 (0.85, 1.90)	3.55 (2.86, 4.41)	2.32 (1.77, 3.04)
12 years	1.33 (0.96, 1.84)	1.26 (0.89, 1.78)	2.24 (1.79, 2.79)	1.78 (1.41, 2.25)
More than 12 years, non-college graduate	1.20 (0.95, 1.53)	1.19 (0.93, 1.53)	1.65 (1.31, 2.09)	1.46 (1.16, 1.83)
College graduate	Referent	Referent	Referent	Referent

Table 9

Bivariate and Multivariate Poisson regression analysis of over- and under-reporting for HPV 3+ shots

Bivariate and Multivariate Poisson regression analysis to estimate Prevalence Ratio of over- and under-reporting by sociodemographic variables (HPV 3+ shots)				
	Over-report Bivariate Analysis	Over-report Multivariate Analysis	Under-report Bivariate Analysis	Under-report Multivariate Analysis
	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)
Region				
Northeast	0.81 (0.69, 0.94)	0.82 (0.71, 0.96)	0.99 (0.76, 1.28)	1.14 (0.88, 1.47)
Midwest	0.82 (0.72, 0.93)	0.84 (0.74, 0.95)	0.91 (0.72, 1.14)	1.10 (0.88, 1.39)
South	Referent	Referent	Referent	Referent
West	0.93 (0.77, 1.13)	0.95 (0.79, 1.14)	1.30 (0.95, 1.78)	1.19 (0.89, 1.59)
Age				
13 years	1.43 (1.21, 1.70)	1.43 (1.21, 1.70)	1.07 (0.75, 1.53)	1.00 (0.71, 1.43)
14 years	1.20 (1.00, 1.44)	1.20 (1.00, 1.44)	1.23 (0.89, 1.71)	1.17 (0.84, 1.62)
15 years	1.07 (0.87, 1.31)	1.07 (0.87, 1.32)	1.32 (0.93, 1.86)	1.29 (0.93, 1.80)
16 years	1.08 (0.90, 1.31)	1.09 (0.90, 1.31)	1.35 (0.93, 1.97)	1.32 (0.92, 1.90)

17 years	Referent	Referent	Referent	Referent
Race/Ethnicity				
Hispanic	1.09 (0.91, 1.31)	1.05 (0.87, 1.26)	3.12 (2.46, 3.96)	2.20 (1.69, 2.86)
Non-Hispanic white	Referent	Referent	Referent	Referent
Non-Hispanic black	1.21 (1.02, 1.44)	1.18 (0.99, 1.41)	2.10 (1.58, 2.80)	1.91 (1.41, 2.58)
Other	1.12 (0.93, 1.35)	1.12 (0.93, 1.34)	1.23 (0.89, 1.69)	1.18 (0.86, 1.64)
Sex				
Male	1.05 (0.93, 1.18)	1.05 (0.93, 1.18)	1.22 (0.98, 1.53)	1.24 (1.00, 1.53)
Female	Referent	Referent	Referent	Referent
Poverty Status				
Above Poverty	Referent	Referent	Referent	Referent
Below Poverty	1.00 (0.85, 1.18)	0.93 (0.78, 1.12)	2.14 (1.71, 2.66)	1.19 (0.90, 1.58)
Education Level of Mother				
Less than 12 years	1.08 (0.87, 1.34)	1.08 (0.86, 1.36)	4.01 (3.09, 5.21)	2.42 (1.74, 3.37)
12 years	1.00 (0.84, 1.20)	1.00 (0.83, 1.21)	2.17 (1.63, 2.88)	1.65 (1.23, 2.21)
More than 12 years, non-college graduate	1.00 (0.88, 1.15)	0.99 (0.86, 1.14)	1.66 (1.22, 2.26)	1.43 (1.07, 1.92)
College graduate	Referent	Referent	Referent	Referent

Table 10

Sensitivity and Specificity for the vaccines

	Sensitivity for Adequate Provider Data	Specificity for Adequate Provider Data	Initial Coverage based on Parental Report	Adjusted prevalence of vaccination
1+ HPV Vaccination	90.4%	57.4%	42.9%	63.1%
3+ HPV Vaccination	85.5%	58.4%	22.5%	51.4%
MenACWY Vaccination	90.8%	26.3%	74.5%	86.4%
Tdap Vaccination	89.8%	32.7%	92.6%	88.1%

Table 11

Distributions of parental report for MenACWY vaccine in NIS-Teen 2018

MEN_ANY stratified by different variables with LEV					
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)	Inadequate with missing consent (lev 4)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	0.53 (0.39, 0.68)	41.4 (40.5, 42.3)
		w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)
Region					
Northeast	16.2	48.7 (46.6, 50.9)	7.15 (6.16, 8.13)	0.42 (0.15, 0.68)	43.7 (41.6, 45.9)
Midwest	21.2	49.3 (47.6, 51.0)	9.56 (8.50, 10.6)	0.34 (0.13, 0.56)	40.8 (39.1, 42.5)
South	38.6	46.6 (45.1, 48.0)	11.4 (10.5, 12.4)	0.58 (0.34, 0.81)	41.4 (40.0, 42.9)
West	24.0	48.9 (45.8, 51.9)	11.7 (9.74, 13.6)	0.50 (0.09, 0.91)	39.0 (35.9, 42.0)
Age					
13 years	20.0	50.7 (48.3, 53.1)	10.3 (8.68, 12.0)	0.32 (0.06, 0.59)	38.7 (36.4, 41.0)
14 years	20.1	47.5 (45.1, 49.8)	9.69 (8.32, 11.1)	0.86 (0.31, 1.41)	42.0 (39.7, 44.3)
15 years	20.0	48.9 (46.7, 51.2)	11.0 (9.52, 12.4)	0.57 (0.26, 0.88)	39.5 (37.4, 41.7)
16 years	19.8	47.8 (45.4, 50.2)	9.94 (8.70, 11.2)	0.30 (0.10, 0.51)	41.9 (39.6, 44.3)
17 years	20.1	45.5 (43.2, 47.9)	11.0 (9.50, 12.4)	0.35 (0.17, 0.54)	43.1 (40.8, 45.5)
Race/Ethnicity					
Hispanic	24.2	49.0 (46.4, 51.5)	16.2 (14.3, 18.1)	0.58 (0.15, 1.00)	34.3 (31.9, 36.7)
Non-Hispanic white	52.0	49.4 (48.1, 50.7)	7.57 (6.93, 8.22)	0.39 (0.24, 0.54)	42.6 (41.3, 43.9)
Non-Hispanic black	13.5	43.0 (40.2, 45.9)	12.2 (10.4, 13.9)	0.64 (0.23, 1.05)	44.2 (41.3, 47.1)
Other	10.3	45.8 (42.2, 49.4)	9.41 (7.52, 11.3)	0.52 (0.04, 1.00)	44.3 (40.7, 47.9)
Sex					
Male	51.0	48.5 (47.0, 50.0)	10.1 (9.24, 10.9)	0.42 (0.26, 0.58)	41.0 (39.6, 42.5)
Female	49.0	47.6 (46.1, 49.0)	10.7 (9.71, 11.7)	0.55 (0.30, 0.80)	41.2 (39.8, 42.7)
Poverty Status					

Above Poverty	79.7	48.0 (46.8, 49.1)	9.29 (8.62, 9.97)	0.51 (0.33, 0.69)	42.2 (41.1, 43.4)
Below Poverty	20.3	54.0 (51.3, 56.6)	15.4 (13.4, 17.4)	0.34 (0.15, 0.53)	30.3 (27.8, 32.7)
Education Level of Mother					
Less than 12 years	12.3	53.0 (49.9, 56.1)	18.9 (16.4, 21.4)	0.68 (0.30, 1.05)	27.4 (24.7, 30.2)
12 years	21.9	44.9 (42.4, 47.5)	11.7 (10.2, 13.3)	0.72 (0.22, 1.23)	42.6 (40.0, 45.2)
More than 12 years, non-college graduate	24.2	47.7 (45.8, 49.7)	9.46 (8.26, 10.7)	0.30 (0.11, 0.49)	42.5 (40.5, 44.5)
College graduate	41.7	48.4 (46.9, 50.0)	8.04 (7.18, 8.91)	0.42 (0.24, 0.60)	43.1 (41.6, 44.6)

Table 12

Distributions of parental report for MenACWY vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all gave consent to provider data)

MEN_ANY stratified by different variables with LEV_A				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	52.0 (51.1, 52.9)	0.53 (0.39, 0.68)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	48.7 (46.6, 50.9)	50.9 (48.7, 53.0)	0.42 (0.15, 0.68)
Midwest	21.2	49.3 (47.6, 51.0)	50.3 (48.6, 52.1)	0.34 (0.13, 0.56)
South	38.6	46.6 (45.1, 48.0)	52.9 (51.4, 54.3)	0.58 (0.34, 0.81)
West	24.0	48.9 (45.8, 51.9)	50.6 (47.6, 53.7)	0.50 (0.09, 0.91)
Age				
13 years	20.0	50.7 (48.3, 53.1)	49.0 (46.6, 51.4)	0.32 (0.06, 0.59)
14 years	20.1	47.5 (45.1, 49.8)	51.7 (49.3, 54.0)	0.86 (0.31, 1.41)
15 years	20.0	48.9 (46.7, 51.2)	50.5 (48.3, 52.7)	0.57 (0.26, 0.88)
16 years	19.8	47.8 (45.4, 50.2)	51.9 (49.5, 54.3)	0.30 (0.10, 0.51)
17 years	20.1	45.5 (43.2, 47.9)	54.1 (51.8, 56.4)	0.35 (0.17, 0.54)
Race/Ethnicity				
Hispanic	24.2	49.0 (46.4, 51.5)	50.5 (47.9, 53.0)	0.58 (0.15, 1.00)
Non-Hispanic white	52.0	49.4 (48.1, 50.7)	50.2 (48.9, 51.5)	0.39 (0.24, 0.54)

Non-Hispanic black	13.5	43.0 (40.2, 45.9)	56.3 (53.5, 59.2)	0.64 (0.23, 1.05)
Other	10.3	45.8 (42.2, 49.4)	53.7 (50.1, 57.3)	0.52 (0.04, 1.00)
Sex				
Male	51.0	48.5 (47.0, 50.0)	51.1 (49.6, 52.6)	0.42 (0.26, 0.58)
Female	49.0	47.6 (46.1, 49.0)	51.9 (50.4, 53.4)	0.55 (0.30, 0.80)
Poverty Status				
Above Poverty	79.7	48.0 (46.8, 49.1)	51.5 (50.3, 52.7)	0.51 (0.33, 0.69)
Below Poverty	20.3	54.0 (51.3, 56.6)	45.7 (43.0, 48.4)	0.34 (0.15, 0.53)
Education Level of Mother				
Less than 12 years	12.3	53.0 (49.9, 56.1)	46.3 (43.2, 49.5)	0.68 (0.30, 1.05)
12 years	21.9	44.9 (42.4, 47.5)	54.3 (51.7, 56.9)	0.72 (0.22, 1.23)
More than 12 years, non-college graduate	24.2	47.7 (45.8, 49.7)	52.0 (50.0, 53.9)	0.30 (0.11, 0.49)
College graduate	41.7	48.4 (46.9, 50.0)	51.1 (49.6, 52.7)	0.42 (0.24, 0.60)

Table 13

Distributions of parental report for MenACWY vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all denied consent to provider data)

MEN_ANY stratified by different variables with LEV_B				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	41.9 (41.0, 42.8)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	48.7 (46.6, 50.9)	7.15 (6.16, 8.13)	44.1 (42.0, 46.3)
Midwest	21.2	49.3 (47.6, 51.0)	9.56 (8.50, 10.6)	41.1 (39.4, 42.8)
South	38.6	46.6 (45.1, 48.0)	11.4 (10.5, 12.4)	42.0 (40.6, 43.5)
West	24.0	48.9 (45.8, 51.9)	11.7 (9.74, 13.6)	39.5 (36.4, 42.5)
Age				
13 years	20.0	50.7 (48.3, 53.1)	10.3 (8.68, 12.0)	39.0 (36.7, 41.3)
14 years	20.1	47.5 (45.1, 49.8)	9.69 (8.32, 11.1)	42.8 (40.5, 45.2)
15 years	20.0	48.9 (46.7, 51.2)	11.0 (9.52, 12.4)	40.1 (38.0, 42.2)
16 years	19.8	47.8 (45.4, 50.2)	9.94 (8.70, 11.2)	42.2 (39.9, 44.6)
17 years	20.1	45.5 (43.2, 47.9)	11.0 (9.50, 12.4)	43.5 (41.2, 45.8)

Race/Ethnicity				
Hispanic	24.2	49.0 (46.4, 51.5)	16.2 (14.3, 18.1)	34.9 (32.5, 37.2)
Non-Hispanic white	52.0	49.4 (48.1, 50.7)	7.57 (6.93, 8.22)	43.0 (41.7, 44.3)
Non-Hispanic black	13.5	43.0 (40.2, 45.9)	12.2 (10.4, 13.9)	44.8 (41.9, 47.7)
Other	10.3	45.8 (42.2, 49.4)	9.41 (7.52, 11.3)	44.8 (41.2, 48.4)
Sex				
Male	51.0	48.5 (47.0, 50.0)	10.1 (9.24, 10.9)	41.4 (40.0, 42.9)
Female	49.0	47.6 (46.1, 49.0)	10.7 (9.71, 11.7)	41.8 (40.3, 43.2)
Poverty Status				
Above Poverty	79.7	48.0 (46.8, 49.1)	9.29 (8.62, 9.97)	42.7 (41.6, 43.9)
Below Poverty	20.3	54.0 (51.3, 56.6)	15.4 (13.4, 17.4)	30.6 (28.2, 33.0)
Education Level of Mother				
Less than 12 years	12.3	53.0 (49.9, 56.1)	18.9 (16.4, 21.4)	28.1 (25.3, 30.9)
12 years	21.9	44.9 (42.4, 47.5)	11.7 (10.2, 13.3)	43.3 (40.8, 45.9)
More than 12 years, non-college graduate	24.2	47.7 (45.8, 49.7)	9.46 (8.26, 10.7)	42.8 (40.8, 44.8)
College graduate	41.7	48.4 (46.9, 50.0)	8.04 (7.18, 8.91)	43.5 (42.0, 45.0)

Table 14

Distributions of provider report for MenACWY vaccine in NIS-Teen 2018

P_UTDMEN stratified by different variables				
	Weighted percentage distribution (%)	UTD	Not UTD	Percentage of UTD from provider report MEN vaccine
		n	n	w% (95% CI)
Region				
Northeast	16.2	3197	240	94.3 (93.1, 95.5)
Midwest	21.2	3585	509	88.7 (87.4, 89.9)
South	38.6	6121	1063	84.5 (83.2, 85.9)
West	24.0	3218	767	85.4 (82.7, 88.1)
Age				
13 years	20.0	3305	547	86.9 (84.9, 88.8)
14 years	20.1	3337	538	86.8 (84.8, 88.8)
15 years	20.0	3249	492	87.1 (84.9, 89.3)
16 years	19.8	3240	511	86.7 (84.5, 88.8)
17 years	20.1	2990	491	88.6 (87.0, 90.3)

Race/Ethnicity				
Hispanic	24.2	3563	459	88.3 (86.1, 90.5)
Non-Hispanic white	52.0	9492	1636	86.7 (85.6, 87.7)
Non-Hispanic black	13.5	1292	195	87.4 (85.0, 89.7)
Other	10.3	1774	289	87.2 (84.2, 90.3)
Sex				
Male	51.0	8405	1367	87.2 (86.0, 88.4)
Female	49.0	7716	1212	87.2 (85.9, 88.6)
Poverty Status				
Above Poverty	79.7	12669	2047	87.2 (86.3, 88.2)
Below Poverty	20.3	2880	447	87.0 (84.8, 89.2)
Education Level of Mother				
Less than 12 years	12.3	2046	320	87.3 (84.9, 89.8)
12 years	21.9	2469	460	85.3 (82.9, 87.7)
More than 12 years, non-college graduate	24.2	3911	809	85.6 (84.0, 87.1)
College graduate	41.7	7695	990	89.1 (87.8, 90.4)

Table 15

Distributions of concordance and discordance for MenACWY vaccine in NIS-Teen 2018

MEN Concordance & Discordance by different variables (MEN_ANY vs. P_UTDMEN)					
	Weighted percentage distribution (%)	Agreement of parent and provider report for MEN vaccine	Disagreement of parent and provider report for MEN vaccine (% Over-reporting)	Disagreement of parent and provider report for MEN vaccine (% Under-reporting)	Missing
		w% (95% CI)	w% (95% CI)	w% (95% CI)	n
Region					
Northeast	16.2	80.5 (77.9, 83.0)	3.53 (2.51, 4.55)	16.0 (13.6, 18.4)	795
Midwest	21.2	78.1 (76.1, 80.0)	6.02 (4.94, 7.09)	15.9 (14.2, 17.7)	1019
South	38.6	74.5 (72.7, 76.3)	9.08 (7.88, 10.3)	16.4 (14.9, 18.0)	1728
West	24.0	77.6 (74.2, 81.1)	8.20 (5.89, 10.5)	14.2 (11.4, 16.9)	1043
Age					
13 years	20.0	77.3 (74.5, 80.1)	7.79 (5.90, 9.68)	14.9 (12.7, 17.1)	1038
14 years	20.1	75.2 (72.4, 78.0)	7.59 (6.03, 9.16)	17.2 (14.6, 19.8)	1023
15 years	20.0	71.7 (68.6, 74.9)	7.86 (5.74, 9.97)	20.4 (17.6, 23.2)	901
16 years	19.8	78.0 (75.6, 80.4)	7.09 (5.66, 8.52)	14.9 (13.0, 16.9)	896
17 years	20.1	82.7 (80.5, 84.9)	6.11 (4.82, 7.40)	11.2 (9.33, 13.0)	727
Race/Ethnicity					
Hispanic	24.2	76.1 (73.0, 79.2)	7.76 (5.93, 9.58)	16.2 (13.5, 18.9)	1115
Non-Hispanic white	52.0	77.2 (75.8, 78.7)	6.87 (5.98, 7.77)	15.9 (14.7, 17.1)	2624

Non-Hispanic black	13.5	75.3 (71.6, 79.0)	7.68 (5.47, 9.88)	17.0 (13.8, 20.3)	304
Other	10.3	80.1 (76.4, 83.9)	7.79 (4.95, 10.6)	12.1 (9.38, 14.8)	542
Sex					
Male	51.0	79.3 (77.8, 80.9)	6.84 (5.96, 7.73)	13.8 (12.5, 15.2)	2378
Female	49.0	74.5 (72.6, 76.4)	7.75 (6.51, 9.00)	17.7 (16.1, 19.3)	2207
Poverty Status					
Above Poverty	79.7	77.0 (75.6, 78.3)	7.13 (6.27, 7.99)	15.9 (14.7, 17.0)	3456
Below Poverty	20.3	75.1 (71.9, 78.3)	8.19 (6.34, 10.0)	16.7 (13.9, 19.6)	935
Education Level of Mother					
Less than 12 years	12.3	74.8 (70.8, 78.9)	8.05 (5.60, 10.5)	17.1 (13.6, 20.7)	759
12 years	21.9	75.7 (72.6, 78.8)	7.94 (6.02, 9.86)	16.3 (13.7, 19.0)	791
More than 12 years, non-college graduate	24.2	75.5 (73.3, 77.8)	8.49 (7.11, 9.86)	16.0 (14.1, 17.9)	1064
College graduate	41.7	79.0 (77.2, 80.7)	6.08 (4.97, 7.19)	14.9 (13.5, 16.4)	1971

Table 16

Bivariate and Multivariate Analysis of over- and under-reporting of MenACWY

Bivariate and Multivariate Poisson regression analysis to estimate Prevalence Ratio of over- and under-reporting by sociodemographic variables (MenACWY)				
	Over-report Bivariate Analysis	Over-report Multivariate Analysis	Under-report Bivariate Analysis	Under-report Multivariate Analysis
	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)
Region				
Northeast	0.38 (0.28, 0.52)	0.39 (0.28, 0.53)	0.93 (0.78, 1.11)	0.95 (0.80, 1.13)
Midwest	0.66 (0.53, 0.82)	0.66 (0.53, 0.83)	0.94 (0.82, 1.09)	0.95 (0.83, 1.10)
South	Referent	Referent	Referent	Referent
West	0.89 (0.66, 1.20)	0.89 (0.67, 1.19)	0.85 (0.69, 1.04)	0.88 (0.72, 1.07)
Age				
13 years	1.34 (0.98, 1.83)	1.30 (0.96, 1.78)	1.37 (1.10, 1.71)	1.35 (1.08, 1.68)
14 years	1.23 (0.92, 1.65)	1.20 (0.89, 1.62)	1.57 (1.26, 1.95)	1.55 (1.25, 1.93)
15 years	1.39 (0.98, 1.96)	1.37 (0.98, 1.93)	1.83 (1.48, 2.25)	1.81 (1.47, 2.24)
16 years	1.16 (0.87, 1.55)	1.13 (0.84, 1.51)	1.31 (1.06, 1.62)	1.31 (1.06, 1.62)
17 years	Referent	Referent	Referent	Referent

Race/Ethnicity				
Hispanic	1.16 (0.89, 1.52)	0.98 (0.74, 1.30)	0.98 (0.82, 1.17)	0.98 (0.81, 1.17)
Non-Hispanic white	Referent	Referent	Referent	Referent
Non-Hispanic black	1.17 (0.85, 1.59)	1.02 (0.74, 1.40)	1.12 (0.91, 1.37)	1.10 (0.90, 1.35)
Other	1.14 (0.79, 1.64)	1.13 (0.79, 1.62)	0.80 (0.64, 1.01)	0.83 (0.66, 1.04)
Sex				
Male	0.82 (0.67, 1.00)	0.82 (0.67, 1.00)	0.78 (0.68, 0.88)	0.79 (0.69, 0.89)
Female	Referent	Referent	Referent	Referent
Poverty Status				
Above Poverty	Referent	Referent	Referent	Referent
Below Poverty	1.21 (0.94, 1.55)	1.08 (0.79, 1.48)	1.04 (0.87, 1.23)	0.99 (0.82, 1.19)
Education Level of Mother				
Less than 12 years	1.35 (0.96, 1.90)	1.27 (0.82, 1.98)	1.10 (0.88, 1.37)	1.11 (0.87, 1.41)
12 years	1.27 (0.94, 1.72)	1.22 (0.86, 1.72)	1.05 (0.87, 1.26)	1.05 (0.87, 1.27)
More than 12 years, non-college graduate	1.43 (1.12, 1.82)	1.38 (1.08, 1.77)	1.10 (0.95, 1.28)	1.09 (0.94, 1.28)
College graduate	Referent	Referent	Referent	Referent

Table 17

Distributions of parental report for Tdap vaccine in NIS-Teen 2018

TET_ANY stratified by different variables with LEV					
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)	Inadequate with missing consent (lev 4)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	0.53 (0.39, 0.68)	41.4 (40.5, 42.3)
		w% (95% CI)	w% (95% CI)	w% (95% CI)	w% (95% CI)
Region					
Northeast	16.2	47.9 (45.9, 49.8)	7.31 (6.37, 8.24)	0.30 (0.12, 0.48)	44.5 (42.5, 46.5)
Midwest	21.2	49.7 (48.1, 51.2)	9.26 (8.35, 10.2)	0.31 (0.13, 0.49)	40.7 (39.2, 42.3)
South	38.6	46.7 (45.4, 48.0)	11.1 (10.3, 11.9)	0.60 (0.38, 0.82)	41.6 (40.3, 42.9)
West	24.0	49.6 (46.8, 52.3)	11.5 (9.75, 13.3)	0.67 (0.17, 1.16)	38.2 (35.6, 40.9)

Age					
13 years	20.0	50.6 (48.4, 52.7)	10.2 (8.79, 11.6)	0.37 (0.11, 0.63)	38.9 (36.8, 40.9)
14 years	20.1	48.0 (45.9, 50.1)	9.41 (8.09, 10.7)	0.77 (0.32, 1.21)	41.8 (39.7, 43.9)
15 years	20.0	48.9 (46.8, 51.0)	10.5 (9.24, 11.8)	0.57 (0.25, 0.89)	40.0 (38.0, 42.0)
16 years	19.8	47.6 (45.4, 49.7)	9.70 (8.56, 10.8)	0.48 (0.04, 0.93)	42.3 (40.1, 44.4)
17 years	20.1	46.1 (43.9, 48.2)	11.2 (9.77, 12.6)	0.09 (0.16, 0.52)	42.4 (40.2, 42.5)
Race/Ethnicity					
Hispanic	24.2	49.3 (46.9, 51.7)	15.7 (13.9, 17.5)	0.72 (0.23, 1.21)	34.3 (32.0, 36.5)
Non-Hispanic white	52.0	49.5 (48.3, 50.6)	7.47 (6.88, 8.06)	0.36 (0.24, 0.49)	42.7 (41.6, 43.8)
Non-Hispanic black	13.5	43.2 (40.5, 45.9)	12.1 (10.4, 13.7)	0.61 (0.23, 0.99)	44.1 (41.4, 46.8)
Other	10.3	45.8 (42.6, 49.0)	9.43 (7.71, 11.2)	0.63 (0.06, 1.20)	44.1 (40.9, 47.3)
Sex					
Male	51.0	48.6 (47.2, 49.9)	9.85 (9.08, 10.6)	0.47 (0.30, 0.64)	41.1 (39.8, 42.4)
Female	49.0	47.8 (46.5, 49.2)	10.6 (9.68, 11.5)	0.55 (0.29, 0.81)	41.0 (39.7, 42.3)
Poverty Status					
Above Poverty	79.7	48.3 (47.2, 49.4)	9.09 (8.47, 9.72)	0.56 (0.36, 0.75)	42.1 (41.0, 43.1)
Below Poverty	20.3	53.8 (51.3, 56.3)	15.5 (13.7, 17.3)	0.27 (0.12, 0.42)	30.4 (28.1, 32.7)
Education Level of Mother					
Less than 12 years	12.3	52.6 (49.8, 55.4)	18.0 (15.9, 20.1)	0.60 (0.21, 0.98)	28.9 (26.3, 31.4)
12 years	21.9	45.8 (43.4, 48.2)	11.9 (10.4, 13.4)	0.85 (0.29, 1.40)	41.4 (39.1, 43.7)
More than 12 years, non-college graduate	24.2	47.8 (45.9, 49.7)	9.37 (8.20, 10.5)	0.35 (0.16, 0.53)	42.4 (40.6, 44.3)
College graduate	41.7	48.5 (47.1, 49.9)	7.81 (7.04, 8.57)	0.40 (0.23, 0.58)	43.3 (42.0, 44.6)

Table 18

Distributions of parental report for Tdap vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all gave consent to provider data)

TET_ANY stratified by different variables with LEV_A				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	52.0 (51.1, 52.9)	0.53 (0.39, 0.68)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	47.9 (45.9, 49.8)	51.8 (49.8, 53.8)	0.30 (0.12, 0.48)
Midwest	21.2	49.7 (48.1, 51.2)	50.0 (48.5, 51.5)	0.31 (0.13, 0.49)
South	38.6	46.7 (45.4, 48.0)	52.7 (51.4, 54.0)	0.60 (0.38, 0.82)
West	24.0	49.6 (46.8, 52.3)	49.8 (47.0, 52.6)	0.67 (0.17, 1.16)
Age				
13 years	20.0	50.6 (48.4, 52.7)	49.1 (46.9, 51.2)	0.37 (0.11, 0.63)
14 years	20.1	48.0 (45.9, 50.1)	51.2 (49.1, 53.3)	0.77 (0.32, 1.21)
15 years	20.0	48.9 (46.8, 51.0)	50.5 (48.4, 52.6)	0.57 (0.25, 0.89)
16 years	19.8	47.6 (45.4, 49.7)	52.0 (49.8, 54.1)	0.48 (0.04, 0.93)
17 years	20.1	46.1 (43.9, 48.2)	53.6 (51.4, 55.8)	0.09 (0.16, 0.52)
Race/Ethnicity				
Hispanic	24.2	49.3 (46.9, 51.7)	50.0 (47.6, 52.3)	0.72 (0.23, 1.21)
Non-Hispanic white	52.0	49.5 (48.3, 50.6)	50.2 (49.0, 51.3)	0.36 (0.24, 0.49)
Non-Hispanic black	13.5	43.2 (40.5, 45.9)	56.2 (53.5, 58.9)	0.61 (0.23, 0.99)
Other	10.3	45.8 (42.6, 49.0)	53.6 (50.4, 56.7)	0.63 (0.06, 1.20)
Sex				
Male	51.0	48.6 (47.2, 49.9)	51.0 (49.6, 52.3)	0.47 (0.30, 0.64)
Female	49.0	47.8 (46.5, 49.2)	51.6 (50.2, 53.0)	0.55 (0.29, 0.81)
Poverty Status				
Above Poverty	79.7	48.3 (47.2, 49.4)	51.2 (50.1, 52.2)	0.56 (0.36, 0.75)
Below Poverty	20.3	53.8 (51.3, 56.3)	45.9 (43.4, 48.4)	0.27 (0.12, 0.42)
Education Level of Mother				
Less than 12 years	12.3	52.6 (49.8, 55.4)	46.8 (44.0, 49.6)	0.60 (0.21, 0.98)
12 years	21.9	45.8 (43.4, 48.2)	53.3 (50.9, 55.7)	0.85 (0.29, 1.40)
More than 12 years, non-	24.2	47.8 (45.9, 49.7)	51.8 (49.9, 53.7)	0.35 (0.16, 0.53)

college graduate				
College graduate	41.7	48.5 (47.1, 49.9)	51.1 (49.7, 52.5)	0.40 (0.23, 0.58)

Table 19

Distributions of parental report for Tdap vaccine in NIS-Teen 2018 (Hypothetical scenario: people with missing consent all denied consent to provider data)

TET_ANY stratified by different variables with LEV_B				
	Weighted percentage distribution (%)	Adequate (lev 1)	Inadequate with consent (lev 2)	Inadequate without consent (lev 3)
		% of lev (95% CI)	% of lev (95% CI)	% of lev (95% CI)
		47.5 (46.5, 48.4)	10.6 (10.0, 11.2)	41.9 (41.0, 42.8)
		w% (95% CI)	w% (95% CI)	w% (95% CI)
Region				
Northeast	16.2	47.9 (45.9, 49.8)	7.31 (6.37, 8.24)	44.8 (42.8, 46.8)
Midwest	21.2	49.7 (48.1, 51.2)	9.26 (8.35, 10.2)	41.1 (39.5, 42.6)
South	38.6	46.7 (45.4, 48.0)	11.1 (10.3, 11.9)	42.2 (40.9, 43.5)
West	24.0	49.6 (46.8, 52.3)	11.5 (9.75, 13.3)	38.9 (36.2, 41.6)
Age				
13 years	20.0	50.6 (48.4, 52.7)	10.2 (8.79, 11.6)	39.2 (37.2, 41.3)
14 years	20.1	48.0 (45.9, 50.1)	9.41 (8.09, 10.7)	42.6 (40.5, 44.6)
15 years	20.0	48.9 (46.8, 51.0)	10.5 (9.24, 11.8)	40.6 (38.6, 42.6)
16 years	19.8	47.6 (45.4, 49.7)	9.70 (8.56, 10.8)	42.7 (40.6, 44.9)
17 years	20.1	46.1 (43.9, 48.2)	11.2 (9.77, 12.6)	42.7 (40.6, 44.9)
Race/Ethnicity				
Hispanic	24.2	49.3 (46.9, 51.7)	15.7 (13.9, 17.5)	35.0 (32.7, 37.2)
Non-Hispanic white	52.0	49.5 (48.3, 50.6)	7.47 (6.88, 8.06)	43.1 (41.9, 44.2)
Non-Hispanic black	13.5	43.2 (40.5, 45.9)	12.1 (10.4, 13.7)	44.7 (42.0, 47.4)
Other	10.3	45.8 (42.6, 49.0)	9.43 (7.71, 11.2)	44.7 (41.6, 47.9)
Sex				
Male	51.0	48.6 (47.2, 49.9)	9.85 (9.08, 10.6)	41.6 (40.3, 42.9)
Female	49.0	47.8 (46.5, 49.2)	10.6 (9.68, 11.5)	41.6 (40.2, 42.9)
Poverty Status				
Above Poverty	79.7	48.3 (47.2, 49.4)	9.09 (8.47, 9.72)	42.6 (41.6, 43.7)
Below Poverty	20.3	53.8 (51.3, 56.3)	15.5 (13.7, 17.3)	30.7 (28.4, 33.0)

Education Level of Mother				
Less than 12 years	12.3	52.6 (49.8, 55.4)	18.0 (15.9, 20.1)	29.5 (26.9, 32.0)
12 years	21.9	45.8 (43.4, 48.2)	11.9 (10.4, 13.4)	42.3 (39.9, 44.6)
More than 12 years, non-college graduate	24.2	47.8 (45.9, 49.7)	9.37 (8.20, 10.5)	42.8 (40.9, 44.7)
College graduate	41.7	48.5 (47.1, 49.9)	7.81 (7.04, 8.57)	43.7 (42.4, 45.1)

Table 20

Distributions of provider report for Tdap vaccine in NIS-Teen 2018

P_UTDTDAP stratified by different variables				
	Weighted percentage distribution (%)	UTD	Not UTD	Percentage of UTD from provider report Tdap vaccine
		n	n	w% (95% CI)
Region				
Northeast	16.2	3151	286	91.1 (89.5, 92.7)
Midwest	21.2	3666	428	89.7 (88.4, 90.9)
South	38.6	6308	876	88.3 (87.1, 89.4)
West	24.0	3429	556	87.7 (85.3, 90.2)
Age				
13 years	20.0	3368	484	87.1 (85.1, 89.2)
14 years	20.1	3415	460	87.7 (85.5, 89.8)
15 years	20.0	3340	401	89.7 (87.9, 91.5)
16 years	19.8	3318	433	89.0 (87.2, 90.8)
17 years	20.1	3113	368	91.0 (89.6, 92.5)
Race/Ethnicity				
Hispanic	24.2	3508	514	87.7 (85.6, 89.9)
Non-Hispanic white	52.0	9937	1191	89.7 (88.7, 90.6)
Non-Hispanic black	13.5	1300	187	88.4 (86.1, 90.7)
Other	10.3	1809	254	88.2 (85.4, 91.0)
Sex				
Male	51.0	8648	1124	89.0 (87.9, 90.1)
Female	49.0	7906	1022	88.8 (87.5, 90.1)
Poverty Status				
Above Poverty	79.7	13087	1629	89.2 (88.3, 90.2)
Below Poverty	20.3	2895	432	87.5 (85.5, 89.5)

Education Level of Mother				
Less than 12 years	12.3	2034	332	87.6 (85.6, 89.6)
12 years	21.9	2536	393	87.5 (85.4, 89.7)
More than 12 years, non-college graduate	24.2	4116	604	87.9 (86.4, 89.5)
College graduate	41.7	7868	817	90.5 (89.3, 91.7)

Table 21

Distributions of concordance and discordance for Tdap vaccine in NIS-Teen 2018

Tdap Concordance & Discordance by different variables (TET_ANY vs. P_UTDTDAP)					
	Weighted percentage distribution (%)	Agreement of parent and provider report for Tdap vaccine	Disagreement of parent and provider report for Tdap vaccine (% Over-reporting)	Disagreement of parent and provider report for Tdap vaccine (% Under-reporting)	Missing
		w% (95% CI)	w% (95% CI)	w% (95% CI)	n
Region					
Northeast	16.2	88.0 (86.0, 90.1)	8.24 (6.60, 9.88)	3.72 (2.42, 5.03)	244
Midwest	21.2	87.3 (85.8, 88.7)	9.07 (7.80, 10.3)	3.66 (2.83, 4.49)	277
South	38.6	85.3 (83.9, 86.6)	10.6 (9.38, 11.7)	4.19 (3.40, 4.97)	542
West	24.0	87.0 (84.4, 89.6)	10.9 (8.44, 13.4)	2.10 (1.27, 2.93)	281
Age					
13 years	20.0	85.4 (83.2, 87.7)	12.1 (10.0, 14.3)	2.41 (1.72, 3.10)	302
14 years	20.1	86.8 (84.5, 89.1)	10.8 (8.54, 13.0)	2.41 (1.68, 3.14)	267
15 years	20.0	86.8 (84.7, 88.9)	8.85 (7.04, 10.7)	4.37 (3.17, 5.58)	284
16 years	19.8	85.8 (83.8, 87.7)	9.95 (8.32, 11.6)	4.26 (3.12, 5.40)	277
17 years	20.1	88.0 (86.2, 89.8)	8.00 (6.59, 9.42)	4.02 (2.82, 5.21)	214
Race/Ethnicity					
Hispanic	24.2	83.9 (81.5, 86.4)	11.3 (8.99, 13.6)	4.78 (3.70, 5.87)	450
Non-Hispanic white	52.0	88.5 (87.4, 89.6)	9.28 (8.32, 10.2)	2.22 (1.74, 2.71)	576
Non-Hispanic black	13.5	83.2 (80.4, 86.1)	10.6 (8.25, 13.0)	6.16 (4.33, 7.99)	114
Other	10.3	86.9 (84.3, 89.5)	9.53 (7.24, 11.8)	3.58 (2.31, 4.86)	204
Sex					
Male	51.0	86.8 (85.6, 88.0)	9.72 (8.68, 10.8)	3.49 (2.82, 4.16)	670
Female	49.0	86.3 (84.9, 87.7)	10.2 (8.87, 11.5)	3.50 (2.89, 4.12)	674
Poverty Status					
Above Poverty	79.7	87.2 (86.2, 88.3)	9.91 (8.96, 10.9)	2.85 (2.40, 3.30)	862

Below Poverty	20.3	83.4 (81.0, 85.9)	10.7 (8.58, 12.8)	5.88 (4.39, 7.36)	390
Education Level of Mother					
Less than 12 years	12.3	80.8 (77.9, 83.7)	11.0 (8.93, 13.2)	8.17 (6.07, 10.3)	358
12 years	21.9	83.8 (81.2, 86.4)	11.1 (8.81, 13.4)	5.09 (3.80, 6.38)	262
More than 12 years, non-college graduate	24.2	86.0 (84.3, 87.8)	10.8 (9.22, 12.4)	3.15 (2.32, 3.98)	265
College graduate	41.7	89.7 (88.5, 91.0)	8.58 (7.42, 9.75)	1.67 (1.26, 2.09)	459

Table 22

Bivariate and Multivariate Analysis of over- and under-reporting of Tdap

Bivariate and Multivariate Poisson regression analysis to estimate Prevalence Ratio of over- and under-reporting by sociodemographic variables (Tdap)				
	Over-report Bivariate Analysis	Over-report Multivariate Analysis	Under-report Bivariate Analysis	Under-report Multivariate Analysis
	PR (95% CI)	aPR (95% CI)	PR (95% CI)	aPR (95% CI)
Region				
Northeast	0.76 (0.61, 0.96)	0.79 (0.63, 0.99)	0.90 (0.61, 1.35)	1.04 (0.70, 1.54)
Midwest	0.84 (0.70, 1.00)	0.87 (0.72, 1.04)	0.95 (0.71, 1.27)	1.12 (0.83, 1.51)
South	Referent	Referent	Referent	Referent
West	0.96 (0.74, 1.25)	0.94 (0.74, 1.21)	0.51 (0.32, 0.82)	0.51 (0.32, 0.80)
Age				
13 years	1.46 (1.15, 1.86)	1.45 (1.14, 1.85)	0.63 (0.41, 0.96)	0.63 (0.41, 0.96)
14 years	1.26 (0.96, 1.65)	1.24 (0.95, 1.61)	0.64 (0.41, 0.99)	0.61 (0.40, 0.95)
15 years	1.13 (0.85, 1.50)	1.12 (0.85, 1.49)	1.00 (0.66, 1.50)	1.01 (0.67, 1.52)
16 years	1.21 (0.96, 1.53)	1.20 (0.95, 1.52)	1.10 (0.73, 1.66)	1.09 (0.73, 1.63)
17 years	Referent	Referent	Referent	Referent
Race/Ethnicity				
Hispanic	1.30 (1.03, 1.64)	1.17 (0.91, 1.50)	2.29 (1.66, 3.16)	1.59 (1.16, 2.18)
Non-Hispanic white	Referent	Referent	Referent	Referent
Non-Hispanic black	1.22 (0.95, 1.55)	1.14 (0.88, 1.47)	2.85 (1.98, 4.09)	2.17 (1.49, 3.17)
Other	1.12 (0.86, 1.45)	1.12 (0.87, 1.45)	1.60 (1.07, 2.39)	1.63 (1.09, 2.42)
Sex				
Male	0.91 (0.77, 1.07)	0.91 (0.77, 1.07)	0.96 (0.74, 1.25)	0.94 (0.72, 1.21)

Female	Referent	Referent	Referent	Referent
Poverty Status				
Above Poverty	Referent	Referent	Referent	Referent
Below Poverty	1.17 (0.95, 1.45)	0.97 (0.77, 1.23)	2.12 (1.59, 2.83)	1.08 (0.80, 1.47)
Education Level of Mother				
Less than 12 years	1.39 (1.11, 1.76)	1.30 (0.96, 1.76)	5.35 (3.75, 7.63)	4.42 (2.98, 6.56)
12 years	1.39 (1.07, 1.80)	1.35 (1.04, 1.75)	3.25 (2.29, 4.63)	2.84 (1.98, 4.07)
More than 12 years, non-college graduate	1.27 (1.05, 1.54)	1.24 (1.01, 1.52)	1.87 (1.31, 2.66)	1.72 (1.20, 2.47)
College graduate	Referent	Referent	Referent	Referent

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