Statistical Methodology of the National Immunization Survey, 2005–2014

Programs and Collection Procedures

Vital and Health Statistics

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Abstract

Objectives

The National Immunization Survey (NIS) family of surveys includes NIS–Child, which monitors vaccination coverage for the U.S. population of children aged 19–35 months; NIS–Teen, which monitors vaccination coverage for the U.S. population of adolescents aged 13–17; and NIS–Flu, which monitors influenza vaccination coverage for the U.S. population of children aged 6 months through 17 years. This report describes the methods used in this family of surveys during the 2005–2014 period.

Methods

NIS–Child and NIS–Teen collect data throughout the year in two phases: a telephone survey to identify households with age-eligible children and adolescents, followed by a mail survey to vaccination providers to obtain vaccination histories for the children and adolescents for whom parental consent was obtained to contact providers. The household interview is conducted for all children aged 19–35 months in the household. A random subsample of the telephone numbers is selected for NIS–Teen, and following the household interview for children (if any), the NIS–Teen interview is conducted for one randomly selected adolescent in the household. NIS–Flu collects data throughout the influenza season (October–June) and combines the household responses to influenza vaccination questions from NIS–Child, NIS–Teen, and a short instrument administered for children aged 6–18 months and 3–12 years screened in the same sample of telephone numbers.

Results

During 2005–2014, NIS–Child and NIS–Teen conducted household interviews by telephone for 255,644 children and 250,330 adolescents. From the 2010–2011 through the 2014–2015 flu seasons, NIS–Flu obtained information on 559,788 children.

Keywords: dual-frame design • survey weighting • vaccination coverage rates • total survey error

Statistical Methodology of the National Immunization Survey, 2005–2014

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Introduction

The history of surveillance of vaccination coverage in the United States (1) includes the 1921 Hagerstown Morbidity Study (2), the 1928–1931 U.S. Morbidity Study (3), the 1936 U.S. Public Health Service Study (1), and the 1943 national survey of public attitudes toward immunizations (4). A resurgence of polio in the early 1950s led to the United States Immunization Survey, which was conducted annually from 1957 through 1985 as a supplement to the Current Population Survey (5,6). After a hiatus in vaccination coverage assessment from 1986 through 1991 and a resurgence of measles (7,8), the Childhood Immunization Initiative (9) was established in 1992 to improve the delivery of vaccines to children; reduce the cost of vaccines for parents; enhance awareness, partnerships, and community participation; improve vaccinations and their use; and monitor vaccination coverage rates and occurrences of disease.

To fulfill the Childhood Immunization Initiative mandate to monitor vaccination coverage and track progress toward achieving its goals, National Immunization Survey–Child (NIS–Child) was implemented by the National Immunization Program (the agency changed its name to the National Center for Immunization and Respiratory Diseases [NCIRD] in 2006) in partnership with the National Center for Health Statistics (NCHS) starting in 1994. NIS–Teen was launched in late 2006. Beginning in 2015, the implementation of the National Immunization Surveys (NIS), the family of surveys that started with NIS–Child, was transferred entirely to NCIRD.

The Centers for Disease Control and Prevention (CDC) has used estimates of vaccination coverage from NIS to monitor vaccine uptake to allocate resources to state and selected immunization programs, in accordance with Section 317 of the Public Health Services Act (10) to conduct authorized activities to increase vaccination coverage, identify under-vaccinated subpopulations, and conduct epidemiologic research to help increase vaccination coverage. CDC has used data from NIS to monitor Healthy People objectives for 2000 (https://www.cdc.gov/nchs/data/statnt/statnt11.pdf), 2010 (https://wonder.cdc.gov/data2010/FOCUS.HTM), and 2020 (https://www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases).

NIS–Child

From its beginning, the target population of NIS–Child has been children aged 19–35 months living in households in the United States. The official vaccination coverage estimates reported from NIS–Child are the proportions of children fully vaccinated with the number of doses according to

the recommended vaccination schedule (11,12). The recommended vaccines that were monitored in the 2014 NIS–Child are presented in Table 1, and a copy of the recommended vaccination schedule for 2014, including the timing of the doses of each vaccine, is shown in Appendix I. (The recommended vaccination schedule can change over time. Visit the Advisory Committee on Immunization Practices website at: https://www.cdc.gov/vaccines/acip.) In addition to individual vaccines, interest in NIS–Child has focused on various vaccine series, ranging from the 4:3:1 series (see Appendix II for definition) to the 4:3:1:H:3:1:3 (with routine Hib) series used to monitor progress toward a Healthy People 2020 objective.

CDC publishes NIS–Child vaccination coverage estimates annually for the country, states, select cities, and U.S. territories (13,14). NCHS released annual microdata files to the public (15) (https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html) from 1995 through 2014.

The NIS–Child sample was designed to be large enough to produce precise estimates of vaccination coverage in 56 geographic (or estimation) areas. These areas include 6 urban areas that receive Section 317 immunization grant funding directly from CDC (Bexar County, Tex.; City of Chicago; City of Houston; City of New York; the District of Columbia; and Philadelphia County, Pa.); 4 rest-of-state areas (rest of Illinois, rest of New York, rest of Pennsylvania, and rest of Texas); and the remaining 46 whole states. The design has been flexible with the capacity to be expanded to support precise estimation for additional local areas and U.S. affiliated jurisdictions; the additional areas have varied from year to year. By using very similar survey designs, questionnaires, data-collection protocols, and statistical estimation procedures in all areas and from year to year, NIS–Child was designed to produce vaccination statistics that are comparable across geographic areas and across time, with little or no bias attributable to changing methodology.

NIS–Teen

Before 2005, vaccines were administered to adolescents on a "catch up" basis, meaning vaccinations were provided to teenagers who did not receive them at the recommended age. During 2005 and 2006, three new vaccines were licensed in the United States and recommended for adolescents, including meningococcal conjugate vaccine (MenACWY); tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine (Tdap); and human papillomavirus vaccine (HPV) (16,17). In response, systematic surveillance of the vaccination status of U.S. teenagers was instituted through NIS–Teen, which was launched in Q4/2006 (in this report, Q4 signifies the fourth quarter [October, November, and December] of the year 2006) and Q4/2007 as national samples and continuously starting in 2008 with state and selected local area samples (18). NIS–Teen's target population is adolescents aged 13–17 living in U.S. households at the time of the interview. The official vaccination coverage estimates reported from NIS–Teen (19) are rates of being up to date (UTD) with respect to the numbers of doses of recommended and catch-up vaccines. Table 2 presents the recommended vaccines that were monitored in the 2014 NIS–Teen, and the recommended immunization schedule for 2014 and the timing of these doses appears in Appendix I.

Starting in 2008, the NIS–Teen sample was designed to be large enough to support precise annual estimation of vaccination coverage rates for the same 56 geographic areas used in the survey of children aged 19–35 months. It was also designed to support additional local areas and territories, although the additional areas may vary from year to year and may not be exactly the same additional areas used for the survey of children.

Outline of the Report

This NCHS Vital and Health Statistics Series 1 report describes the methodology used in the NIS family from 2005 through 2014. For brevity, this report illustrates survey outcomes for 1 year, using 2013 as the focal year. Previous NCHS reports (20,21) discussed the methodology used to obtain offical estimates of vaccination coverage between 1994 and 2002. During the period of the current report, NORC at the University of Chicago has been the data-collection contractor.

"Sampling Design, Questionnaire, and Response Rates" describes the sampling design of NIS–Child, the survey questionnaires, and the survey response rates. As in the 1994–2004 survey years, the 2005–2014 surveys are based on a two-phase sampling design in which the first phase of data collection involves a random-digit-dialing (RDD) telephone survey within each of its statistical sampling strata to identify households in which one or more age-eligible children (aged 19–35 months) reside. Among households with age-eligible children, an interview is conducted and sociodemographic data are collected about the children, the mother of the children, and the household. At the end of the telephone interview, the interviewers request consent to contact the vaccination providers of the age-eligible children and providers' contact information. In the second phase of data collection, a mail survey is sent to the vaccination providers of the children identified in the first phase to collect provider-reported vaccination histories for the children for whom consent was obtained.

During the past decade, an increasing number of young families have foregone use of a home (or landline) telephone and opted to have only a cellular (also known as "cell") phone. In this report, these families are classified as having a cell-phone-only (CPO) telephone status. This shift away from landline telephones is one of the biggest changes to the survey's environment since the beginning of NIS–Child (22,23). This change has meant that an increasing number of children in the population are not included in a single-frame, landline RDD telephone survey. In response, CDC and NORC at the University of Chicago conducted considerable research to study potential bias arising from the under-representativeness of the landline RDD survey and to formulate

methods of design and estimation to limit any sample-frame noncoverage bias. Beginning in Q4/2010 and continuing through 2014, NIS–Child has included not only the landline RDD sample but a nationally representative RDD sample of cell-phone numbers. Official vaccination statistics for 2010, however, were based only on the landline RDD sample. For 2011 through 2014, official vaccination statistics were based on the combined dual-frame sample (24).

The cell-phone samples used in 2010 and 2011 were relatively small national samples. Beginning in 2012 and continuing through 2014, much larger samples of cell-phone subscribers were included to support estimation for the previously mentioned states, local areas, and territories, optimally allocating the survey resources to the landline and cell-phone RDD frames. This allocation minimized the cost of data-collection operations while achieving a specified constraint on the sampling variance of the estimated vaccination coverage rate within estimation areas (25). The growing under-representativeness of the landline RDD survey and its effects are described.

Methods of estimation for the 2005–2014 NIS–Child are described in "Estimation Methodology for NIS–Child." This section traces the evolution of estimation methods used as the survey transitioned from a single-frame design, to a dual-frame design featuring a relatively small national cell-phone RDD sample, to a dual-frame design that included a large cell-phone RDD sample and optimum allocation of the overall survey resources between the two sampling frames.

"NIS–Teen" focuses on the methodology of the survey of adolescents, which is based on subsamples of the RDD samples of telephone numbers selected for NIS–Child. NIS–Teen also screens for presence of age-eligible adolescents and conducts household interviews about the adolescents following completion of all NIS–Child interviewing for the household. The material in this section refers to earlier sections of the report whenever the NIS–Teen method is similar to the corresponding NIS–Child

method, and otherwise describes any differences between the NIS–Child and NIS–Teen methods. For 2010 and prior years, the official vaccination statistics were based on the landline RDD samples; for 2011–2014, the official statistics were based on the combined dual-frame RDD samples (26).

Special questionnaires, which are administered either once or periodically, are discussed in "Topical Modules." The topical modules administered as part of the NIS–Child household interviews included the Health Insurance Module, the Parental Concerns Module, and the Socioeconomic Status Module. The topical modules administered in NIS–Teen included the Health Insurance Module and the Parental Attitudes Module. The Health Insurance Module has been administered annually as part of NIS–Child and NIS–Teen since 2006.

"Quality Assurance and Data Dissemination" is discussed next, followed by "Evaluation of NIS Estimates and Methods." The former discusses the quality assurance procedures employed throughout all phases of the survey, including data collection, data processing, data delivery phases, and the final dissemination of NIS statistics to the public. "Evaluation of NIS Estimates and Methods" assesses nonsampling error in NIS–Child and NIS–Teen statistics, and it assesses the completeness of the vaccination histories reported by the providers in the second phase of the surveys, the bias due to nonresponse in the first- and second-phase interviews, and the total survey error (TSE) in NIS–Child and NIS–Teen.

"Other Surveys in the NIS Family of Surveys" describes other vaccination surveys within the broader NIS family conducted during the period of this report, including NIS–Adult, the National 2009 H1N1 Flu Survey, NIS–Kindergarten, and the ongoing NIS–Flu.

Sampling Design, Questionnaire, and Response Rates

Introduction

NIS–Child uses two phases of data collection to obtain vaccination information for a large national probability sample of young children: an RDD telephone survey designed to identify households with children aged 19–35 months, followed by a provider record check (PRC) survey, which obtains provider-reported vaccination histories for these children. Data from the PRC show the number of doses each child received from the 10 vaccines shown in Table 1. These counts are compared with the recommended number of doses (see Appendix I and https://www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html) to determine whether the child is UTD. These data, along with sampling weights and NIS–Child survey design information, are used to obtain estimated vaccination coverage rates for the country, states, selected large metropolitan areas, and U.S. territories.

From its beginning in 1994, the household phase of NIS–Child relied on an RDD sampling frame that included only landline telephone numbers. As NIS–Child was implemented, the telephone system in the United States underwent a massive, fundamental change. By the mid-2000s, a growing percentage of U.S. households had dropped their landline telephone service in favor of keeping only cell-phone service. In addition, some people who intermittently or never had landline telephone service now had cell-phone service.

The rapid growth of the CPO population has been well documented (22). Figure 1 shows trends in the percentages of U.S. adults and children living in CPO households over time. CPO adults made up less than 5% of the population of adults in 2003 but more than 44% of the population by 2014. More than 54% of children under age 18 years lived in CPO households by 2014.
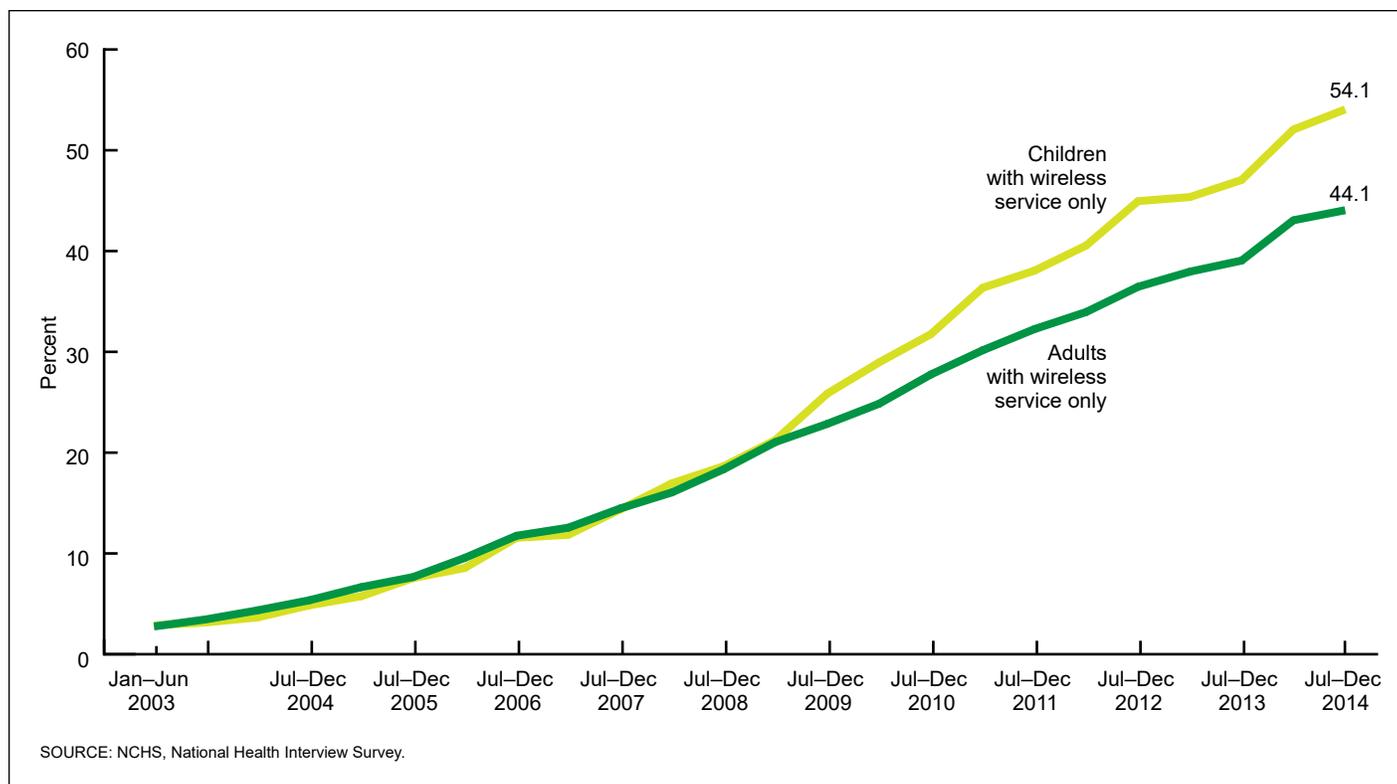
Figure 1. Percentages of adults and children living in households with only wireless telephone service: United States, 2003–2014

These percentages increased with time.

Beginning in 2008, a cell-phone RDD sampling frame was evaluated for use in the NIS family of surveys (see "Assessment of Representativeness of Alternative Sampling Frames for NIS–Child"). In Q4/2010, a national cell-phone RDD sample was piloted in the household phase of NIS–Child (not used in producing the official vaccination coverage rates for 2010), and in all four quarters of 2011 there was a more complete implementation of a cell-phone RDD sample into NIS. In 2012 and in subsequent years, a full dual-frame RDD sample was used to produce NIS–Child estimates.

This section of the report summarizes the household and provider phases of NIS–Child data collection, focusing on descriptions of the major methodological changes implemented from 2005 through 2014. First, an overview of the sample design is provided, including recent innovations made in response to the changing telephony in the United States. This is followed by a description of the household survey and the PRC. Next, response rates and key monitoring

statistics over time are discussed. The final topic is the completeness of the survey's sampling frames.

Major changes from 2005 through 2014 in the protocol of the household phase of NIS–Child are shown in Table 3.

Sampling Design

See references 27–29 for descriptions of the NIS–Child sample design for the period 1994–2004.

Precision constraint

The main objective of NIS–Child is to monitor vaccination coverage rates nationally and by estimation area. The samples must be large enough to achieve the required statistical precision within each area. The NIS–Child design requires that within each estimation area, the coefficient of variation (CV) of a 50% statistic for the domain of age-eligible children based on an annual sample be no more than 7.5%. Assuming a simple random sampling of age-eligible children from a single sampling frame, the CV

constraint within a single estimation area is given approximately by

$$CV = \frac{\sqrt{\dfrac{p\,(1-p)}{n}}}{p} \leq 0.075$$

where $p = 0.5$ is the assumed true vaccination coverage rate, and n is the number of effective completed interviews. To achieve the required precision, a minimum of 178 effective completed interviews must be obtained.

Because official vaccination coverage rates refer to children and are based on provider-reported information, this precision requirement and the corresponding effective sample sizes refer to children with provider information sufficient to determine whether the child has received the recommended vaccines. Such children are said to have "adequate provider data" (APD); see Appendix II for the definition. Since 2005, the survey has been designed to achieve an effective sample size of 180 APD children per estimation area.

The target number of household

interviews per area can be calculated by multiplying the effective sample size of APD children by the estimated design effect (mainly to account for a weighting effect), and then dividing by an estimate of the adequacy rate. This rate is the percentage of children with completed household interviews for whom consent was given to contact providers who returned sufficient data to measure the child's vaccination status. The result of this calculation, divided by an estimate of the average number of children per household, yields the required number of household interviews. The estimated rates and design effect used to make these calculations are prepared using NIS–Child data from prior time periods. Further, division of the number of household interviews by the interview completion rate, the age-eligibility rate, the screening completion rate, the working residential number (WRN) rate, and the resolution rate yields the target number of telephone numbers required to obtain the number of household interviews. In other words, the annual target number, say n', of telephone numbers is calculated as

$$ n' = \frac{nD}{\delta_{APD}\gamma_{CLD}\delta_{INT}\delta_{ELG}\delta_{SCR}\delta_{WRN}\delta_{RES}} $$

where $n = 180$ is the annual effective sample size of APD children,

D is the estimated design effect,

δ_{APD} is the rate of children with APD,

γ_{CLD} is the average number of children per eligible household,

δ_{INT} is the household interview completion rate,

δ_{ELG} is the age-eligibility rate among screened households,

δ_{SCR} is the screening completion rate,

δ_{WRN} is the WRN rate among resolved households,

and

δ_{RES} is the resolution rate of the residential status of the released telephone numbers.

The household phase of NIS–Child uses independent quarterly samples of landline telephone numbers in each of the estimation areas. Each sample is about one-fourth of the annual sample size. The procedures for managing the quarterly landline RDD samples ensure that the interviews in each estimation area are spread evenly across the quarter. To maintain an even workload, telephone interviewing of each quarterly sample extends for about 19 weeks, including 13 weeks within the calendar quarter and about 6 weeks beyond the end of the calendar quarter overlapping the next following quarter.

Within established cost constraints, the main goals of the NIS–Child household phase are to:

- Maintain an up-to-date sampling frame of telephone numbers
- Minimize the number of age-eligible children in the population who are excluded from the sampling frame
- Select a probability sample of telephone numbers within each area
- Complete the telephone interviewing operations with minimal nonresponse bias and response error
- Ensure that the desired sample size of children with completed household interviews is achieved in each area

To accomplish these goals, NIS–Child uses the list-assisted method of landline RDD sampling (30). This method selects a sample of landline telephone numbers from banks of 100 consecutive telephone numbers (e.g., 617–495–0000 to 617–495–0099) that contain one or more directory-listed residential telephone numbers (known as the 1+ working banks). The sampling frame of landline telephone numbers is updated each quarter to include new banks and exclude old banks that no longer contain any listed numbers. An independent systematic sample of telephone numbers of the target size is selected each quarter in each estimation area, with no deeper stratification within each area. This method of sampling telephone numbers continues the method used by NIS–Child prior to 2005 (22).

Shifting from 78 to 56 estimation areas

From 1994 through 2004, NIS–Child was designed to produce precise and direct estimates of vaccination coverage rates within each of 78 subnational estimation areas, called immunization action plan (IAP) areas. These IAPs were defined based on measles outbreaks in the late 1980s and early 1990s. For 2005 and 2006 NIS–Child data collection, selected IAPs were rotated off the survey to allow vaccination coverage assessment in other areas that would benefit from vaccination coverage measurement. CDC decided the rotations in collaboration with the National Association of City and County Health Officers. Beginning in 2007, NIS–Child data collection was limited to the current 56 core estimation areas, in part to allow funding of NIS–Teen with the 56-core-area sampling design. Figure 2 and Table 4 present the 56 core estimation areas and the population counts of age-eligible children by household telephone status as of July 2013.

Optional estimation areas

Beginning in 2007, a varying number of additional subnational or territorial estimation areas were added to NIS–Child design annually to allow calculation of precise and direct estimates of vaccination coverage rates. The subnational and territorial areas included in NIS–Child for each data-collection year are available through CDC's ChildVaxView at: https://www.cdc.gov/vaccines/imz-managers/coverage/childvaxview/data-reports/index.html. The new areas arise when individual states agree to sponsor extra sample for the designated area. In 2013, one optional estimation area was added: El Paso County, Tex.

When a new estimation area is added to the NIS–Child design, the sample in the state containing the area is stratified such that the new area receives a full estimation-area sample size (180 effective ADP children), and the new rest-of-state area is allocated the number of effective ADP children that it received (in expectation) before the new area was
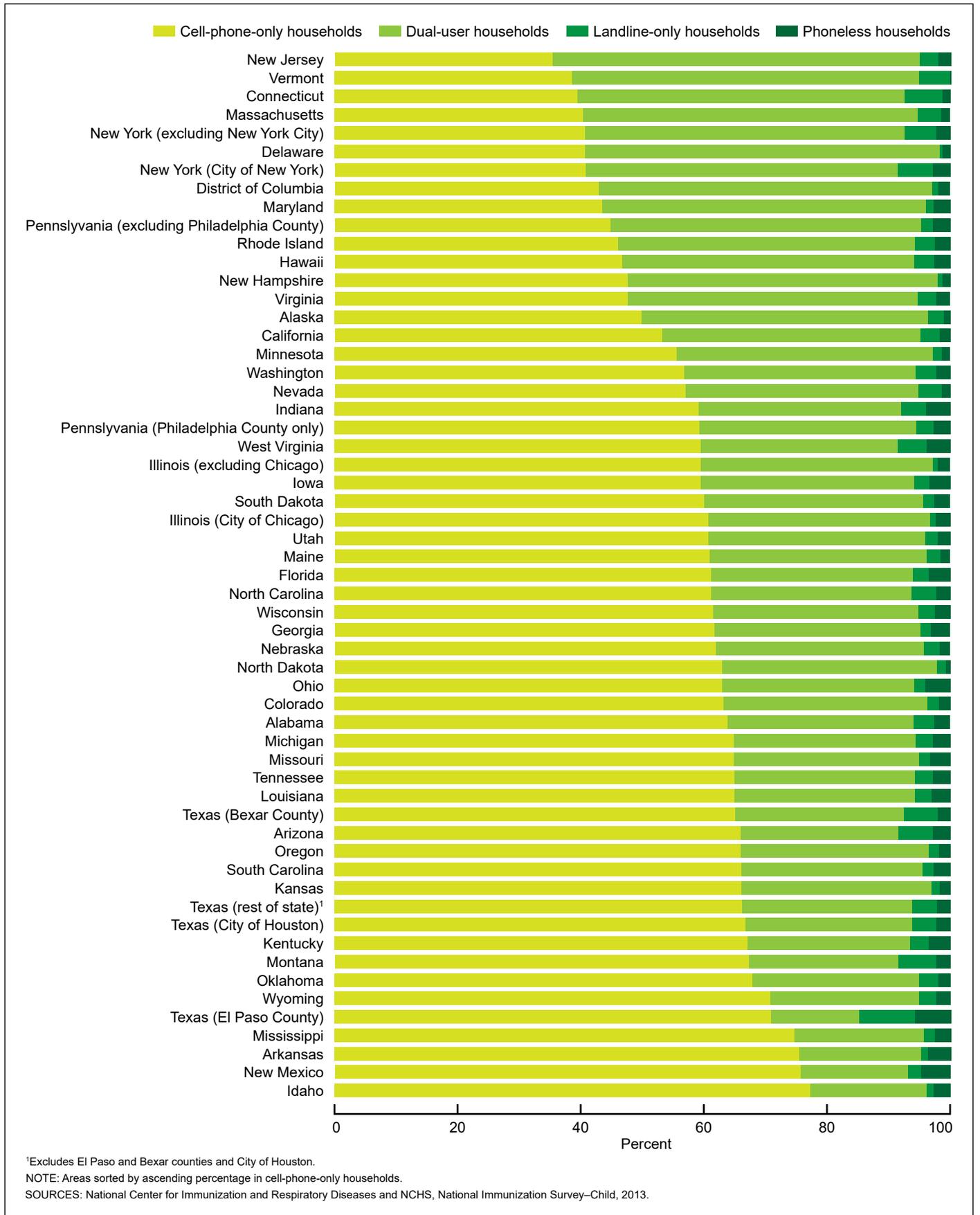
Figure 2. Percentage of children aged 19–35 months in the population, by telephone status within estimation area, 2013

[1]Excludes El Paso and Bexar counties and City of Houston.

NOTE: Areas sorted by ascending percentage in cell-phone-only households.

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2013.

added. Unless the rest-of-state area is also sponsored by the state, no provision is made for precise and direct estimation for the new rest-of-state area.

To illustrate, consider El Paso County, Tex., which is contained entirely within the original rest-of-Texas estimation area (one of the 56 core estimation areas). Houston and Bexar County are the other two core estimation areas in Texas. American Community Survey (ACS) estimates show that approximately 15% of age-eligible children in the original rest of Texas reside in El Paso County, and 85% reside in the remaining counties in the original rest of Texas. In years in which El Paso County was not sampled, the full sample in the original rest-of-Texas estimation area of 180 effective ADP children was distributed at random across the counties contained within the area, with about 27 expected in El Paso County and about 153 expected in the balance of the estimation area. Otherwise, in years when El Paso County was sampled, the sample in El Paso County was increased to the full size of 180 effective APD children, while the remainder of original rest of Texas was assigned its usual allocation of 153 effective ADP children.

Preprocessing the landline RDD sample

Because more than one-half of selected landline telephone numbers are business numbers or not in service, NIS–Child has used several preprocessing steps to prepare the sample before dialing to improve the efficiency of dialing. These steps include:

1. An automated screening procedure to determine the working status of unlisted phone numbers; nonworking numbers and business numbers are coded as ineligible for the NIS surveys
2. Matching of the remaining telephone numbers to lists of residential addresses
3. Mailing of advance notification letters to matched residential addresses

Dual-frame sampling design

Beginning in 2008, a series of experiments was conducted involving the sampling and interviewing of cell-phone respondents. From 2008 through 2010, these experiments were undertaken as research projects that were not tied to the actual NIS–Child sample in production.

In Q4/2010, a small national cell-phone sample was added to the actual NIS–Child sample in production at that time to evaluate differences in vaccination rates between children in landline households and those in cell-phone households, and to gain additional experience with interviewing persons on cell phones. The interviewers screened respondents for CPO or cell-phone-mainly (CPM) status. While the existing landline RDD sample targeted 180 effective APD children in each estimation area, the Q4/2010 cell-phone sample targeted 630 effective APD children nationally in CPO or CPM households.

Beginning in Q1/2011, a somewhat larger cell-phone sample was implemented as part of the actual NIS–Child sample in production, with stratification by estimation area to permit calculation of dual-frame estimates of vaccination coverage in each of the core and optional estimation areas. In Q2/2011, interviewing was changed to a "take-all" protocol in which all cell-phone respondents were interviewed regardless of telephone status.

There are a few substantial differences between the procedures applied to the landline and cell-phone RDD samples. Because there are no reliable commercially available listings of cell-phone subscribers, the cell-phone sample does not use the list-assisted method of RDD sampling, but rather uses pure RDD sampling from all cell-phone banks in service.

The cell-phone sample is not prescreened to remove business and nonworking numbers prior to being released to the phone centers for interviewing. Because there are no directory listings of cell-phone numbers, addresses for the cell-phone sample cannot be obtained, and so advance letters are not mailed. Assignment of a cell-phone number to a specific

geographic area is generally less precise than the assignment of a landline number. Consequently, for the cell-phone sample, the actual areas of residence as determined in the NIS–Child interview are used to adjust the size of the area-specific sample release in subsequent periods.

Due to restrictions imposed by the Telephone Consumer Protection Act of 1991, in effect during the period of data collection covered in this report (2005–2014), cell-phone numbers could not be dialed using automated dialing equipment. As a result, no automated screening procedures were used prior to releasing the sample to interviewers.

Redefinition of age eligibility

Prior to Q2/2011, children's eligibility for NIS–Child was calculated in reference to their age in months on the day of the screening interview. Theoretical and empirical analysis revealed that the eligibility rate could be increased and the sample size of telephone numbers decreased, while maintaining the survey's precision requirement, by changing the definition of eligibility to treat children as eligible if they will be aged 19–35 months on any date during the quarter. The benefits to NIS–Child in cost savings due to the smaller released sample size of telephone numbers were estimated to be considerable, and as a result, it was decided to shift to the any-day-during-the-quarter eligibility rule beginning in Q2/2011.

Changes for the 2012–2014 samples

Beginning in 2012, NIS–Child shifted to a much larger cell-phone RDD sample while minimizing the cost of data-collection operations. Within each estimation area, the overall NIS–Child sample was allocated optimally to the landline and cell-phone sampling frames to achieve the specified constraint on the CV of the estimated vaccination coverage rate of 7.5%.

Details of the optimum allocation with screening and take-all protocols are described elsewhere by Wolter *et al*. (31).

Because NIS–Child continued use of the take-all protocol throughout 2013, its corresponding optimum allocation was used as the basis for the NIS–Child sample. In 2014, use of an optimal allocation between sampling frames was not possible due to budget constraints, resulting in a smaller allocation to the cell-phone sample in 2014 compared with 2013.

To illustrate the dual-frame sampling design, Table 5 lists the 57 (= 56 + 1) estimation areas used in 2013, excluding the U.S. territory samples, and shows the 2013 landline RDD sample size of telephone numbers, households, and children aged 19–35 months in each area. The released sample included 3,395,198 landlines, 4,741 completed household interviews, 4,963 children aged 19–35 months with completed household interviews, and 3,152 children with APD. Table 6 shows the 2013 cell-phone RDD sample, which included 4,537,972 selected and released cell-phone numbers, 16,818 completed parental interviews, 17,499 children with completed parental interviews, and 10,459 children with APD.

2013 Household-survey Phase

This section addresses calling rules used for NIS–Child. The calling rules were largely unchanged from year to year, so this section focuses on the rules in use in 2013. The 2013 household survey phase of NIS–Child used the following primary calling rules for discontinuing call attempts to sample landline telephone numbers:

- A maximum of 10 call attempts to ring-no-answer numbers
- A maximum of 15 call attempts to numbers that resulted in a residential or potentially residential answering-machine message
- A maximum of 25 call attempts to likely and known households
- No additional call attempts to hostile refusals
- No additional call attempts after requests to "take me off your list"
- A verbal refusal at any point after indicating that the household

contained children under age 4 years qualified the household to receive a token of appreciation ($11) for continuing the interview
- No further attempts after a second verbal refusal
- No further call attempts after a hang up during the introduction on three call attempts

For cell phones, the calling rules were:

- A maximum of 4 call attempts to ring-no-answer numbers
- A maximum of 6 call attempts to numbers that resulted in a personal (i.e., nonbusiness) or potentially personal voicemail message
- A maximum of 12 call attempts to likely and known personal numbers
- No additional call attempts to hostile refusals
- No additional call attempts after requests to "take me off your list"
- A verbal refusal by adult respondents at any point after indicating that they were the parent of a resident child under age 4 years, qualifying them to receive a token of appreciation ($11) for continuing the interview
- No further attempts after a second verbal refusal
- No further call attempts after a hang up during the introduction on 3 call attempts

The computer-assisted telephone interview (CATI) questionnaire used in the household survey phase of NIS–Child includes both a screening section to identify households with children aged 19–35 months and a main interview section. The CATI questionnaire has been translated into Spanish, and Language Line Services (formerly part of AT&T) provided real-time translation of the interview into many other languages. People who are deaf, hard of hearing, or speech-impaired are included in NIS–Child interviews by using text telephone (TTY). When a number is dialed and the TTY tone is encountered, the number is put in a separate queue for handling by a specialist with access to the TTY equipment needed to communicate with the household.

2013 Household Questionnaire

Table 7 summarizes the content of each section of the 2013 NIS–Child household interview questionnaire. Links to NIS questionnaires, data, and documentation are available from: https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html. In Section S, the interviewer explains the reason for the telephone call, including an introduction to the sponsoring agency and the purpose of the survey to the respondent, and screens the household to determine whether it contains one or more children aged 19–35 months.

In Section MR, if the household has an age-eligible child, the interviewer asks the respondent whether he or she is the most knowledgeable person about the child's vaccination history. If the respondent indicates that another person in the household is the most knowledgeable and that person is unavailable, a call back is scheduled to interview the most knowledgeable person. If a new person comes to the phone, parts of Section S are reread to the respondent.

Prior to 2012, the NIS–Child questionnaire contained Sections A and B. When information from the child's vaccination record (shot card) was available during the interview, the respondent was asked to provide that information in Section A. When shot card information was not available, the respondent was asked to recall from memory information about the child's vaccination history in Section B. In 2011, the NIS–Child Questionnaire Redesign Experiment was administered to determine if portions of the questionnaire could be removed or shortened. Shortening the questionnaire reduced the burden on the respondent, consequently increasing interview completion rates and reducing the costs associated with each completed interview by reducing the time interviewers spent on the phone with respondents. Beginning in 2012, Section A was removed from the instrument, and Section B was modified to include a shorter set of questions about influenza vaccination and history of chicken pox. Section A was retained only in the

instrument administered to the sample in the U.S. territory of Guam, to allow for a comparison of vaccination histories reported by households and providers, as little was known about the completeness of provider reports in this area.

Section C obtains information that includes the relationship of the respondent to the child, Hispanic ethnicity of the child, the race of the child, Hispanic ethnicity of the mother, the race of the mother, household income, educational attainment of the mother, and other information on the socioeconomic characteristics of the household and its eligible children.

In Section D, the interviewer requests consent d to contact the child's vaccination provider(s). If verbal consent is obtained, identifying information (name, address, and telephone number) about the vaccination provider(s) is requested.

In Section E, the Health Insurance Module (HIM) collects data about the child's current insurance coverage and some information about periods without coverage that occurred since the child's birth. It asks whether the cost of vaccinations ever caused respondents not to get or to delay getting a vaccination for their child. The objective of HIM is to produce reasonably precise state-level estimates of age-eligible children who are entitled to vaccines purchased by CDC's Vaccines for Children (VFC) Program (see https://www.cdc.gov/vaccines/programs/vfc/index.html for a more comprehensive description of the program).

2013 Provider Record Check Phase

When an interviewer obtains oral consent from a child's parent or guardian to contact the child's vaccination provider(s), each nominated provider is mailed an immunization history questionnaire (IHQ) (available from: https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html) and documentation of the household's consent.

The IHQ is brief to minimize burden on the providers and encourage participation in the survey. The first page includes space for a label that contains identifying information about the child (including child's name, date of birth, sex, and survey identification number) and about the provider (including provider name and survey identification number). It also contains questions about whether the facility has immunization records for the child; the dates for the child's first and most recent visits to the practice; and questions about the facility to which the IHQ was mailed. The 2013 facility questions include whether the facility:

- Is a federally qualified health center (FQHC), a rural health clinic (RHC), or a "look alike" FQHC or RHC
- Has been deputized to administer VFC Program vaccines
- Is a private practice (solo, group, or health maintenance organization), a hospital-based clinic, a public health department-operated clinic, a community health center, a rural health clinic, a migrant health center, an Indian Health Service-operated center, Tribal health or urban Indian health care facility, a military health care facility, a clinic associated with the WIC program, or a pharmacy
- Orders vaccines from the state or local health department
- Reported any of the child's immunizations to a community or state immunization registry

The IHQ also collects contact information for the person returning the questionnaire.

The second page of the IHQ provides instructions for returning it and for completing a shot grid, which appears on the third page. This grid allows providers to enter the dates and types of doses of the vaccines administered, and to indicate whether they were administered at the provider practice that is completing the IHQ or at another location.

The fourth page provides additional information about NCIRD, vaccine recommendations, and data sources and statistics from previous years of NIS. This page also provides a telephone number for questions or comments and an e-mail address along with a warning against sending confidential information about the child via e-mail. Additionally, this page includes definitions of terms used in the IHQ (e.g., federally qualified health center (FQHC), rural health clinic, FQHC look-alike, and deputization).

Major changes to the IHQ

Between 2005 and 2014, the IHQ shot grid was modified multiple times to ensure the information collected about recommended vaccines and available vaccine types was accurate. In particular, check boxes were added to indicate the brands of Hib and rotavirus vaccines that were administered. Boxes were added for recording dates of receipt of the 2009 H1N1 influenza vaccine. Space was also added on the shot grid to indicate the type of PCV vaccine, that is, PCV7 or PCV13. In 2012, a checkbox was added to track whether the child has a history of chicken pox. In the third quarter of 2013, several footnotes were added to vaccinations to make it easier for the person completing the form to code brand names: Pediarix was added to the DTaP-HepB-IPV vaccination, Pentacel was added to the DTaP-IPV-Hib vaccination, and the Hiberix booster GSK was added to the PRP-T vaccination. An additional vaccine dose checkbox, HibMenCY, was added to the Hib section.

PRC methodology

The PRC data-collection process aims to maximize responses using two separate methodologies: standard and accelerated (used near the end of PRC data collection to ensure cases were worked adequately in order to be included in the delivery). In the standard methodology, each provider may receive up to three separate mailings and a telephone call. The initial mailing includes a cover letter from NCIRD's director describing the study and its goals; a copy of a *Morbidity and Mortality Weekly Report* (MMWR) article with national estimates from NIS–Child; a signed consent form; an IHQ for each child; a roster of all IHQs issued; frequently asked questions about the Health Insurance Portability and Accountability Act of 1996 (HIPAA)

and NIS; a copy of the Institutional Review Board (IRB) approval; a NIS–Child Documentation Notice for HIPAA Accounting, which is to be placed in the child's medical record; and a business reply envelope.

Letters are sent to providers 2 weeks after the initial mailing, regardless of whether they have responded. The letters thank those who have responded and remind those who have not to do so. Five weeks after the initial mailing, a second mailing is sent to nonresponding providers. The new mailing includes a cover letter asking the provider to complete the immunization information for the child listed on the questionnaire, an IHQ, documentation of telephone consent, a notice for HIPAA accounting, an MMWR, frequently asked questions, an IRB approval letter, and a business reply envelope. Seven weeks after the original mailing, the remaining nonrespondents are contacted by telephone. Generally, these prompting calls are made to remind providers to return the completed questionnaires and to offer to mail or fax new materials to those providers who request them. In some cases, the questionnaire is completed by telephone. This approach prompts providers as inexpensively and as easily as possible at each stage. The most expensive and labor-intensive steps are reserved for the least-responsive providers.

In the accelerated methodology, the initial mailing is identical to that used in the standard approach. Two weeks later, rather than send a reminder letter, prompting calls begin. As with standard prompting, the calls serve as a reminder to return the questionnaire; an opportunity to answer any questions the provider may have; and a time to encourage completion of the materials by phone, fax, or mail depending on which mode is least burdensome for the provider. A second mailing of the full set of materials is sent only upon provider request. This approach is aimed at generating an earlier return of IHQs. There is additional cost associated with prompting a larger number of providers, however, that cost is offset by decreases in the cost for reproduction, postage, and labor due to the removal of the reminder letter, mailing, and re-mails of the entire packet. While there are increases in the number of cases that enter prompting in the accelerated method, the net result is a cost savings to the project with no decrease in the volume or quality of the data collected. As a result, accelerated prompting was instituted as a standard operating procedure for PRC in 2010. In 2013, a web link to the MMWR article was added to the initial letter as a cost-saving measure. Separate MMWR documents are no longer included in the provider mailing packets.

Because the goal of the PRC is to maximize the quantity and quality of immunization data returned, all providers are encouraged to respond in whatever way is least burdensome. They can complete the IHQ by phone, mail, or fax. In addition, they can fill out the IHQ by hand or send the child's vaccination record or a record from a registry, which is subsequently transcribed onto an IHQ by trained staff.

In the last several years, providers have increasingly returned vaccination records instead of completing and returning the IHQ. With this trend, there has been a related decrease in the completion of the first page of the IHQ by providers. The majority of the questions on this page capture provider characteristics that are necessary for analysis of vaccinations by type of practice.

In 2007, as part of the editing process, a donor information system (DIS) was instituted to minimize the instances of recontacting providers when provider-level data are missing from the first page. For those questions, it is possible to use previously completed IHQs to fill in the missing information. The DIS contains data from providers who completed IHQs within the previous 2 quarters. If a new IHQ or vaccination record is returned with missing provider information, the DIS is checked to determine if this provider has returned an IHQ with completed page 1 information within the previous 2 quarters. If so, the information from those earlier returns is "donated" to the current IHQ as a method to complete the page 1 information. This procedure reduces the amount of time spent contacting providers for additional information and provides cost savings as well.

The PRC phase faces several important challenges. If the household respondent refuses to give consent to contact the child's providers (consent is denied for about 23% of the children for landline respondents and 30% for cell-phone respondents), the approved interviewing protocol allows only one attempt at refusal conversion. Even with consent, some respondents are unable to provide sufficient contact information to mail to the child's immunization provider(s). An extensive provider look-up file accessed by the telephone interviewer during the household interview helps minimize the amount of missing contact information. In other instances, providers report that they have no records for the child. Finally, some providers refuse to participate by either not returning completed IHQs or indicating that they would not like to receive IHQs. Data-collection efforts aim to minimize data loss at each of these points.

Despite efforts to obtain complete IHQ information, each year roughly 9% of the children for whom the household interview is complete have consent, and yet fail to achieve APD status due to these various data losses. Overall, including cases that do not give consent to contact providers and failure to achieve APD status conditional on consent, about 68% of children with a completed household interview reach APD status for landline respondents and 62% for cell-phone respondents.

Response Rates and Key Monitoring Statistics, 2005–2014

Cooperation rates for various stages of the overall interview process and the response rate are among the key indicators of survey quality. This section describes the key indicators and statistics that are monitored regularly at both the national and estimation-area levels.

Tables of response rates and key monitoring statistics

Table 8 presents key monitoring indicators at the national level for NIS–Child data collection from 2005 through 2014, based on landline RDD samples in the 50 states and the District of Columbia, excluding U.S. territory samples. The key monitoring statistics for the prior NIS–Child data-collection years (1995–2004) are available in the NIS–Child data user's guides; see https://www.cdc.gov/nchs/nis/data_files_09_prior.htm.

The size and growth of NIS–Child are illustrated in Table 8. In 2013, 3,395,198 landline telephone numbers were selected randomly by the methods described earlier in this report to meet the objective of obtaining estimates of vaccination coverage with the specified precision within each estimation area. Among the 363,646 households identified in 2013, 330,986 (91.0 %) were screened for the presence of children aged 19–35 months. Of these, 325,162 (98.2%) did not contain an age-eligible child, and 5,824 (1.8%) did contain one or more age-eligible children. Among the households containing one or more age-eligible children, 4,792 (82.3%) household interviews were completed by adults most knowledgeable about the children's vaccinations.

One common approach for measuring the response rate in an RDD survey is the CASRO response rate, which has been defined by the Council of American Survey Research Organizations (32). The response rate is defined as the number of completed interviews divided by the number of eligible units in the sample. Given the CASRO approach, the unknown WRN rate in the set of unresolved telephone numbers is assumed to be the same as the observed WRN rate in the set of resolved telephone numbers, and the unknown age-eligibility rate in the set of screener incompletes is assumed to be the same as the known age-eligibility rate in the set of screener completes.

For the 2013 NIS–Child, the CASRO response rate was 62.3% for the landline RDD sample. It can be calculated as the product of the resolution rate (83.2%), the age-screening completion rate (91.0%), and the interview completion rate among age-eligible households (82.3%).

Table 8 lists key national monitoring indicators for the PRC phase of the NIS–Child landline RDD sample. The rate of obtaining consent from household respondents to contact their children's vaccination providers was 69.6% of children in the 2013 sample. The number of IHQs that were mailed to vaccination providers was 4,240. This number exceeds the number of children with consent (3,453) because some children had more than one vaccination provider. Among the children with completed NIS–Child household interviews, 3,152 children (63.5%) had adequate vaccination histories returned by their vaccination provider(s) to determine their UTD statuses.

Table 9 presents key national monitoring indicators for the 2013 cell-phone RDD sample. The CASRO response rate was 30.5%, which can be written as the product of the resolution rate (53.8%), the screener completion rate (79.3%), and the interview completion rate (71.6%). The consent rate to contact the children's providers was 67.1%, and among the children with completed NIS–Child household interviews, 10,459 (59.8%) had adequate vaccination histories returned by their vaccination provider(s).

Table 10 presents the response rates for the combined landline and cell-phone RDD samples. By definition, the response rate is the number of households with a completed household interview divided by the estimated number of eligible households in the sample. Within each sample type, the number of eligible households was estimated using the above-mentioned CASRO assumptions. Given these assumptions, within each sample type, the CASRO response rate is equal to the product of the resolution rate, the screener completion rate, and the interview completion rate. For the combined samples, the CASRO response rate is defined as the total number of households with a completed interview across both samples divided by the estimated total number of eligible households across both samples (using CASRO assumptions within each sample). The combined response rate is also algebraically equal to a weighted average of the frame-specific response rates, where the weight given the response rate in the landline frame is the estimated number of eligible cases in the landline sample as a proportion of the estimated total number of eligible cases in both samples. And the weight given the response rate in the cell-phone frame is the estimated number of eligible cases in the cell-phone sample as a proportion of the total number of estimated eligible cases in both samples.

As shown in Table 10, the combined response rates in the 2012–2014 period are tilted toward the response rates in the cell-phone sample, because the cell-phone sample is quite large relative to the size of the landline sample. This larger cell-phone sample is due to the fact that the eligible population has shifted substantially toward CPO telephone status. The downward movement in the combined response rate in the 2011–2013 period, followed by a rebound in 2014, is due to the changing mix of landline and cell-phone samples across those years. (As noted in Table 3, an optimal allocation between sampling frames was not possible in 2014 due to budget constraints, resulting in a smaller allocation to the cell-phone sample than in 2013.)

Note that the response rate does not account for undercoverage of the sampling frame and can be sensitive to the assumed number of eligible units among the nonrespondents. Alternative measures of potential bias that take into account both nonresponse and noncoverage are also used to monitor NIS–Child (see "Evaluation of NIS Estimates and Methods").

Trends in response rates and key monitoring statistics

Trends in the CASRO response rate

Figure 3 displays the key indicators of response for the landline RDD sample over the 7-year period from 2005 through 2014, excluding the U.S. territory samples. (For trends in NIS–Child response rates during the period 1995–2004, see reference 33.)
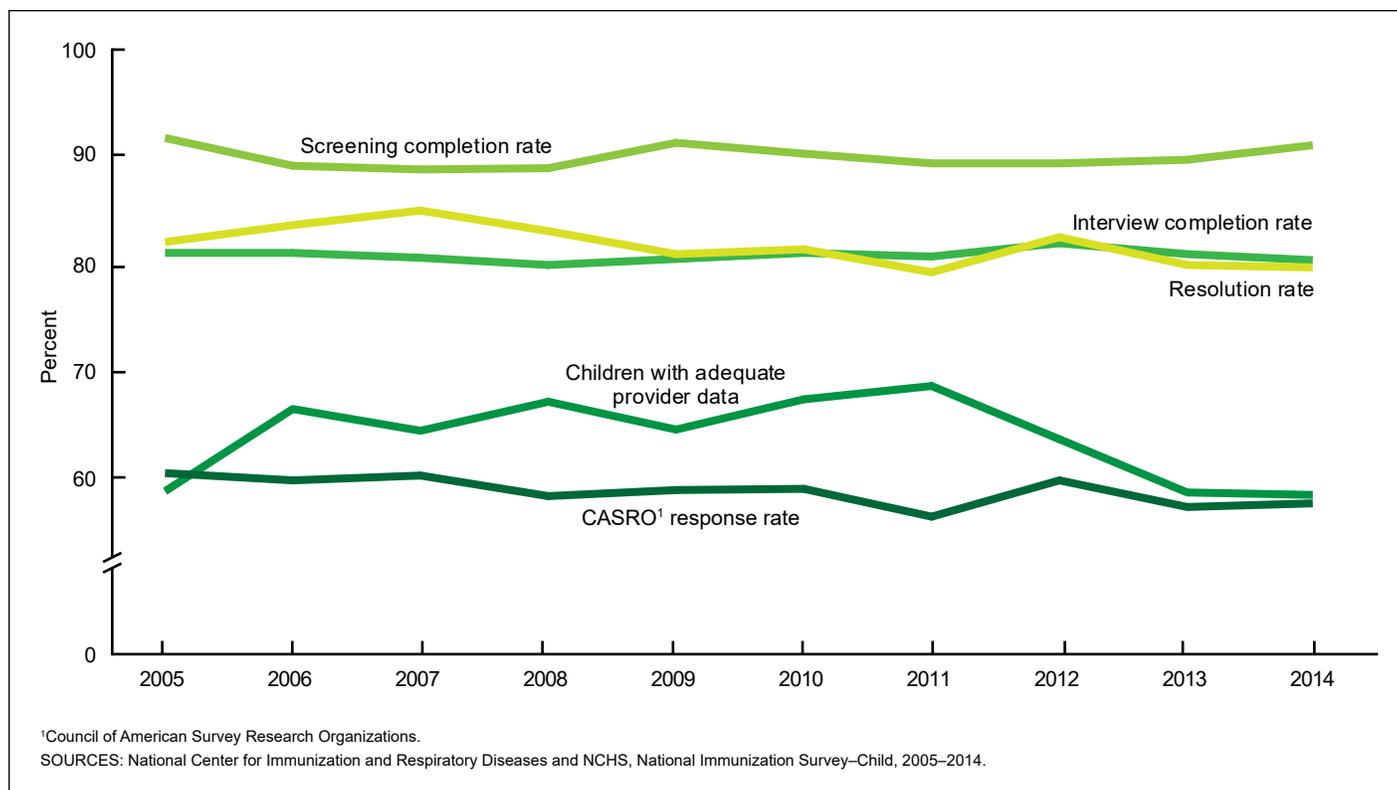
Figure 3. Trends in key indicators from household and provider data collections for National Immunization Survey–Child: Landline random-digit-dialing sample excluding U.S. territories, 2005–2014

The CASRO response rate declined slightly from 65.1% in 2005 to 62.6% in 2014. To understand the decline in the CASRO response rate, it is necessary to examine trends in the three component rates that make up the CASRO response rate: the resolution rate, the age-screener completion rate, and the interview completion rate.

The resolution rate has been very stable, remaining at around 83.0% over the 7-year period. The age-screener completion rate has ranged from a high of 92.8% in 2005 to a low of 90.2% in 2007. A high screener completion rate reflects the ability of the interviewers to complete the age-eligibility screening questions with resolved households. The interview completion rate has ranged from a high of 86.8% in 2007 to a low of 81.7% in 2011. The changes in the interview completion rate from year to year are due in part to the periodic introduction of topical modules to NIS–Child, and to the corresponding time estimate quoted to the respondent at the start of the interview. These modules increase the length of the survey interview, and interviewers must

consequently give potential respondents an estimate of the greater length. With the introduction of the shortened questionnaire in 2012, the interview completion rate increased.

Figure 4 displays the same key indicators of response for the cell-phone RDD samples from 2011 through 2014, excluding the U.S. territory samples.

Trends in the number of advance letters mailed

NIS–Child mails advance letters to the landline RDD sample telephone numbers for which it can obtain valid mailing addresses using a reverse-match procedure. The use of an advance letter has been shown to increase the overall participation and response rate in NIS–Child (34,35). From 2005 through 2007, about 57% of landline telephone numbers released to the telephone centers were mailed an advance letter; this rate declined beginning in 2008 to 42.9% in 2011 and to 40.8% in 2014. The decline is due to the declining WRN rate in the landline RDD sample, as households dropped landline telephones

and increasingly have access only to cell phones (22).

Trends in the WRN rate

Among the telephone numbers in the landline RDD sample that have been resolved as nonworking, nonresidential, or residential, the proportion that are WRNs has declined steadily from 29.2% in 2005 to 10.8% in 2014. As fewer landline telephone numbers are directory-listed, and as more households become CPO, the WRN rate on the landline RDD sampling frame has declined.

Trends in the age-eligibility rate

Among the screened households in the landline sample, the proportion that report the presence of an age-eligible child has declined steadily, from 3.2% in 2005 to 1.5% in 2014. The decline may be due to increasingly low survey participation rates for age-eligible households relative to age-ineligible households or to an increased tendency for age-eligible households to report zero children in the household in order to avoid survey participation. The decline
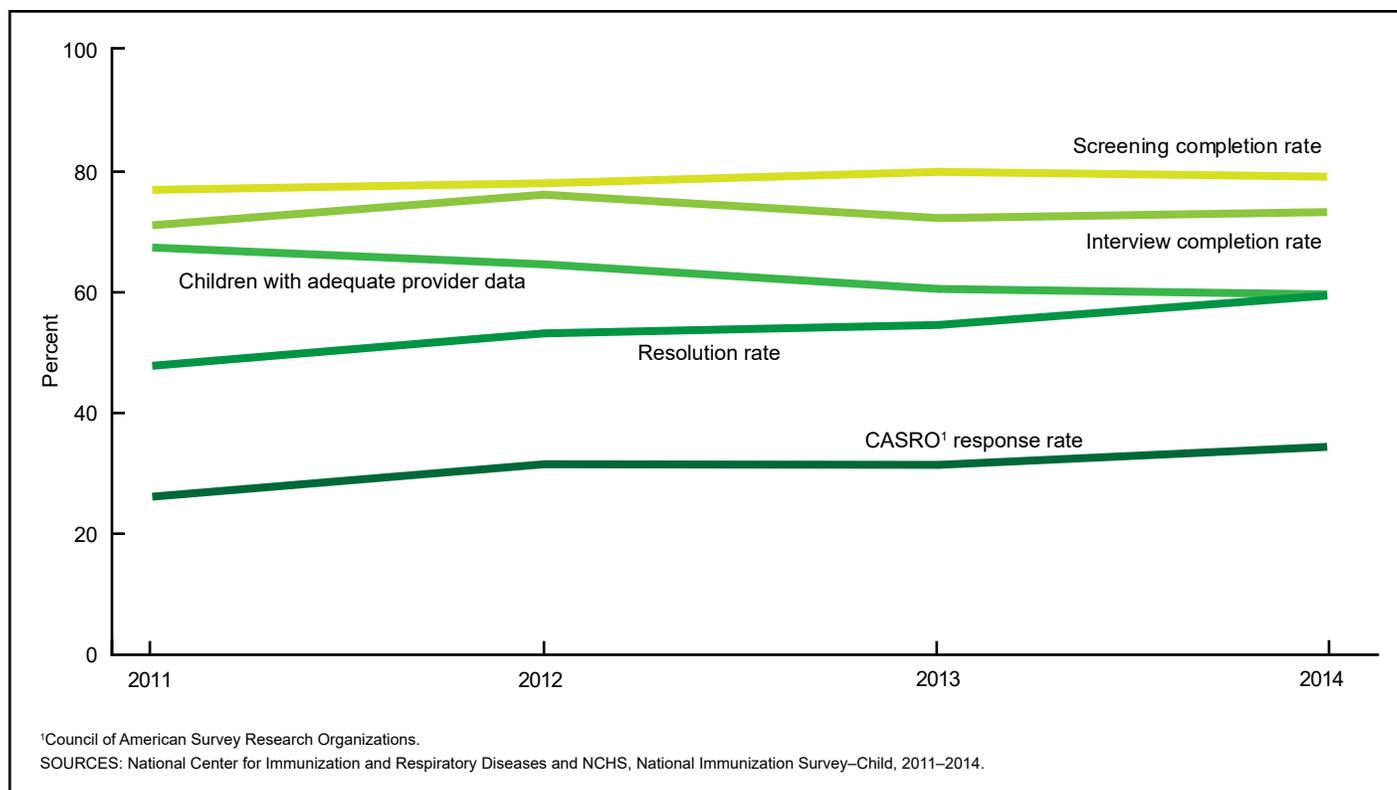
Figure 4. Trends in key indicators from household and provider data collections for National Immunization Survey–Child: Cell-phone random-digit-dialing sample excluding U.S. territories, 2011–2014

may also be due in part to age-eligible households becoming CPO at a faster rate than age-ineligible households. The households retaining landline telephones would then be less likely to contain an age-eligible child, leading to lower observed age-eligibility rates in the landline RDD sample.

Trends in the provider consent rate

Of the children with complete household interviews, the proportion for whom consent to contact vaccination providers was obtained varied over the 2005–2014 period, ranging from a high of 81.0% in 2006 to a low of 69.6% in 2013 for landline respondents. For cell-phone respondents, the proportion for whom consent to contact vaccination providers was obtained also varied over the 2011–2014 period, ranging from 75.0% in 2011 to 66.9% in 2014.

Trends in the percentage of children with APD

In the landline RDD sample, the proportion of children with APD (Table 8) varied between 63.3% and

72.3% during the 2005–2014 period. The increase from 2005 through 2006 was mainly due to a higher IHQ (or vaccination record) return rate, which increased from 88.0% in 2005 to 94.5% in 2006; the return rate has remained well over 91.0% since 2006. (The lower rate in 2005 was due to a delay in funding that resulted in a suspension of PRC data collection for Q1/2005 for a period of 6 months.) During 2011–2014, in the cell-phone RDD sample, the proportion of children with APD (Table 9) ranged from 58.9% to 66.7%. The variability was due to variation in the proportion of such respondents for whom consent to contact vaccination providers was obtained.

Although the CASRO response rate in the landline sample declined slightly from 2005 through 2014, the product of the CASRO response rate and the percentage of children with APD (a measure of the overall success of NIS–Child in obtaining vaccination data for age-eligible children) was higher in 2012 (43.8%) than it was in 2005 (41.4%) and has remained relatively stable in 2013 and 2014 (39.6%). The CASRO response

rate in the cell-phone sample rose from 25.2% in 2011 to 33.5% in 2014, while the product of the CASRO response rate and the APD rate has ranged from 16.8% in 2011 to 19.7% in 2014.

Potential limitations of APD: Incomplete ascertainment of provider-reported vaccination histories

Several steps are taken to maximize the number of children whose provider-reported vaccination data are sufficient to determine their vaccination status. Even for such children, however, the vaccination history reported in the PRC may not be complete. As a result, NIS–Child estimates of vaccination coverage for children with APD are likely to be lower than the true level of coverage for these children.

Children with APD include those for whom all identified vaccination providers returned the IHQ or medical records containing a vaccination history. In addition, if some but not all identified providers responded and reported vaccination histories, a set of rules determines whether the child is

considered to have APD. From 2005 through 2014, these rules were based on the following primary criteria:

- Whether the responding provider(s) reported the child as UTD with the recommended number of doses of vaccines in the 4:3:1:3 series (4 or more doses of DTaP, 3 or more doses of polio, 1 or more doses of any MCV, and 3 or more doses of Hib vaccine)
- Whether the child was UTD for the 4:3:1:3 series when vaccinations given after the date of the household interview were counted
- Whether the responding provider(s) reported at least as many doses of the key recommended vaccines as the household respondent

Children who received zero vaccinations are also considered to have APD. A child is considered to be a "zero-shot" child if either:

- The household respondent reported zero vaccinations for the child and identified zero providers
- The household respondent reported zero vaccinations for the child and identified one or more providers, all of the identified providers returned IHQs or medical records, and none of the providers reported any vaccinations for the child

In 2013, among the 4,963 children in the RDD landline sample for whom household respondents completed the interviews (excluding the U.S. territory samples), 3,152 (63.5%) children had APD. Among these, 25 children (0.8%) were classified as zero-shot children, 2,367 (75.1%) were reported by the household respondent as having only one vaccination provider, and 785 (24.9%) were reported as having two or more vaccination providers. In the latter group, 280 children (35.7%) did not have vaccination histories reported by all identified providers.

In 2013, among the 17,499 children in the RDD cell-phone sample for whom household respondents completed the interviews (excluding the U.S. territory samples), 10,459 (59.8%) children had APD. Among these, 126 (1.2%) were classified as zero-shot children,

7,303 (69.8%) were reported by the household respondent as having only one vaccination provider, and 3,156 (30.2%) were reported as having two or more vaccination providers. In the latter group, 1,223 children (38.8%) did not have vaccination histories reported by all identified providers.

When a child has two or more vaccination providers, the vaccination history may be scattered in such a way that no single provider has the entire vaccination history. A child's vaccination history may be ascertained (determined) incompletely for one or more vaccines when not all providers respond and the reported information does not show that the child is UTD. Literature suggests that children with an incompletely determined vaccination status may be found to be UTD when their entire vaccination history from all providers is assembled and examined (36–39).

Figure 5 shows trends in the percentage of children with two or more providers among children with APD from the 2005–2014 landline RDD samples, excluding the U.S. territory samples.

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2005–2014.
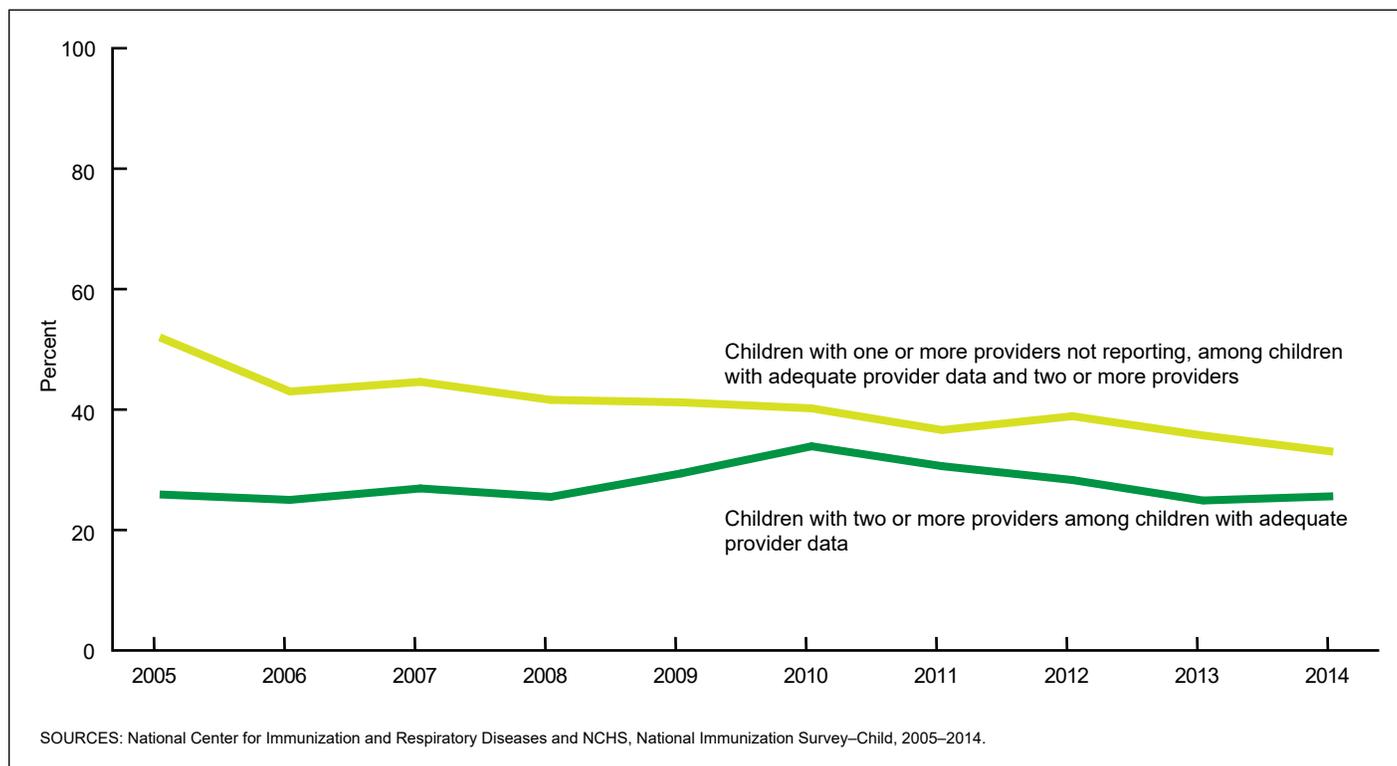
Figure 5. Trends in percentages of children with two or more providers among children with adequate provider data, and children with one or more providers not reporting among children with adequate provider data and two or more providers, for National Immunization Survey—Child: Landline random-digit-dialing sample excluding U.S. territories, 2005–2014

This percentage stayed reasonably steady from 2005 through 2008, ranging between 25% and 27% before increasing in the 2009–2011 period. This percentage decreased from 2011 through 2014, and was at 28.1%. The increase in 2009 and 2010 was due to a questionnaire change made in New York and California between Q3/2009 and Q2/2010; during these quarters, respondents in New York and California were asked to identify the hospital where the child was born, resulting in an increase in the number of providers identified per child. This change was made to determine if the NIS PRC was accurately capturing the number of birth doses of HepB being given at hospitals. Figure 5 also shows, among children with APD and two or more providers, trends in the percentage of children who have fewer than all identified providers returning IHQs or medical records containing a vaccination history. This rate was 52.0% in 2005 and ranged between 35.1% and 44.6% from 2006 through 2014. The higher rate in 2005 reflects the lower IHQ return rate in 2005, which was due to the delay

in funding for PRC data collection for Q1/2005.

Figure 6 shows trends in the percentage of children with two or more providers among children with APD from the 2011–2014 cell-phone samples, excluding the U.S. territory samples.

Because of the potential for incomplete ascertainment of some children's vaccination histories, users of NIS–Child data who wish to compare vaccination coverage rates between subpopulations are cautioned to evaluate whether these differences are statistically significant after adjusting for differing rates of incomplete ascertainment between the subpopulations (40).

Representation of the Target Population

The NIS–Child sampling frames do not directly provide representation of children living in households without access to any telephone (i.e., phoneless households) or of children who live in landline households whose landline

number is not in a bank of telephone numbers containing at least one listed number and whose parents do not use cell phones. Also, prior to Q4/2010, NIS–Child did not include direct coverage of children living in CPO households. All such children not directly represented through the sampling frame, however, were represented indirectly through the NIS–Child estimation procedure, described in "Estimation Methodology for NIS–Child." According to the National Health Interview Survey (NHIS), in the second half of 2013, 2.5% of children under age 18 years lived in phoneless households, and 47.1% lived in CPO households (22). Model-based state-level estimates of the telephone status of households with children aged 19–35 months show that the prevalence of CPO households in 2013 ranged from approximately 38% percent in Vermont to 77% in Idaho. (For a description of the general method of state-level estimation, see "Wireless Substitution: State-level Estimates From the National Health Interview Survey, January 2007–June 2010" (41). Using the general method,
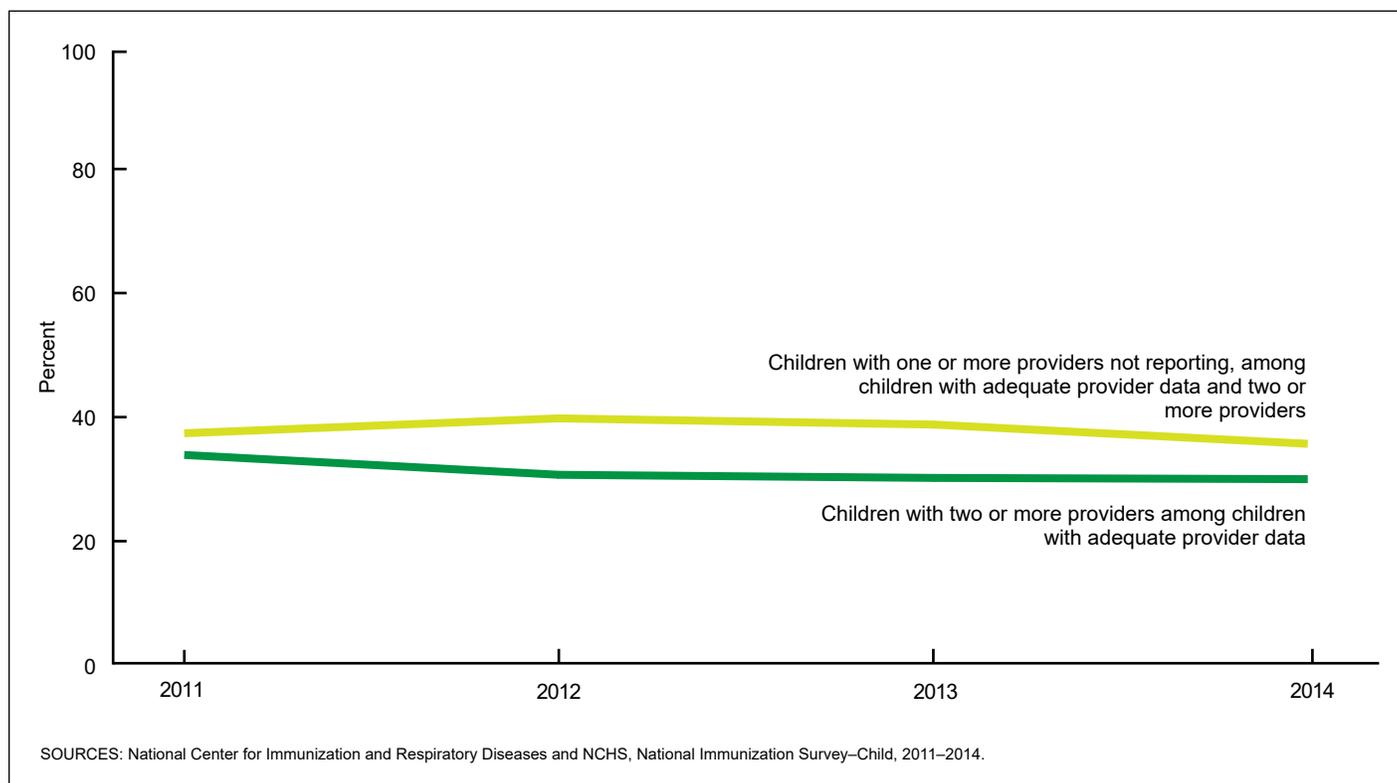
Figure 6. Trends in percentages of children with two or more providers among children with adequate provider data, and children with one or more providers not reporting among children with adequate provider data and two or more providers, for National Immunization Survey—Child: Cell-phone random-digit-dialing sample excluding U.S. territories, 2011–2014

NIS–Child prepares state-level estimates of population size for the domain of children aged 19–35 months by telephone status every year in support of the survey's estimation procedure; see Table 4 and "Estimation Methodology for NIS–Child." The augmentation of the NIS–Child sampling design with a cell-phone RDD sample starting in 2011 extended the direct representation to include children living in CPO households. Estimates of the proportion of landline households not covered by the landline sampling frame (i.e., households in zero-banks) vary, with different studies estimating the proportion to be between 8% and 20% (42–44).

Estimation Methodology for NIS–Child

Introduction

The purpose of estimation in NIS–Child is to infer the vaccination coverage rates in the target population of children aged 19–35 months, based on the data collected from the sample. The NIS–Child estimation (or weighting) procedures make adjustments for variation in sampling rates, differential response rates, and differential undercoverage in the sample relative to the population to produce accurate estimates at different levels. The estimates and variance estimates are produced for each NIS–Child estimation area, for each state, and for the country. Through June 2014, estimates were produced twice each year, with a lag of 6 months between the completion of household data collection and the production of the estimates. The annual June NIS–Child delivery includes the Q1–Q4 surveys from the previous calendar year, and the annual December delivery includes the surveys from the last one-half of the previous year (Q3–Q4) and the first one-half of the current year (Q1–Q2). The annual December delivery of cross-year files was terminated following delivery of the Q3/2013–Q2/2014 file. The estimation

process is preceded by a number of steps, such as imputation of certain missing items and linking the household and PRC data.

In preparation for computing accurate estimates of vaccination coverage rates, NIS–Child derives survey weights for sampled children who have a completed household interview and for the subset of children for whom adequate provider data were obtained. NIS–Child utilizes a complex multistage weighting approach to account for probabilities of selection, adjust for various types of nonresponse, and calibrate weighted survey counts to population control totals. The objective of the weighting approach is to minimize the mean squared error (MSE) of the estimator of the vaccination coverage rate. Overall, there are two types of survey weights created for NIS–Child: child-level RDD survey weights, used to analyze household-reported interview data; and child-level provider survey weights, used to analyze provider-reported vaccination history data.

The following sections will discuss a) the imputation procedure used to complete missing values for variables that are used in the weighting procedure; b) the weighting procedure employed in NIS–Child throughout 2005–2010, during which the NIS–Child sample was based on a single-frame landline RDD survey design (estimation methodology used in earlier years of NIS–Child is described in Smith *et al*. [21]); c) the weighting procedure used from 2011 through 2014 to address the dual-frame survey design (using both landline and cell-phone frames); and d) the estimator of the vaccination coverage rate and the application of the Taylor series method as an estimator of its variance.

Imputation of Weighting Variables, 2005–2014

Among households that respond to the interview, some individual items (such as race of child or education of the mother) may go unanswered. NIS–Child imputes values for variables used in the weighting process.

The NIS–Child structured imputation uses the "hot-deck" procedure to bring

together data for children who are similar on selected characteristics and then to fill in missing items for a child ("recipient") using corresponding items for a child that has no such missing items ("donor"). This is done by categorizing child records into imputation cells using "class" variables, with imputation carried out separately within each imputation cell.

Within a particular imputation cell, all child records are sorted using auxiliary variables determined to be related to, or good predictors of, the missing variable. A child with a missing data value is given the same response as the child not missing that value just above it in the ordered sort. With the implementation of the dual-frame sample design, imputations for 2011–2014 were done separately by sample frame in almost all cases, with cross-donation allowed only when necessary. Records are restricted to being used four times at most as a donor for imputing a variable. Imputation occurs in a hierarchical fashion, because some variables are needed as class and sort variables for the imputation of other variables.

NIS–Child does not use imputation extensively. Table 11 shows the overall item nonresponse rate among landline sample cases by year, from 2005 through 2014, for variables subject to imputation. Item nonresponse rates ranged from 0.0% to 10.2%; for most variables, the item nonresponse rate is generally less than 2% and often less than 1%. The higher item nonresponse rate for race mainly reflects Hispanic respondents who did not report a race. Table 12 shows the item nonresponse rate among cell-phone sample cases for 2011–2014. Results were similar to those observed for the landline sample, ranging from 0.1% to 8.0%, although cell-phone sample item nonresponse rates for race are somewhat higher than those for the landline sample.

2005–2010 Single-frame Estimation Methodology

The NIS–Child weighting scheme for estimation based on the landline sample, used for each year from 2005 through 2010, involved three broad stages: 1) accounting for probabilities of

selection, adjusting for various types of household nonresponse, and combining the four quarterly samples (resulting in annual household weights); 2) adjusting for nonrepresentation of nonlandline telephone households and failure of the sampling frames to represent the entire population of children (resulting in child-level interview weights); and 3) adjusting for provider nonresponse and controlling survey weights to independent population controls (resulting in provider-phase weights). Each of these broad stages included a number of steps, as shown in Figure 7.

The first six steps (described above) of the three-stage NIS–Child weighting scheme produce the final household weights, the next three steps produce the final RDD-phase child weights used to generate estimates for variables collected in the NIS–Child household interview, and the last two steps adjust for provider nonresponse and produce the final provider-phase child weights used to generate vaccination coverage rate estimates and estimates for variables collected from providers in the IHQ. The stages and steps within each stage did not change across the 2005–2010 period; however, details for individual steps have been refined across time, as indicated in the following descriptions.

Household-level weighting

The first stage of weighting involves six steps, of which the first five are carried out separately within each survey quarter and sampling area. Step 6 is carried out separately within each sampling area. These steps are carried out to derive an annual household weight.

Step 1. Base weights—Each telephone number sampled by NIS–Child receives a base sampling weight that is equal to the reciprocal of the probability of selecting the telephone number into the sample. The base weight is computed separately within each quarter.

Steps 2–4. Adjustment for nonresolution of telephone numbers, screener nonresponse, and household interview nonresponse—Adjustments to the survey weights are necessary to account for telephone numbers for which the WRN status is not resolved

(Step 2); telephone numbers for which the screening interview is incomplete (Step 3); and households for which the household interview is incomplete (Step 4). Because little covariate information is known at this point about the households with sampled telephone numbers, each adjustment is made within cells formed by cross-classifying the sample by the directory-listed status of the telephone number and by two telephone-exchange level variables: percentage of the population that is white (75% or greater, less than 75%), and metropolitan statistical area (MSA) status (in MSA, not in MSA).

The exchange-level variables reflect census summary data at the census-tract

level. The telephone vendor provides a crosswalk between tracts and exchanges, based on the addresses of listed telephone numbers, which is used to translate the census summary data to exchange-level data. These cell definitions are used for all three weight adjustments. If the number of cases (resolved, screened, and interviewed, respectively) is fewer than 20 in a cell, the categories are collapsed prior to adjustment, in the reverse order as listed above. These adjustments assume that, after controlling for known covariates, the rate of WRNs among unresolved landline phone numbers is the same as the rate of WRNs among resolved landline phone numbers (Step 2); the incidence of eligible children in

Stage 1: Household-level weighting

Step 1 — Base weights → Step 2 — Nonresolution adjustment → Step 3 — Screener nonresponse adjustment

Step 4 — Household noninterview adjustment → Step 5 — Adjustment for multiple telephone lines → Step 6 — Combination of quarterly samples → Annual household weights

Stage 2: Child-level weighting

Annual household weights → Step 7 — Adjustment for noncoverage of children in nonlandline telephone households → Step 8 — Simple post-stratication to population controls → Step 9 — Raking adjustment to population controls → Child-level interview weights

Stage 3: Provider-phase weighting

Child-level interview weights → Step 10 — Adjustment for provider nonresponse → Step 11 — Raking adjustment to population controls → Provider-phase weights

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2005–2010.

Figure 7. Weighting flowchart for National Immunization Survey–Child, 2005–2010

unscreened households is the same as that among screened households (Step 3); and noninterviews among eligible households are considered as missing at random (Step 4).

Step 5. Adjustment for multiple telephone lines—Among the households that completed the main interview, some reported having more than one residential telephone number for home use (excluding cell-phone numbers and telephone numbers used only for fax or computer). An adjustment to the weight is required for these households to compensate for their multiple chances of selection. The adjustment, which divides the survey weight from Step 4 by the reported number of landline telephone numbers, is calculated separately for each household. The number of telephone lines used in deriving the adjustment is capped at three, both to control variability in the adjusted survey weights and to guard against reporting bias.

Step 6. Combination of quarterly samples—The survey weights resulting from Step 5 relate to a given quarterly sample, each of which represents the full sampling-frame population of age-eligible children in landline telephone households. However, annualized estimates of vaccination coverage are produced by combining data from 4 consecutive quarters. Consequently, the quarterly weights need to be adjusted when the 4 quarters are combined. Since NIS–Child completed sample sizes in different quarters can vary, the adjustment factor for a quarter is computed as the number of households with a complete interview in the quarter divided by the total number of households with a complete interview over the 4 quarters.

The survey weights resulting from Step 6 represent the final annual household weights.

Child-level weighting

The next weighting step shifts from the household level to the child level. All age-eligible children from screened households are selected into NIS–Child. The initial child-level weight for each age-eligible child in a household with a completed household interview is the corresponding annual household weight

from Step 6. Three weight adjustments are carried out separately within each estimation area.

Step 7. Adjustment for noncoverage of children in nonlandline telephone households—The NIS–Child landline RDD sample does not cover households without access to any landline telephones, so an adjustment is required to compensate for the noncoverage of children living in households without access to a landline telephone.

This adjustment is applied to weights for children in households reporting an interruption in landline telephone service of 1 week or more during the past 12 months. The adjustment approach is based on empirical evidence suggesting that socioeconomic, demographic, and vaccination characteristics of phoneless households are more similar to households with an interruption in landline telephone service than to other landline telephone households. (45,46). The adjustment for children in households reporting a telephone service interruption is capped at three times the adjustment for children in households not reporting a telephone service interruption to control variability in the adjusted survey weights.

This adjustment was initially intended to provide a means of representing children in phoneless households. Over time, however, the adjustment increasingly provided a means of representing children in both phoneless and CPO households. Although there were concerns with use of this adjustment to represent the latter category of children, research suggested use of this adjustment would become even more appropriate as the proportion of CPO households increased (47).

Step 8. Simple poststratification to population controls—While the aim of Step 7 is to reduce bias due to the noncoverage of the nonlandline telephone population, NIS–Child is undoubtedly also subject to differential coverage of the population by race and ethnicity and other factors. As in almost any census or survey, some categories of persons are underreported at a higher rate than other categories. NIS–Child uses a simple poststratification scheme to reduce bias due to differential coverage.

Within each estimation area, the poststratification cells are defined by the race or ethnicity of the child's mother (Hispanic, non-Hispanic black alone, all other), educational attainment of the child's mother (less than or equal to 12 years, more than 12 years), and age category of the child (19–23 months, 24–29 months, 30–35 months). To control sampling variability, cells with fewer than 25 children are collapsed with neighboring cells. The derivation of population controls is presented following discussion of the weighting steps.

Step 9. Raking adjustment to population controls—During the simple poststratification adjustment, a number of cells have to be collapsed, either to ensure the minimum cell size of 25 records or to avoid an adjustment factor greater than 2. As a result, the marginal totals of the poststratified weights for some categories of the poststratification variables do not exactly match the population control totals at the marginal level within an estimation area. In addition, one other desired demographic variable—sex of the child—could not be used in simple poststratification to avoid sparseness of the weighting adjustment cells. To gain agreement with marginal totals, a raking-ratio estimator (48) is applied to the poststratified weights by using the following raking dimensions within each estimation area: three categories of race or ethnicity of the child's mother (Hispanic, non-Hispanic black alone, all other); two categories of educational attainment of the child's mother (12 years or less, more than 12 years); three categories of age of the child (19–23 months, 24–29 months, 30–35 months); and sex of the child (male, female). The raking adjustment utilized one additional raking dimension for 2005 and 2006, defined by telephone-service interruption status (interruption, no interruption).

The various adjustments may occasionally yield some extreme survey weights that are substantially larger than other survey weights in the same estimation area, which could adversely affect variances of the estimated vaccination coverage rates. Thus, in calculating the final child-level interview

weights, checks are made for weights that exceed a threshold defined as the median weight plus six times the interquartile range of the weights in the estimation area. Any weight exceeding this threshold is truncated to a value slightly lower than the threshold value. The overall goal of truncation is to reduce the mean squared error of the estimators.

Raking and trimming are iterated until convergence of the weighted counts to the population controls is achieved. The survey weights resulting from Step 9 are the child-level interview weights, which weight up to the overall population of age-eligible children, including children for whom provider consent was not obtained, provider consent was obtained but the provider(s) did not respond to the IHQ, provider consent was obtained but adequate provider data were not obtained, and provider consent was obtained and the provider data were determined to be adequate. The child-level interview weights are used to generate child-level estimates for data collected from the household interview.

Provider-phase weighting

The third stage of weighting involves two steps. Children who had no vaccinations (zero-shot kids) are not included in these steps. These are children without provider-reported vaccination histories for whom the household respondent reported that the child has zero vaccinations. See Appendix II for the complete definition of zero-shot status.

Step 10. Adjustment for provider nonresponse—For children for whom a household interview was completed, the respondent was requested to provide information to locate the child's vaccination provider(s) and consent to contact those provider(s). After obtaining the provider information and consent, the provider was contacted and asked to report vaccination information for the child. Provider data are missing for approximately 30% of the children for whom the household interview is complete, due to various factors, including parental nonconsent, provider nonresponse, and provider failure to supply adequate vaccination data. To

compensate for this form of nonresponse (missing APD), NIS–Child segments the children with a completed household interview in each estimation area into five essentially equal-sized cells on the basis of their model-based predicted response propensity (i.e., response to the provider phase of the survey or the event of having APD). Then, within each of these cells the child-level interview weight of each child with adequate provider data is multiplied by an adjustment factor equal to the ratio of the total child-level interview weight for all children to the total child-level interview weight for the children with APD. For more details on this method of adjustment, see Smith *et al*. (20).

A child's response propensity is the predicted probability that the child has APD, calculated from a logistic-regression model. The model is based on the data from all children with a completed household interview, excluding unvaccinated children, and the outcome or dependent variable is an indicator of whether the child has APD. In preparation for building the model, a list of potential predictor variables was assembled. These variables, available from the completed household interviews, have been found to be associated with vaccination status. Those characteristics were also relevant to the presence or absence of provider data, because empirical results suggested that children who have provider data are more likely to be UTD on their vaccinations than children who do not have provider data.

The logistic-regression model is updated annually, using NIS–Child data from the corresponding 4-quarter period. As such, the set of variables selected for inclusion in the model may change from year to year. Table 13 provides the list of variables considered for inclusion in the model, along with information showing which variables were selected each year.

Step 11. Raking adjustment to population controls—While the propensity-based adjustment reduces bias due to missing provider data, the adjusted weights do not generally match the control totals used for simple poststratification or raking or the weighted totals of other variables thought

to be associated with being UTD. It is possible, however, to arrive at weights that satisfy all these constraints through further raking. Within each estimation area, final adjusted weights are computed by a raking procedure using the following variables: race or ethnicity of the child (Hispanic, non-Hispanic black only, all other); educational attainment of the child's mother (12 years or less, more than 12 years); age of child (19–23 months, 24–29 months, 30–35 months); sex of child (male, female); firstborn status of child (yes, no); and child's response propensity adjustment cell ($q = 1,2,3,4,5$).

The survey weights resulting from Step 11 represent the provider-phase weights and are used to generate child-level estimates for data collected in the PRC and to generate official estimates of vaccination coverage, as described in a later section. Provider-phase weights for zero-shot kids are defined to be their child-level interview weights.

Summary information relative to sample sizes and variability of child-level interview and provider-phase weights is provided in Table 14.

Population control totals

The NIS–Child survey weights are controlled to independently derived estimates of the total number of age-eligible children in each estimation area. Because the NIS–Child target population is children aged 19–35 months, population controls are derived from natality data produced by the National Vital Statistics System (49), rather than from sources such as the U.S. Census Bureau, which typically provide estimates based on smaller samples and by single year of age or for age categories defined by a range of whole years of age. The natality data also yield population totals for several important subgroups to which it is desirable to control the weights, including subgroups defined by race or ethnicity, mother's education, sex, and age of child.

For each estimation area, the natality files (for the time period 19–35 months prior to the midpoint of the 4-quarter period to be estimated) provide the size of the population of eligible live births

(e.g., for the 2007 NIS–Child, live births occurring between July 1, 2004, and November 30, 2005, inclusive. These children would have been aged 19–35 months on June 30, 2007, the midpoint of the 2007 data year). The raw counts of births are adjusted to reflect three factors: infant mortality, immigration (i.e., children aged 19–35 months living in the United States who were born outside the United States), and domestic migration (i.e., children aged 19–35 months living in one area who were born in a different area). The first two adjustments are applied separately for Hispanic children, non-Hispanic black children, and non-Hispanic white children who are also of other races. Population control totals for 2006–2008 included an additional adjustment to account for the out-migration from Orleans Parish, La., and surrounding areas associated with Hurricane Katrina.

Infant mortality

The period linked birth/infant death *National Vital Statistics Reports* for a given year are referenced to obtain 1-year infant mortality rates for each racial or ethnic group within each state (50). These rates are applied to the counts of live births. However, this is an overestimate of the survivors to NIS–Child eligibility because it does not consider the deaths that occur between ages 12 and 19 months. The most recent life table available from NCHS' *National Vital Statistics Reports* was used to inflate the 1-year mortality rates to account for this additional time period (with three different adjustments for three different child-age subgroups).

Immigration

For 2005–2009, Public Use Microdata Sample (PUMS) data from the 2000 decennial census were used to estimate the number of immigrants to add. In order to obtain more current estimates of immigration rates, beginning with the 2010 population estimates process, the most recent 3-year American Community Survey (ACS) PUMS data were used to estimate the number of immigrants to add for the 50 states and the District of Columbia. Because ACS

is not conducted in the U.S. territories, the most recent decennial census PUMS sample is used for estimating immigration and migration to and from the U.S. territories.

Domestic migration

The most recent 3-year ACS PUMS and decennial census PUMS include state of current residence for children aged 1 and 2 years, and also the state where the child was born. This information cannot be used directly to estimate geographic mobility, because some children are born in a state different from their state of residence (e.g., children born in hospitals in the District of Columbia to mothers who live in Maryland). Vital statistics data on the state of residence of the mother at the time of birth and the state where the birth occurred are used to adjust the PUMS estimates to reflect only geographic mobility.

2011–2014 Dual-frame Estimation Methodology

Beginning in 2011, NIS–Child implemented a dual-frame sampling design, with the cell-phone sample design utilizing a "take-all" approach, in which all eligible cell-phone households are targeted for interview. For Q1/2011, the NIS sample design called for screening the cell-phone sample to restrict inclusion to CPO and CPM households ("screening" approach). NIS shifted to the take-all design in Q2/2011. The dual-frame weighting scheme involves the same three broad stages as for the landline-weighting scheme used in the 2005–2010 period and discussed previously: accounting for probabilities of selection and adjustment for household nonresponse (yielding annual household weights), adjusting for nonrepresentation of phoneless households and failure of the sampling frames to represent the full population of children (yielding child-level interview weights), and adjusting for provider nonresponse and controlling survey weights to independent population controls (yielding provider-phase weights). The objectives of the dual-frame weighting approach are to account for overlap between the two sampling

frames and to minimize the mean-square error of the estimated vaccination coverage rate at the estimation-area level.

Overview of dual-frame estimation and differences from landline-frame estimation

Survey weights for the landline and cell-phone samples must be integrated to provide weights yielding appropriate and efficient estimates for the full target population of children aged 19–35 months. The landline and cell-phone sampling frames overlap in coverage of the age-eligible population (i.e., children in dual-user households) and exclude a small portion of the age-eligible population (i.e., children in phoneless households). Consequently, the estimated coverage of the landline sampling frame for 2013 NIS–Child estimates was 52.9% of the child population, and it was 94.5% for the cell-phone sampling frame.

In addition to carrying out weighting steps as in the landline-frame estimation methodology, the dual-frame estimation methodology focuses on adjustment for overlap to minimize resultant variability in estimates from the dual-user domain and on adjustment for noncoverage of age-eligible children in phoneless households. In addition, survey weights must also adjust for any sample-frame coverage error associated with the landline-only (LLO) and CPO domains.

Adjustment to population controls by telephone status

Prior to adjusting for overlap between the landline and cell-phone samples, survey weights are adjusted to agree with independent estimates of the size of the population by telephone status, with adjustment to population estimates of the dual-user population being made separately for the landline sample and the cell-phone sample.

Telephone status population control totals are derived at the estimation-area level using a similar small area modeling approach as described in Blumberg *et al*. (51); see Table 4.

Adjustment for overlap of landline and cell-phone sampling frames

The landline-sampling frame covers the population in dual-user households as well as the population in LLO households, while the cell-phone sampling frame also covers the population in dual-user households as well as the population in CPO households. Thus, the sampling design supports one estimator each for the LLO and CPO domains and two estimators for the dual-user domain.

The sum of the telephone status-adjusted weights for the landline sample (which estimates the number of age-eligible children in landline households) and the sum for the cell-phone sample (which estimates the number of age-eligible children in cell-phone households) each encompass age-eligible children in dual-user households. The landline sample also encompasses age-eligible children in LLO households, and the cell-phone sample also encompasses age-eligible children in CPO households. Thus, when combining the landline and cell-phone samples, the telephone status-adjusted weights for children in dual-user households within each estimation area must be composited so the sum of the further adjusted weights across landline and cell-phone samples provides an appropriate estimate of age-eligible children in dual-user households (i.e., does not double count the number of children in dual-user households), while also providing efficient estimates for this domain.

Compositing of the telephone status-adjusted weights for the landline and cell-phone sample cases is carried out using factors derived so that the resulting composited weights yield minimum variance estimates. This compositing takes the form

$$\hat{Y}_{Da} = \lambda_a\, \hat{Y}_{L(D)a} + (1 - \lambda_a)\, \hat{Y}_{C(D)a}\,,$$

where $\hat{Y}_{L(D)a}$ is the estimated total of a characteristic of interest in estimation area a (e.g., total number of children in the population who are breast fed or UTD for the 4:3:1:3:3:1 vaccine series), based on children from the landline sample living in dual-user households; and $\hat{Y}_{C(D)a}$ is the estimated total in estimation area a based on children from the cell-phone sample living in dual-user households.

The composition factors λ_a that minimize the variance of the estimated total for the dual-user domain (assuming $\hat{Y}_{L(D)a}$ and $\hat{Y}_{C(D)a}$ are unbiased) can be expressed as

$$\lambda_a = \frac{Var\{\hat{Y}_{C(D)a}\}}{Var\{\hat{Y}_{L(D)a}\} + Var\{\hat{Y}_{C(D)a}\}}$$

$$= \frac{\dfrac{n_{L(D)a}}{DEFF_{L(D)a}}}{\dfrac{n_{L(D)a}}{DEFF_{L(D)a}} + \dfrac{n_{C(D)a}}{DEFF_{C(D)a}}}$$

where $n_{L(D)a}$ is the number of children in estimation area a from the landline sample living in dual-user households, $n_{C(D)a}$ is the number of children in estimation area a from the cell-phone sample living in dual-user households, $DEFF_{L(D)a}$ is the design effect (i.e., a weighting effect) associated with children in dual-user households from the landline sampling frame in estimation area a, and $DEFF_{C(D)a}$ is the design effect (i.e., a weighting effect) associated with children in dual-user households from the cell-phone sampling frame in estimation area a.

Adjustment of the weights is then implemented in consideration of the derived compositing factors:

$$W_j' = \begin{cases} W_j, & j \in L(LLO),\, a \\ \lambda_a W_j, & j \in L(D),\, a \\ (1 - \lambda_a)W_j, & j \in C(D),\, a \\ W_j, & j \in C(CPO),\, a \end{cases}$$

where W_j represents the weight for sample unit j following the preceding weighting step, $L(LLO)$ indicates the set of children from the landline sample living in LLO households, $L(D)$ indicates the set of children from the landline sample living in dual-user households, $C(D)$ indicates the set of children from the cell-phone sample living in dual-user households, and $C(CPO)$ indicates the set of children from the cell-phone sample living in CPO households.

Other refinements to the NIS–Child estimation methodology to accommodate the dual-frame sample design

Other refinements to the NIS–Child landline estimation methodology reflect the addition of the cell-phone sample. First, in Steps 1–6, base weights are derived and adjustments are carried out separately for the samples selected from the landline and cell-phone sample frames. Second, in Steps 9 and 11, telephone status is added as an extra dimension to the raking adjustments.

Description of dual-frame estimation methodology, 2011–2014

The dual-frame estimation methodology used for NIS–Child in 2011–2014 followed the three major stages used in 2005–2010: 1) derivation of annual household weights, 2) derivation of child-level interview weights, and 3) derivation of provider-phase weights (Figure 8).

The dual-frame annual household weight

Annual household weights are derived separately within each sample (landline, cell phone), following the same six steps (Step 1–Step 6) described previously for the 2005–2010 weighting methodology. When deriving annual household weights for the cell-phone sample, appropriate adjustments are made to the weighting methodology. Cell phone sample nonresponse adjustment cells are defined by cross-classifying the census region and MSA status (in MSA, not in MSA), and adjustments are made to account for the number of links between the eligible child and cell-phone numbers used by the child's parents in the household (52).

Child-level interview weights

Each age-eligible child in households with completed household interviews receives the survey weight for their household, with the second stage of weighting involving five steps all carried out within the estimation area. The first step (Step 7 in the overall weighting

Stage 1: Household-level weighting

Landline sample

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	
Base weights	Nonresolution adjustment	Screener nonresponse adjustment	Household noninterview adjustment	Adjustment for multiple landline telephone lines	Combination of quarterly samples	Landline sample, annual household weights

Cell-phone sample

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	
Base weights	Nonresolution adjustment	Screener nonresponse adjustment	Household noninterview adjustment	Adjustment for multiple cell-phone telephone lines	Combination of quarterly samples	Cell-phone sample, annual household weights

Stage 2: Combining landline and cell-phone samples and child-level weighting

Landline sample, annual household weights → Step 7: Ratio adjustment to landline population totals

Cell-phone sample, annual household weights → Ratio adjustment to cell-phone population totals

Step 8: Adjustment for combining landline and cell-phone samples

Step 9: Attenuation of cell-phone-only sample weights (2011 only)

Step 10: Ratio adjustment to estimation-area-level population totals

Step 11: Raking adjustment to population controls

→ Child-level interview weights

Stage 3: Provider-phase weighting

Child-level interview weights →

Step 12: Adjustment for provider nonresponse

Step 13: Ratio adjustment to population totals, by telephone status (2011 only)

Step 14: Adjustment for combining landline and cell-phone samples (2011 only)

Step 15: Attenuation cell-phone-only sample weights (2011 only)

Step 16: Raking adjustment to population controls

→ Provider-phase weights

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2011–2014.

Figure 8. Weighting flowchart for National Immunization Survey–Child, 2011–2014

methodology) is carried out separately by sample, with the remaining steps being carried out on the combined landline and cell-phone sample.

Step 7. Ratio adjustment to population totals by telephone status— The annual household weights are adjusted to agree with independent estimates of the size of the population by telephone status, with adjustment to population estimates of the dual-user population made separately for the landline and cell-phone samples (with adjustment for the overlap conducted in the next step).

*Step 8. Adjustment for combining landline and cell-phone samples—*The landline-sampling frame covers children in dual-user households as well as children in LLO households, while the cell-phone sampling frame also covers

children in dual-user households as well as children in CPO households. Compositing of the telephone status-adjusted weights for the landline and cell-phone sample cases is carried out as described previously, resulting in child-level weights W_j'.

Step 9. Attenuation of the CPO sample weights (2011 only)—An optimal balance of landline and cell-phone sample was not feasible in 2011 due to funding limitations. The cell-phone sample was relatively small, resulting in weights dramatically larger than those for the landline sample. The variability in the weights increased the variance of the estimated vaccination coverage rates. For 2012, 2013, and 2014, cell-phone sample sizes were sufficiently large, and so this step of attenuation of the CPO sample weights was not applied.

Attenuation of the sample weights for CPO cases was utilized to minimize the MSE of estimates. Attenuation was achieved by compositing the direct estimator of the CPO domain total with an estimator of the same domain total derived from a subset of the landline sample deemed to be "similar" to CPO sample cases (and referred to as proxy CPO cases). The predicted probability of a landline sample case being similar to CPO cases was determined using a logistic-regression model for predicting a CPO status run on the full set of dual-frame sample cases (i.e., both landline and cell), and including both sociodemographic characteristics and vaccination status variables as explanatory variables.

Landline cases with a predicted probability above a determined cutoff level were classified as proxy CPO cases.

This compositing was carried out using adjustment factors based on the variance and bias associated with the component estimates. The resulting adjusted survey weights yield minimum MSE estimates. This adjustment was accomplished through the expression

$$\hat{Y}_{CPOa} = \kappa_a\, \hat{Y}_{C(CPO)a} + (1-\kappa_a)\, \hat{Y}_{L(Proxy\ CPO)a}$$

where $\hat{Y}_{C(CPO)a}$ is the estimated total number of children in estimation area a with the attribute of interest (e.g., UTD for the 4:3:1:3:3:1 vaccine series) based on children with completed interviews

living in CPO households; $\hat{Y}_{L(Proxy\ CPO)a}$ is the estimated total number of children in estimation area a with the attribute of interest based on children obtained through the landline frame with completed interviews living in proxy CPO households; and the composition factor, κ_a, is

$$\kappa_a = \frac{V_{La} + B_{La}^2}{V_{Ca} + V_{La} + B_{La}^2}$$

where $V_{Ca} = Var\{\hat{Y}_{C(CPO)a}\}$,

$\qquad V_{La} = Var\{\hat{Y}_{L(ProxyCPO)a}\}$, and

$\qquad B_{La} = Bias\{\hat{Y}_{L(ProxyCPO)a}\}$

$\qquad\qquad = E\{\hat{Y}_{L(ProxyCPO)a} - \hat{Y}_{C(CPO)a}\}$

Adjustment of the weights for true and proxy CPO sample was then carried out in consideration of the empirical compositing factors

$$W_j'' = \begin{cases} \hat{\kappa}_a W_j'\,, & j \in C(CPO),\ a \\[4pt] \{1 + (1 - \hat{\kappa}_a)\} W_j'\,, \\ & j \in L(Proxy\ CPO),\ a \\[4pt] W_j'\,, & j \in C(D) \\[4pt] W_j'\,, & j \in L(D), \\ & j \notin L(Proxy\ CPO) \\[4pt] W_j'\,, & j \in L(LLO), \\ & j \notin L(Proxy\ CPO), \end{cases}$$

where $\hat{\kappa}_a$ is a sample-based estimator of κ_a. More information about the overall estimation procedure, and specifically the attenuation procedure, is discussed in Wolter, *et al* (53).

Step 10. Ratio adjustment to estimation area population totals (2012–2014)—A simple poststratification scheme to reduce bias due to differential coverage was carried out in 2011, using the same approach as that described for the 2005–2010 weighting methodology (ratio adjustment to poststratification cells defined by mother's race or ethnicity, mother's educational attainment, and child's age). This step was changed for 2012–2014 from a simple ratio adjustment to only estimation area overall population totals.

Within each estimation area, the poststratification cells are defined by the race or ethnicity of the child's mother

(Hispanic, non-Hispanic black alone, all other), educational attainment of the child's mother (12 years or less, and more than 12 years), and age category of the child (19–23 months, 24–29 months, 30–35 months). To control sampling variability, cells with fewer than 25 children are collapsed with neighboring cells.

Step 11. Raking adjustment and trimming of poststratified child weights—This step mirrors raking for the 2005–2010 weighting methodology, with one additional raking dimension: telephone status. The 2011 weighting methodology used four categories of telephone status: LLO, dual-user, CPO, and phoneless. For 2012–2014, because of the small proportion of LLO and phoneless households containing children, two categories were used (CPO, other).

The survey weights resulting from Step 11 represent the child-level interview weights, and they are used to generate dual-frame child-level estimates for data collected in the household interview.

Provider-phase weights

Dual-frame provider-phase weights are derived following the same two steps described previously for the 2005–2010 weighting methodology. For 2011 only, three additional steps were included between provider nonresponse adjustment (Step 12) and raking adjustment to population totals (Step 16). These steps were 1) adjustment to population totals by telephone status, 2) adjustment for combining the landline and cell-phone samples (repeated to optimize estimates based on data from the PRC), and 3) attenuation of the CPO domain weights. With the implementation of optimal allocation across the landline and cell-phone samples, these three steps were deemed unnecessary for 2012–2014. With the transition to a dual-frame sample design in 2011, additional variables (OWNER, TEL_SAMPFRAME) were considered and included in the response-propensity model for provider nonresponse, along with interactions between TEL_SAMPFRAME and other variables. Table 15 provides the list of additional

variables and shows which variables were selected each year.

The resulting survey weights represent the provider-phase weights, and they are used to generate dual-frame child-level estimates for data collected in the PRC, including estimates of vaccination coverage rates.

Population control totals by telephone status

With the inclusion of a cell-phone sample, more detailed population estimates by telephone status were needed for weighting the combined landline and cell-phone samples. Data from NHIS show that the percentage of children under age 18 years living in CPO households in the United States has grown from 4.9% in the second half of 2004 to 47.1% in the second half of 2013, and those living in LLO households has decreased from 31.4% to 3.8% during this same period (22). Moreover, there is significant variation across states in the CPO estimates for children under age 18 (51).

NHIS is designed to produce national-level estimates but does not have a sufficient sample size to produce reliable, direct estimates at the NIS–Child estimation-area level. In order to produce telephone status estimates at the estimation-area level, small-area modeling techniques are used to combine direct estimates for each telephone-service-use category obtained from NHIS with auxiliary data from ACS to produce model-based estimates for children aged 19–35 months and adolescents aged 13–17. Initial model-based estimates are produced for the proportion of children under age 18 who lived in households that were CPO, cell-phone-mostly, dual-user, landline mostly, and LLO, following the methodology (51).

Because NIS–Child requires telephone status estimates for children aged 19–35 months, the annual estimates for children aged 0–17 years for each estimation area are adjusted using a multistep process. The annual estimates for children aged 0–17 years are ratio adjusted using NHIS estimates for children aged 1–2 years (used as an approximation for children aged 19–35

months) at the census region level. Next, these adjusted estimates of proportions are calibrated so that they agree by estimation area with the most recent 1-year ACS estimate for the proportion of children living in households with a telephone. These calibrated estimates are the final telephone status estimates. Finally, population control totals (Table 4) for children aged 19–35 months by estimation area and telephone status are obtained by multiplying these proportions by telephone status, times the population totals for children aged 19–35 months by estimation area, obtained using natality data from NCHS' National Vital Statistics System (49).

Ratio Estimator of the Vaccination Coverage Rate and the Taylor Series Estimator of Its Variance

Ratio estimator

Estimates of vaccination coverage in NIS–Child are weighted proportions of children who are UTD, often in some domain of interest (such as an estimation area or a racial or ethnic population). Formally, those proportions are ratio estimators, either within a sampling stratum (sampling frame by estimation area), or combining the data across strata.

In this section, let L represent the number of sampling strata, N_h be the number of households in the population in stratum h, M_{hi} be the number of age-eligible children in household i of stratum h,

$$Y_{hij} = \begin{cases} 1, & \text{if the } j\text{th child in the } (h,i)\text{-th} \\ & \text{household is UTD for a given} \\ & \text{vaccine} \\ 0, & \text{otherwise,} \end{cases}$$

and

$$\delta_{hij} = \begin{cases} 1, & \text{if the } j\text{th child in the } (h,i)\text{-th} \\ & \text{household is in the} \\ & \text{domain of interest} \\ 0, & \text{otherwise.} \end{cases}$$

Letting

$$Y_h = \sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} \delta_{hij} Y_{hij}$$

and

$$T_h = \sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} \delta_{hij}$$

the true but unknown vaccination rate for the domain is

$$\theta = \frac{\sum_{h=1}^{L} Y_h}{\sum_{h=1}^{L} T_h}$$

Let n_h be the number of households sampled in stratum h, m_{hi} the number of age-eligible children in household i of stratum h, and W_{hij} the final provider-phase weight for the (h, i, j)-th child. Then, the combined ratio estimator of the vaccination rate for the domain of interest is given by

$$\hat{\theta} = \frac{\sum_{h=1}^{L} \hat{Y}_h}{\sum_{h=1}^{L} \hat{T}_h}$$

where

$$\hat{Y}_h = \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} W_{hij} \delta_{hij} Y_{hij}$$

and

$$\hat{T}_h = \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} W_{hij} \delta_{hij}$$

Taylor-series estimator of variance

If any biases are small (due to the use of model-based population estimates by estimation area for calibration purposes and to any other measurement factor), then variance estimates can be used to make valid inferences to the population of age-eligible children. (Nonsampling errors and bias are discussed in "Assessment of Total Survey Error".) To estimate the variance of $\hat{\theta}$, a Taylor-series approximation is used (54).

Let

$$\bar{Z}_h = \frac{\sum_{i=1}^{n_h} Z_{hi}}{n_h}$$

$$Z_{hij} = \frac{W_{hij} \delta_{hij} (Y_{hij} - \hat{\theta})}{\sum_{h=1}^{L} \hat{T}_h}$$

and

$$Z_{hi} = \sum_{j=1}^{m_{hi}} Z_{hij}$$

then, the Taylor-series estimator of the variance of $\hat{\theta}$ is (neglecting higher-order terms)

$$v(\hat{\theta}) = \sum_{h=1}^{L} \frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} (Z_{hi} - \bar{Z}_h)^2$$

For NIS–Child, the crossing of frame (landline and cell phone) by estimation area serves as the sampling strata, while the household serves as the primary sampling unit. This estimator of variance is based on an assumption of with-replacement sampling of primary sampling units within strata, which closely mirrors the situation found in NIS–Child, because the sampling fractions of household primary sampling units within frame-by-estimation-area strata are generally quite small.

Program code

Program code for estimating vaccination coverage rates and their standard errors using SUDAAN, SAS, and *R* are available in the NIS–Child data user's guide (55).

NIS–Teen

Introduction

NIS–Teen, which targets the national population of adolescents aged 13–17, was launched in Q4/2006 and in Q4/2007 (56,57). Annual data collection for the estimation areas began in 2008, for all 4 quarters of the year, and continued through 2014. NIS–Teen uses a subsample of the telephone numbers selected for NIS–Child and the two-phase data-collection model of NIS–Child. (The household and provider surveys are closely modeled after the corresponding surveys used in NIS–Child.) Vaccines routinely recommended for adolescents and selected childhood catch-up vaccines are monitored in NIS–Teen (Table 2). As new vaccines are added to the Advisory Committee on Immunization Practices "Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger" (available from: https://www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html), they are included in NIS–Teen data collection as

soon as 2 calendar quarters after being added to the schedule. CDC first published the NIS–Teen estimated vaccination coverage rates in a 2007 report (17); this report and additional publications are available from: https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations.html. Public-use microdata files for data analysis are available from: https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html.

Sample Design

NIS–Teen was designed initially to achieve a nationally representative sample of 5,000 completed household interviews for adolescents in each of the years 2006 and 2007. For survey years 2008 and 2009, NIS–Teen was redesigned and expanded to produce state and local-area estimates to achieve 180 effective completed interviews for adolescents with adequate provider data (APD) in each of the core 56 estimation areas defined for NIS and additional substate supplemental areas and U.S.-affiliated jurisdictions, as defined from year to year. In 2010–2014, the target sample size per estimation area was increased further to achieve a coefficient of variation (CV) of the estimated annual vaccination coverage rate of no more than 6.5%, assuming the true coverage rate is 50%, which required approximately 230 effective adolescents with APD per estimation area. The supplemental areas (beyond the core 56 areas) included in NIS–Teen varied from year to year and were not always the same as the supplemental areas included in NIS–Child.

In households with multiple adolescents, one age-eligible adolescent is selected at random to be the subject of the survey. This process differs from NIS–Child, which targets all children aged 19–35 months in the household. Since the eligibility rate in the population is much higher for adolescents aged 13–17 than for children aged 19–35 months, the screening sample size requirements are smaller than what is required for NIS–Child. The required adolescent sample size per estimation area can

generally be met utilizing a subsample of the NIS–Child RDD screening sample.

Prior to 2011, the sampling for NIS–Teen was based on a subsample of the NIS–Child single-frame landline RDD sample. In Q4/2010, just as a small national cell-phone sample was piloted to assess and prepare for eventual integration of a cell-phone RDD sample with the traditional landline RDD sample for NIS–Child, a small national cell-phone subsample of the NIS–Child sample was piloted for NIS–Teen. See "Evaluation of NIS Estimates and Methods" for a description of this pilot study. In the 2011 NIS–Teen, a cell-phone RDD sample stratified by estimation area was fielded, and NIS–Teen became a dual-frame telephone survey. At that point, the cell-phone sample size within each estimation area remained relatively small. Beginning in 2012, a much larger and optimally allocated cell-phone RDD sample was introduced in NIS–Child. Correspondingly, NIS–Teen used a larger and near optimally allocated cell-phone sample starting in 2012 (31). In a few estimation areas, it was not possible to use a fully optimal allocation for NIS–Teen because children aged 19–35 months tended to live in CPO households at a higher rate than adolescents aged 13–17. A fully optimal allocation for NIS–Teen would require a larger sample size than NIS–Child provides.

NIS–Child 2006 completion rates were used to plan the sample size required for the 2006 NIS–Teen. The planning value of the eligibility rate for the 2006 NIS–Teen sample was determined by estimating the proportion of households with adolescents aged 13–17, using the Current Population Survey for Q4/2006 and applying a conservative discount factor to ensure the sample drawn and prepared for NIS–Teen fielding would be of sufficient size. Eligibility rates and completion rates for planning the 2007–2014 NIS–Teen sample sizes were determined using both NIS–Child and NIS–Teen actual rates from previous surveys.

As noted, age-eligible adolescent households are generally more prevalent than age-eligible child households. The NIS–Teen sample size needed in the

telephone sampling frame to obtain the required number of completed household interviews at the estimation area level is generally, though not always, smaller than the sample size needed for NIS–Child. For this reason, only a subsample of the telephone numbers released for NIS–Child are needed for screening to identify a sufficient sample of households with age-eligible adolescents. The subsampling rates are based on the ratios of the estimated sample sizes needed for NIS–Teen to those needed for NIS–Child at the estimation-area level, and the telephone numbers chosen to be screened for adolescents aged 13–17 are randomly selected from the NIS–Child sample within each estimation area. At the national level in 2013, approximately 70% of NIS–Child landline RDD sample telephone numbers and approximately 85% of NIS–Child cell-phone RDD sample telephone numbers were needed to conduct NIS–Teen. The required numbers vary by estimation area, due to variation in area-specific eligibility and completion rates. In some estimation areas, 100% of the telephone numbers in the NIS–Child sample are needed for NIS–Teen. Sample release occurs continuously throughout a data-collection quarter and the fielding of the sample is monitored on a daily basis within and across quarters to assure the completion of the required number of household and provider interviews.

The data user's guide for NIS–Teen contains additional information on the sample selection procedures (57).

NIS–Teen Survey Instruments

Similar to NIS–Child, the NIS–Teen household questionnaire contains a screening section to determine household eligibility (has at least one age-eligible adolescent), followed by the main household questionnaire administered only to eligible households. The NIS–Teen screening section collects a roster of all age-eligible adolescents in the household, which is used to make a random selection of only one eligible adolescent from each household reporting multiple eligible adolescents.

The standard sections included in the NIS–Teen household questionnaire are the same as for NIS–Child. The NIS–Teen PRC questionnaire, known as the immunization history questionnaire (IHQ), collects information about the provider's practice and the vaccination history of the selected adolescent. It has a similar structure, format, and content as the NIS–Child IHQ. The NIS–Teen household questionnaire and IHQ are available from: https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html.

The NIS–Teen screening interview is conducted following all NIS–Child interviewing of the household. If the household is determined to be ineligible for NIS–Child, then the overall interview flows directly into the NIS–Teen screening interview and then to the NIS–Teen main interview, if an age-eligible adolescent is identified. Otherwise, the NIS–Teen screening interview is delayed until after the NIS–Child main interview is completed. Approximately 3% of age-eligible and interviewed NIS–Child households are also age-eligible and interviewed for NIS–Teen each year.

Response Rates and Key Indicators

As with NIS–Child, multiple indicators of survey progress and data quality are produced routinely for NIS–Teen for each estimation area and at the national level both for the landline and cell-phone RDD samples in each data-collection year. These indicators include the resolution rate of released telephone numbers, the age-screening completion rate, and the interview completion rate. Key indicators for the landline RDD sample (Table 16), key indicators for the cell-phone RDD sample (Table 17), and response rates based on the combined landline and cell-phone RDD samples (Table 18) are presented below.

Table 16 presents key indicators at the national level for data collection for Q4/2006, Q4/2007, and each year from 2008 through 2014. For example, in the 2013 landline RDD sample, 958,731 telephone numbers were called via CATI to obtain estimates of vaccination

coverage with predefined precision (CV is 6.5% or lower within each estimation area) for NIS–Teen. Among the identified households, 6.5% contained one or more age-eligible adolescents. The CASRO response rate was 51.1%. It can be calculated as the product of the resolution rate (83.5%), the age-screening completion rate (86.1%), and the interview completion rate among age-eligible households (71.1%).

Table 17 shows that among the identified households in the cell-phone RDD sample in 2013, 6.7% contained one or more age-eligible adolescents. The 2013 CASRO response rate was 23.3%.

It is instructive to compare the age-eligibility rates in the two samples. In the landline sample (Table 16), the eligibility rate experienced a long-term decline—from around 10% in 2006 to around 6% in 2014—due to the general migration of U.S. households from landline to CPO status. Meanwhile, eligibility was relatively stable in the cell-phone sample (Table 17), and the rate of eligibility—around 7%—was slightly higher than the rate of eligibility in the landline sample by 2014.

For the PRC phase of NIS–Teen, Table 16 shows that interviews were completed for 10,148 age-eligible adolescents in the 2013 landline sample and lists the monitoring indicators for the PRC phase for those interviewed households. Specifically, 68.3% of household respondents provided consent to contact their adolescent's vaccination providers. The number of IHQs mailed to vaccination providers was 11,659. This is greater than the total number of adolescents with consent because some adolescents had more than one nominated vaccination provider. In 2013, among adolescents with completed household interviews in the landline sample, 6,039 (59.5%) were determined to have APD.

In the 2013 cell-phone sample, among the adolescents with completed parental interviews, consent to contact vaccination providers was obtained for 65.0%, and APD were obtained for 54.5% of adolescents (Table 17).

The response rate for the combined NIS–Teen landline and cell-phone samples is defined as the total number of

households with a completed adolescent interview, divided by the estimated total number of eligible adolescent households across both sample types, where the estimated total number of adolescent eligible households is equal to the sum of the estimated number of adolescent eligible households in the landline sample and the estimated number of adolescent eligible households in the cell-phone sample. Table 18 presents the response rates for the combined samples.

Trends in Key Indicators for NIS–Teen, 2006–2014

Trends in the CASRO response rate

Figure 9 displays the trends in key indicators of data-collection progress for NIS–Teen for each year from 2006 through 2014 for the landline RDD samples (with 2006 and 2007 fielding only in Q4 of each year), excluding U.S. territories. The CASRO response rate (Table 16) rose from 56.2% in Q4/2006 to 60.3% in 2014, with the lowest CASRO rate over the period occurring in 2013. Of the three completion rates contributing to the CASRO response rate, the resolution rate remained relatively stable during the period, the screening completion rate rose over the 9-year period, and the interview completion rate declined slightly, from 83.7% in Q1/2006 to 71.1% in 2013 before rebounding to 83.8% in 2014. The rebound in the interview completion rate is attributed to the shorter NIS–Teen questionnaire introduced in 2014, which eliminated questions that gathered parental reporting of adolescent vaccinations. Part of the decline in the interview completion rate during the 2010–2013 period may be due to the inclusion of the Parental Attitudes topical module (see "Topical Modules") and the addition of new vaccine-related questions for HPV and meningitis shots. Respondents were advised of longer administration times due to the inclusion of the additional topical module questions, which may in turn, have resulted in more interview break-offs.

Trends in key indicators for the cell-phone RDD sample for the 2011–2014 period are presented in Figure 10. The CASRO rate increased from 22.4% to 31.2% over the 4-year period, with the resolution and screening completion rates contributing to the upward trend.

The broad movements in the combined response rate documented in Table 18 are the result of the changing composition of the two NIS–Teen samples. A relatively small cell-phone sample was added to NIS–Child and NIS–Teen beginning in 2011. In 2012 and especially in 2013, the NIS surveys moved toward an optimum allocation of the overall survey resources, which resulted in a surge in the size of the

[1]Percentage of resolved working residential numbers for which the respondent completed the household age-eligibility screener.
[2]Percentage of sampled telephone numbers that were resolved as working residential numbers, nonworking numbers, or nonresidential numbers.
[3]Percentage of screened, eligible households for which a National Immunization Survey–Teen household interview was completed.
[4]Percentage of adolescents with completed household interviews for which adequate provider data was obtained.
[5]CASRO is Council of American Survey Research Organizations. The CASRO response rate is the product of the resolution rate, the screening completion rate, and the interview completion rate.
SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Teen, 2006–2014.

Figure 9. Trends in key indicators from household and provider data collections for National Immunization Survey–Teen: Landline random-digit-dialing sample excluding U.S. territories, 2006–2014
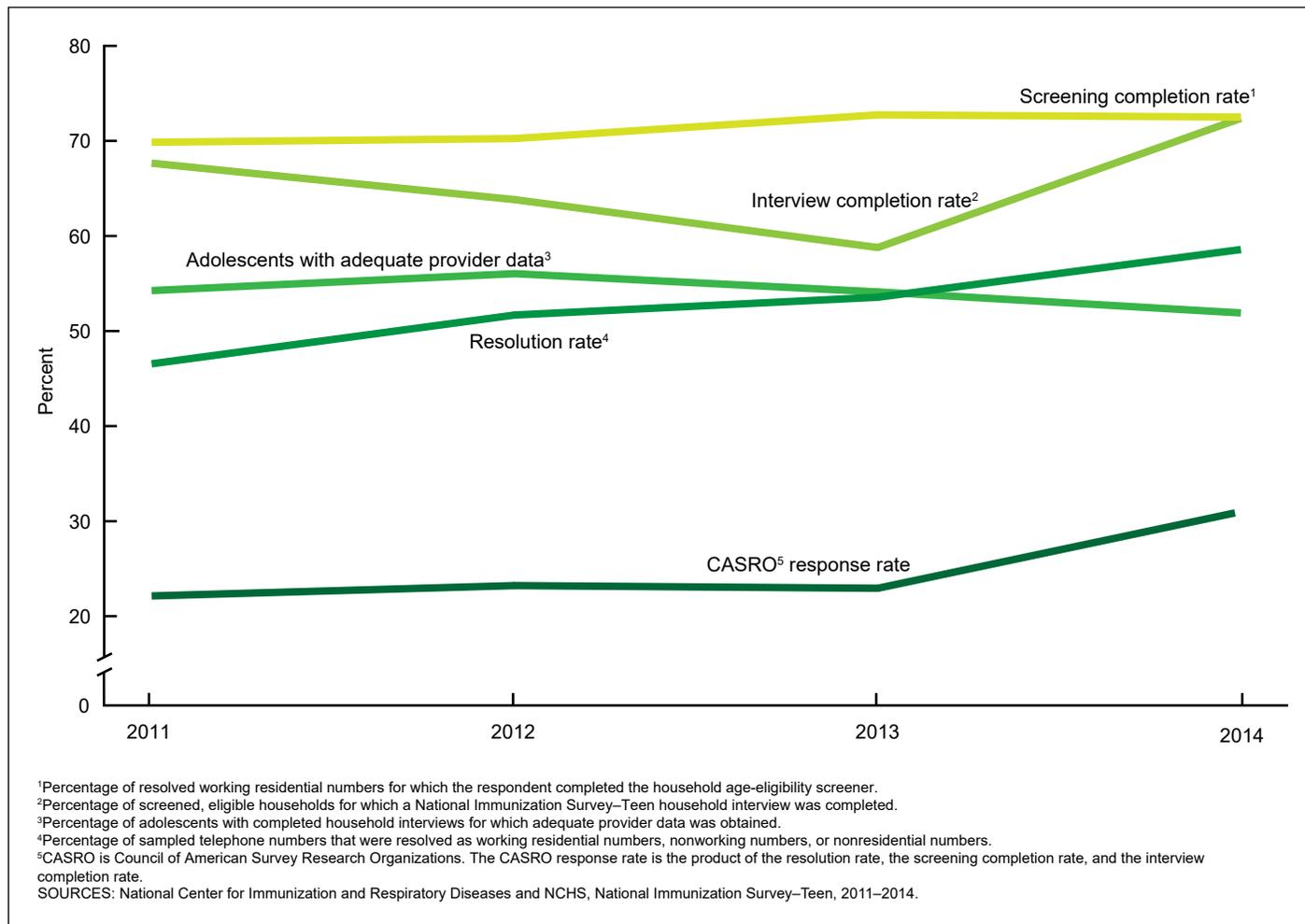
Figure 10. Trends in key indicators from household and provider data collections for National Immunization Survey–Teen: Cell-phone random-digit-dialing sample excluding U.S. territories, 2011–2014

[1]Percentage of resolved working residential numbers for which the respondent completed the household age-eligibility screener.
[2]Percentage of screened, eligible households for which a National Immunization Survey–Teen household interview was completed.
[3]Percentage of adolescents with completed household interviews for which adequate provider data was obtained.
[4]Percentage of sampled telephone numbers that were resolved as working residential numbers, nonworking numbers, or nonresidential numbers.
[5]CASRO is Council of American Survey Research Organizations. The CASRO response rate is the product of the resolution rate, the screening completion rate, and the interview completion rate.
SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Teen, 2011–2014.

cell-phone sample starting in 2012 and increasing even more in 2013, and a corresponding decline in the size of the landline sample. The following year the surveys faced a budget restriction in 2014, which forced use of a suboptimum allocation of the survey resources, resulting in an increase that year in the size of the landline sample and a decrease in the size of the cell-phone sample. The budget problem was temporary—by 2015 and 2016, the cell-phone samples returned to their optimum sizes. For NIS–Teen, the landline response rate has generally been around twice the cell-phone response rate. Thus, as the size of the cell-phone sample increased (or decreased) from year to year, the combined response rate decreased (or increased). This pattern is evident in the lower combined response rate in 2013 and the higher rate in 2014.

Trends in the number of advance letters mailed

To maximize response rates, advance letters are mailed to sample telephone numbers for which addresses are obtained using a reverse-match procedure. From Q4/2006 through Q4/2014, mailed advance letters, a percentage of telephone numbers released to CATI in the NIS–Teen landline sample, steadily declined, from 59.1% to 40.4%. The decline is likely due to the declining WRN rate in the landline sample, as households increasingly have only cell phones (22). Advance letters were not used for the cell-phone RDD sample because mailing addresses were not available for cell-phone numbers.

Trends in the percentage of adolescents with APD

The percentage of adolescents with APD in the landline RDD sample increased, from 52.7% in Q4/2006 to 57.1% in 2014 (Table 16). The increase beginning in 2007 was mainly due to the IHQ return rate, which increased from 89.2% in Q4/2006 to 94.9% in Q4/2014 data collection. As the NIS–Teen PRC became integrated into the NIS–Child PRC operations, it benefitted from the best practices that had been established for NIS–Child.

Potential limitations of APD

Among adolescents for whom at least one identified vaccination provider returned the IHQ or medical records containing a vaccination history, a set of

rules determined whether the adolescent was considered to have APD. From Q4/2006 through Q4/2013, these rules were as follows:

- The adolescent was considered to have APD if the responding provider(s) reported the adolescent was UTD with the recommended number of doses of the following vaccines: 1 or more doses of Td/Tdap; 3 or more doses of hepatitis B or 2 or more doses of 1.0 ml hepatitis B Recombivax; 2 or more doses of measles-mumps-rubella; and 1 or more doses of varicella vaccine or a history of chicken pox disease.

- The adolescent was also considered to have APD if the adolescent was UTD for the vaccines listed above when vaccinations after the date of the household interview were counted.

- The adolescent was still considered to have APD unless the responding provider(s) reported fewer doses of the key recommended vaccines

than the household respondent, in which case the adolescent was not considered to have APD.

Beginning in 2014, the rules for classifying an adolescent as having APD in NIS–Teen were updated to coincide with the shortening of the NIS–Teen questionnaire in which most parental reporting of specific vaccinations was eliminated. The updated rules classify an adolescent as having APD if 1) one or more of the named providers report vaccination history data or 2) a parent and provider reports agree that the adolescent is completely unvaccinated.

The rules for an adolescent to be considered zero-shot (adolescent is also classified as having APD) are the same as for NIS–Child.

Among adolescents with APD, Figure 11 shows the trends in the percentage of adolescents with two or more providers from Q4/2006 to Q4/2014 in the landline sample, excluding U.S. territories. This percentage increased slightly over the 2006–2009 period, ranging between 37% and 40%, before

increasing to more than 50% in 2010–2014.

The increase was due to a household questionnaire change. When respondents were asked to identify the adolescent's vaccination providers, beginning in Q1/2010, they were specifically asked to include hospitals, school and workplace clinics, juvenile detention centers, and emergency rooms, resulting in an increase in the number of providers identified per adolescent. Figure 11 also shows, among adolescents with APD and two or more providers, the percentage that have some, but not all providers reporting. This rate was 65.0% in Q4/2006 and 66.5% in Q4/2007 and dropped slightly to 62.0% by 2014. The decrease beginning in 2008 reflects the higher IHQ return rates beginning that year.

Vaccination records for a given adolescent may be scattered across the offices of the various providers who have seen the adolescent. An adolescent's vaccination history may be established incompletely for one

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Teen, 2006–2014.
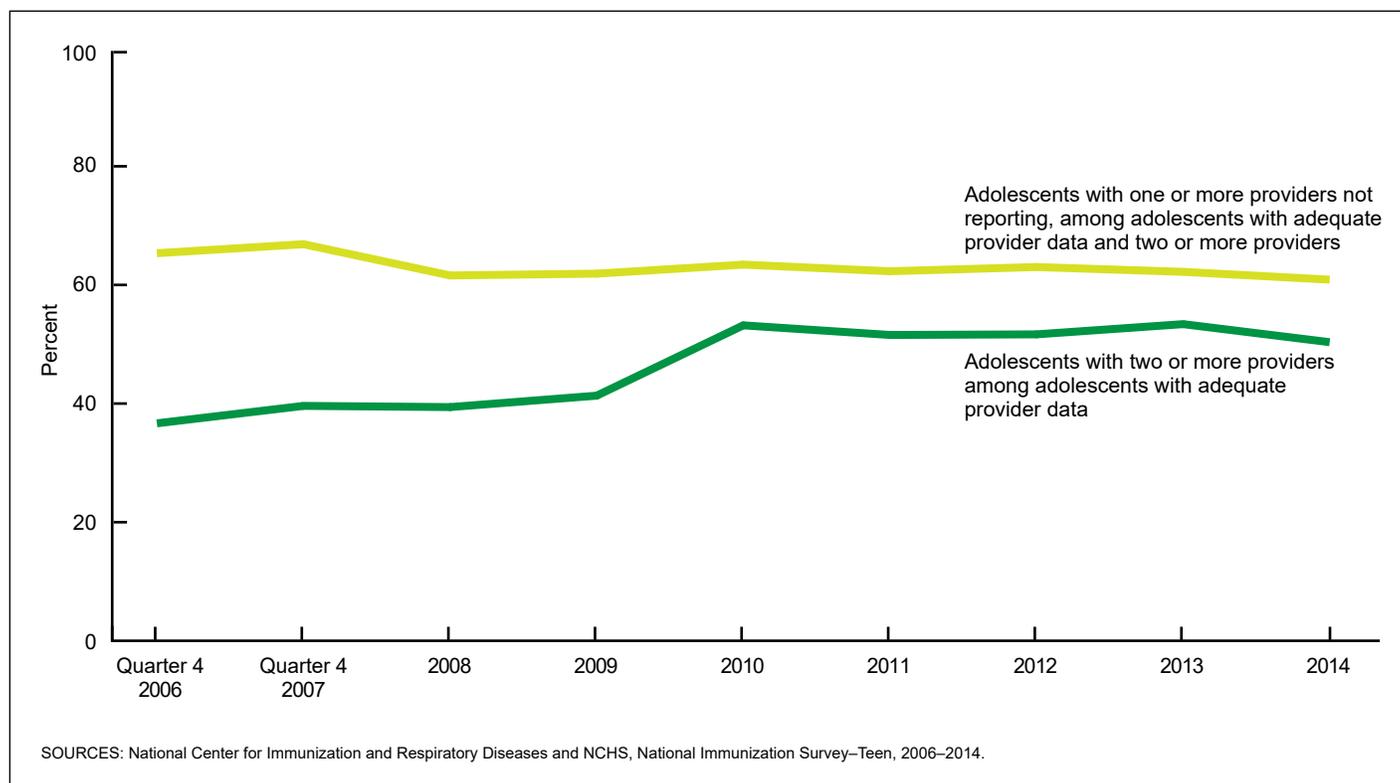
Figure 11. Trends in percentages of adolescents with two or more providers among adolescents with adequate provider data, and adolescents with one or more providers not reporting among adolescents with adequate provider data and two or more providers, for National Immunization Survey–Teen: Combined landline and cell-phone random-digit-dialing samples excluding U.S. territories, 2006–2014

or more vaccines, depending on the completeness of the reported set of providers available to include in the PRC, whether providers respond to the PRC, and whether the reported information indicates that the adolescent is not UTD with recommended vaccinations. Compiling an incomplete vaccination history due to record scattering has been shown to exist for children aged 19–35 months (37,38). Furthermore, in NIS–Child, the gathering of vaccination history has been shown to differ by sociodemographic characteristics, including race and ethnicity (40). The potential for incomplete gathering of some adolescents' vaccination histories from Q4/2006 to Q4/2014 due to record scattering may have impacted which adolescents in NIS–Teen were deemed to have APD, since the rules relied heavily on provider-reported vaccination statuses. Users of NIS–Teen data are cautioned to consider whether differences observed in vaccination coverage rates between sociodemographic and geographic subpopulations may, at least in part, be attributed to differences in incomplete gathering by subpopulation.

Estimation Methodology

Vaccination coverage rate estimates and corresponding variance estimates for NIS–Teen are produced for each estimation area, each state, and the country once a year in May (in June, prior to 2014). The annual estimates include data collected in the Q1–Q4 surveys from the previous calendar year.

NIS–Teen followed similar data-processing steps and editing procedures as those used by NIS–Child for merging the household and provider data, determining the most accurate date of birth, and synthesizing the vaccination histories from possible multiple provider reports to determine whether the adolescent had APD. Missing values in variables necessary for creating sampling weights were imputed using hot-deck imputation methods, as described for NIS–Child. These variables included the adolescent's sex; number of landline telephone numbers in the household; mobility status; household income; and

demographic variables, such as maternal marital status, maternal education, race, ethnicity, and maternal age.

The weighting procedure for the NIS–Teen annual landline sample accounts for variation in sampling rates, differential response rates, and differential sample-frame undercoverage, and it mirrors the multistep weighting procedure used for NIS–Child, with one difference. The NIS–Teen procedure includes an additional step after adjusting for nonresponse to the age-eligibility screener: to multiply the emergent weight by the number of eligible adolescents in the household as a means of accounting for the random selection of one adolescent per household.

Two final weights are calculated annually for NIS–Teen: an RDD-phase weight to analyze household-reported data and a provider-phase weight to analyze provider-reported data. The set of adolescents with APD and their weights are then used to tabulate vaccination coverage rates for publication in reports, journals, and on CDC's TeenVaxView website (available from: https://www.cdc. gov/vaccines/imz-managers/coverage/ teenvaxview/data-reports/index.html).

Figure 12 and Table 19 provide the estimated percentages of adolescents by telephone status within estimation areas that were used to provide population control totals in the dual-frame weighting procedure for the 2013 NIS–Teen data. The data user's guide for NIS–Teen contains additional information about the estimation methodology (57).

Topical Modules

Introduction

From the inception of NIS–Child in 1994, its primary purpose has been to provide data to estimate vaccination coverage rates for specified local geographic areas, the 50 states and the District of Columbia, and the United States. In addition, the survey collects child, maternal, and household characteristics to identify and track disparities in vaccination coverage associated with those factors, and to

track progress in achievement of Healthy People vaccination coverage objectives (58).

In 2001, "topical modules" were added to NIS–Child to provide further information about financial barriers to vaccinations, VFC, parental concerns about vaccines as a barrier to becoming vaccinated, the effect of vaccine shortages, and the use of NIS–Child as a sampling frame for data collection on other childhood and maternal topics. From 2001 through 2014, a wide array of topical modules were added to NIS–Child and NIS–Teen. Although topical modules are most commonly administered as additional questionnaires within the NIS–Child or NIS–Teen interviews and to all household respondents, they were also conducted as separate follow-up surveys to previous respondents or offered to a subset of survey respondents at the time of the NIS–Child or NIS–Teen interviews.

This section provides a synopsis of the topical modules conducted from 2001 through 2004 and more in-depth descriptions of the topical modules conducted from 2005 through 2014. Table 20 gives a quick summary of these modules.

NIS–Child Knowledge, Attitudes, and Practices Module

The first topical module administered was the Knowledge, Attitudes, and Practices (NIS–KAP) module. Its objective was to determine how parental knowledge and attitudes and health care provider's attitudes and practices affected children's vaccination status. Conducted in 2001 as a follow-up interview of households that participated in the 2000–2001 NIS–Child, NIS–KAP was designed to collect data on parents' concerns about vaccinating their children. Upon consent from the parents, a mail survey was sent to children's providers asking questions about provider attitudes and practices. Published results from the NIS–KAP study documented the prevalence of parents who sought medical attention for a child due to an adverse event following immunization,
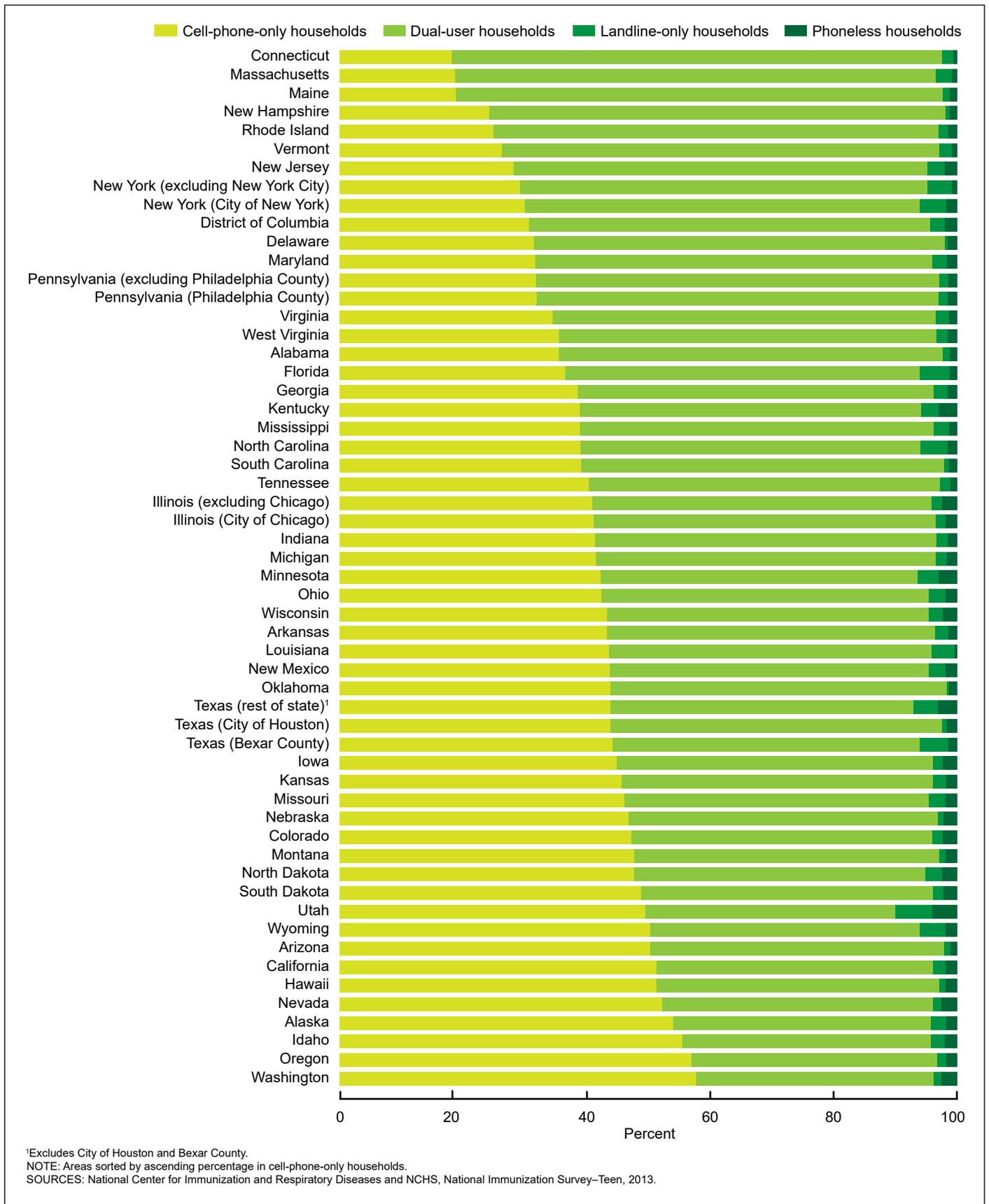
Figure 12. Percentage of adolescents aged 13–17 in the population, by telephone status within estimation area, 2013

and vaccine-related attitudes and beliefs of parents who sought medical attention for a child after an adverse event following immunization (59).

Concurrent Modules, 2001–2002

NIS–Child added three topical modules and conducted them concurrently between Q3/2001 and Q4/2002 using a split sampling design (21). Those modules were the Health Insurance and Ability to Pay for Vaccines Module (HIM); Parental Knowledge and Experiences Module (PKM); and Daycare, Breastfeeding Practices, and WIC Module (DCM) (available from: https://www.cdc.gov/nchs/data/nis/nisdug01.pdf).

The purpose of HIM was to provide information on economic and health insurance-related barriers to vaccinations, to evaluate how those barriers were associated with vaccination coverage levels, and to provide information on vaccination coverage levels for children who were entitled to the VFC Program (60–62). The PKM aimed to provide further information on how parental concerns about vaccine safety affected vaccination coverage (63–68). Data from the DCM were collected to evaluate the vaccination status of children aged 19–35 months who were enrolled in the Women, Infants, and Children (WIC) Program (69). These data were precursors for a series of questions now part of the routine NIS–Child that assess breastfeeding practices and WIC participation (available from: https://www.cdc.gov/nchs/data/nis/nisdug01.pdf).

Vaccine Shortage and Vaccine Safety Modules

Two new topical modules were conducted from Q2/2003 through Q4/2003: Vaccine Shortage Module and Vaccine Safety Module (available from: https://www.cdc.gov/nchs/data/nis/nisdug04.pdf). Data from the 2003 Vaccine Shortage Module were used to evaluate the effects of shortages at that time of the pneumococcal vaccine (70), while data from the 2003 Vaccine Safety

Module were used to show how parents' concerns about vaccine safety might be moderated to achieve high levels of vaccination coverage (71).

Influenza Module

NIS–Child conducted an Influenza Module from Q1/2004 through Q4/2004, and data were used in unpublished analyses of seasonal influenza coverage rates.

Revisions to HIM

HIM was revised in 2005 to conform to changes in insurance questions used in NHIS. NIS–Child introduced the revised module in 2006. Since then, HIM is asked of sampled households that complete sections A–D of the NIS–Child telephone interview, and is administered in English, Spanish, and other languages via Language Line Services (available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISPUF07_DUG.pdf). HIM was included as section E of the NIS–Child household interview questionnaire starting in 2006, available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISPUF13_HHQuex.pdf. In 2006, 29,880 children had a completed household interview. Among these children, 24,712 completed HIM, resulting in a completion rate of 82.7%.

The HIM data enabled researchers to determine whether sampled children are covered by private insurance, public insurance (Medicaid or their state's Children's Health Insurance Program), military insurance (TRICARE), or the Indian Health Service. The HIM data were used to identify children entitled to receive publicly purchased vaccines through their state's VFC Program at the time of the NIS–Child telephone interview. The VFC Program helps provide vaccines to children whose parents or guardians may not be able to afford them. Children are eligible for the VFC Program if they are under age 19 years and are on Medicaid, uninsured (not covered by health insurance), underinsured (insurance does not

cover vaccines or covers only selected vaccines), or American Indian or Alaska Native persons. Underinsured children are eligible to receive VFC vaccines only at federally qualified health centers or rural health clinics.

CDC policy analysts have used data from NIS–Child and HIM to provide information about the percentage of children who are entitled to VFC vaccines and about the needs of the 317 Immunization Grant Program (72). Section 317 of the Public Health Service Act provides federal funding to state, local, and territorial public health agencies for program operations and vaccine purchase. Section 317 program funds also are used to support infrastructure functions, such as vaccine effectiveness studies, disease surveillance, outbreak detection and response, vaccine coverage assessment, vaccine safety, and provider education programming.

Peer-reviewed publications written by CDC staff using HIM data have focused on vaccine financing issues related to underinsured children (73) and on vaccination coverage among VFC-entitled children (74).

HIM for NIS–Teen

Since 2006, NIS–Teen has included the HIM questions from NIS–Child, enabling the same determinations to be made regarding insurance coverage and VFC eligibility for adolescents aged 13–17. The 2013 household questionnaire is available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISteenPUF13_HHQuex.pdf. In 2006, 5,468 adolescents had a completed household interview. Among them, 4,356 completed HIM, resulting in a completion rate of 79.7%.

A peer-reviewed publication written by CDC staff using HIM data from NIS–Teen focused on vaccine financing issues related to underinsured adolescents (75) and on vaccination coverage among VFC-entitled adolescents.

Socioeconomic Status Module

The Socioeconomic Status (SES) Module was developed to assess the contributions of socioeconomic factors to racial, ethnic, and economic disparities in vaccination coverage. Questions were developed to measure factors, such as household education level, maternal employment status, home ownership or rental, car ownership, child's general health status, experience with regular doctor or office for medical visits, travel time to doctor's office, wait time in doctor's office, and routine use of child daycare services. Adding these types of questions to NIS–Child provided researchers with additional tools to determine how socioeconomic factors influence vaccination coverage and to develop more targeted strategies to address racial and ethnic and economic disparities in childhood vaccination.

The SES module was conducted in households with age-eligible children in Q1/2008 and Q2/2008. Administered immediately after HIM, the SES module was also translated into Spanish and conducted in other languages by use of Language Line Services. The SES module was designed to gather household-level data, child-level data for each eligible child in the household, and data for the maternal primary caregiver. Where no maternal primary caregiver was available, data were gathered for the paternal primary caregiver.

A total of 11,102 children had a completed household interview and were flagged to receive the SES module. Of those, 8,768 had a completed module, resulting in a completion rate of 79.0%; 7,450 children had both a completed module and adequate provider-reported vaccination data. Data from the SES module have been used to explore how employment and socioeconomic factors are associated with children's UTD vaccination status (76).

NIS–Child Parental Concerns Module and NIS–Teen Parental Attitudes Module

In February 2006, the National Vaccine Program Office (NVPO) Subcommittee on Public Engagement expressed concerns about the lack of detailed surveillance on public concerns and knowledge about vaccine safety and acceptance. In 2007 and 2008, NVPO funded a proposal to develop a new parental concerns topical module for NIS–Child that would collect data over 4 consecutive quarters. The structure of the survey questions in the Parental Concerns Module (PCM) was based on the 2001–2002 PKM described previously, and included sections on parents' perceptions about vaccines, their satisfaction with their experience getting their child vaccinated, influences on their decisions to vaccinate their child, and vaccine delay or refusal. Starting in Q3/2008 and continuing through Q4/2009, PCM was incorporated as Section F of the NIS–Child household questionnaire (available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISPUF09_HHQUEX.pdf).

Questions from PCM were administered to parents completing the NIS–Child telephone interview. From Q3/2008 through Q4/2009, 38,248 children completed the household interview and were flagged for the PCM; 29,509 children also completed the PCM, resulting in a completion rate of 77.2%. Additionally, 24,875 children had both a completed PCM and APD available to evaluate sampled children's provider-reported vaccination status. The PCM was conducted again in 2011.

Data from the 2009 PCM characterized parents' psychosocial attitudes in terms of a behavioral model that was developed during the 1950s polio epidemic by Rosenstock, Derryberry, and Carriger at the U.S. Public Health Service to explain why parents failed to vaccinate their children with the salk polio vaccine (77). Their findings, published in the journal *Public Health Reports* as the basis for the Health Belief Model, showed there were four psychosocial domains that influenced parents' decisions to vaccinate their children. These domains were 1) susceptibility (their assessment of their child's risk of getting polio); 2) seriousness (their assessment of whether polio was a sufficient health concern to warrant vaccination); 3) efficacy and safety (their assessment of whether vaccinating their child can reduce the chances of getting polio, and whether the vaccine is safe); and 4) social pressures and convenience (the concerns and influences that facilitated or discouraged their decision to get their child vaccinated) (78–85).

Data from the 2009 NIS–PCM have been used to investigate psychosocial factors that influence parental vaccination decisions for infants; to assess the prevalence of reported refusal or delay of vaccination among parents of children aged 19–35 months; and to assess how the psychosocial factors that index the Health Belief Model are associated with parental refusal or delay of vaccinations, and coverage for recommended childhood vaccines (86).

Funding from the American Recovery and Reinvestment Act (ARRA) of 2009 was used to develop and implement a Parental Attitudes Module (PAM) for NIS–Teen. ARRA funding was sufficient to allow data collection for PAM in NIS–Teen for Q3/2010 and Q4/2010. The structure of the survey questions was based on the NIS–Child PCM and sections on parents' perceptions about vaccines, influences on parents' decision to vaccinate their adolescent, and vaccine delay or refusal. The NIS–Teen PAM was incorporated as Section F of the 2010 NIS–Teen household questionnaire. A total of 15,438 adolescents had a completed household interview and were flagged to receive PAM. Of those, 10,808 completed the module, resulting in a completion rate of 70.0%; 8,490 adolescents had both a completed module and adequate provider-reported vaccination data.

Data from the 2010 NIS–Teen PAM have been used to investigate factors that influence parental vaccination decisions for adolescents (87,88), assess the prevalence of reported refusal or delay of

vaccination among parents of adolescent girls aged 13–17, and assess the relationship between refusal or delay of vaccination and coverage for HPV (89).

Data from the 2011 NIS–Child PCM and 2010 NIS–Teen PAM were used to evaluate the extent to which children and adolescents in the United States are not vaccinated against measles. (90). A total of 18,633 children had a completed household interview and were eligible to receive the PCM. Of those, 13,921 had a completed module, resulting in a completion rate of 74.7%; 12,259 children had both a completed module and adequate provider-reported vaccination data. Results showed that in 2011, 7.5% of children and 4.5% of adolescents were unvaccinated against measles; 80.0% of unvaccinated children lived in counties containing 41.9% of the country's children; and 80.0% of unvaccinated adolescents lived in counties containing 30.4% of the country's adolescents. Multivariable statistical analyses found that 74.6% of children who were unvaccinated against measles were not vaccinated for reasons other than parents' negative vaccine-related beliefs, and 89.6% had at least one missed opportunity for being vaccinated against measles because they were administered at least 1 dose of other recommended vaccines after age 12 months. Among adolescents, multivariable analyses found that only demographic factors, and not vaccine-related parental beliefs, were associated with being unvaccinated.

Quality Assurance and Data Dissemination

Introduction

NIS maintains dedication to the quality of the survey data throughout all of its phases, including sample design, questionnaire development, data collection, data processing, derivation of weights and estimates, data delivery, and dissemination. The ultimate goal is to provide reliable and actionable surveillance of childhood and adolescent vaccinations.

The NIS approach to quality assurance consists of specific processes that provide assurance of three dimensions of quality: accuracy, timeliness, and accessibility to researchers. Quality assurance procedures were implemented consistently and continuously across all years of data collection and throughout every phase of NIS. In what follows, this report highlights the specific quality assurance procedures used in both NIS–Child and NIS–Teen, including those implemented throughout household data collection, PRC data collection, data processing, and production of final data files. Confidentiality, disclosure avoidance, and the commitment to accessibility and timely data dissemination are also discussed.

The quality assurance procedures implemented in NIS–Child from 1994 through 2000 have been described previously (91). Their use has continued in the NIS family of surveys throughout 2001–2014. To avoid repetition, this report focuses on additional quality assurance procedures and enhancements since 2005 and provides additional details regarding procedures described previously.

Quality Assurance Procedures

All surveys, including NIS, are subject to two types of error: sampling and nonsampling. Sampling errors are typically a function of the survey's sample design and affect the variability of survey estimators. Nonsampling errors are the result of sample frame undercoverage, nonresponse, and measurement problems, and may introduce bias into survey estimators. Methodological responses to the problems of sample undercoverage and nonresponse bias have been described in previous sections of this report. This section focuses on quality assurance procedures to monitor and reduce measurement errors. These errors may arise due to problems in data collection, transcription, or editing.

Household data collection

The household survey phase of NIS–Child and NIS–Teen consists of sampling of telephone numbers, sample preparation and management, household survey instrument preparation and testing, training of interviewers, and computer-assisted telephone interview (CATI) data collection by telephone interviewers.

Sample preparation—This step includes the selection of sample telephone numbers, the preparation of addresses for mailing letters to households matched to sampled telephone numbers, and the preparation of sampled telephone numbers for dialing in the CATI system. Routine monitoring by a team of NIS professionals helps identify potential quality issues in sample preparation. Additional quality assurance steps during these procedures include:

- Comparing prefinalization (i.e., resolution of telephone numbers as nonworking, nonresidential, or residential by the sample vendor prior to dialing) rates to prior years
- Comparing address matching rates with prior years
- Reviewing the frequencies of all variables loaded into the CATI system, comparing the frequencies of these variables with their corresponding values in previous quarters, and identifying any potentially invalid values

Sample management—This step includes monitoring the performance of the sampled telephone numbers that have been released into the CATI system, determining a schedule for the release of additional sample lines, and releasing additional sample lines as determined. Additional quality assurance steps during these procedures include:

- Continuous monitoring of the difference between projected and actual numbers of cumulative completed interviews
- Monitoring the landline and cell-phone samples separately to assess differences in and issues with expected response rates, age-eligibility rates, and completion targets

Household survey instrument preparation and testing—Questionnaires and advance letters are thoroughly tested before use. Additional quality assurance procedures include:

- Testing of questionnaires by NIS interviewers using test samples
- Programming English and Spanish versions of the questionnaire in the CATI system to aid accessibility

The CATI system and data collection by telephone interviewers—The CATI system incorporates a number of features designed to assure the quality of the household interview data, including:

- Programmed range and consistency checks to prevent entry of invalid or inconsistent responses to questionnaire items (e.g., the child's date of birth is verified multiple times during the interview to ensure the correct date is used to initiate the provider phase)
- Advance testing to ensure proper questionnaire flow (i.e., appropriate questionnaire items are presented in the appropriate order and unnecessary items are skipped)
- Regular review of the interview data by professional staff members to inspect item response distributions and reveal potential questionnaire errors

Catching potential errors early increases the efficiency of postsurvey data cleaning and processing. Out-of-range and inconsistent responses produce a warning screen, allowing the interviewer to correct errors in real time. Warning screens focus on items critical to the survey, such as those that determine a child's eligibility (e.g., date of birth).

In addition to the quality assurance safeguards in the CATI system, interviewers receive extensive and ongoing training.

- Interviewers undergo consistent, in-depth training and certification and are monitored and evaluated by supervisory staff.
- Supervisors act in real time to assist interviewers and identify and solve problems with the survey.
- Interviews are recorded, facilitating

review by supervisors and methodology experts who can identify inefficiencies and translate this knowledge into questionnaire revisions.

Quality assurance for PRC data collection

Vaccination histories are collected from vaccination providers identified during the household interview. The PRC process consists of transferring questionnaire data for each child-provider pair from the CATI system into the PRC case management system, locating provider addresses and mailing IHQs to providers, reviewing the returned IHQ or medical record data, and editing, transcribing, and entering data.

Transferring household questionnaire data and generation of the IHQ documents—Data from completed telephone interviews are transferred from the CATI system into the PRC case management system, which is the software and database system that controls PRC data-collection operations. Child-provider pairs identified in the telephone interview are checked for comprehensive and accurate information. They are also checked to verify that all steps were successfully completed, for complete transfer of data from CATI to the PRC case management system, duplicate cases, missing information on children and providers, and valid signatures by interviewers verifying that consent to contact medical providers was obtained. Next, IHQ documents are generated electronically for mailing to providers. The PRC staff reviews these new cases weekly before the mailing to ensure that documents are generated correctly for both initial mailings and remailings. Additional quality assurance steps include:

- Checking contact information for each child's nominated providers for identifying duplicates and deleting any verified duplicates
- Reviewing cases with missing or incomplete child name or consent-giver name or provider address, and making repeat calls to obtain the missing information

- Checking that all consent forms were signed by interviewers and correctly attached during document generation

Locating provider addresses and mailing IHQs to providers—During this process, the PRC production team seeks a complete and accurate mailing address and telephone number for health care providers identified during the household interview. A database of collected provider information, available in real time to the telephone interviewers, improves the accuracy and efficiency in identifying and locating providers. The PRC production team reviews IHQ documents that have been generated and assembled prior to mailing the packages to the located providers. Additional quality assurance procedures include:

- Review of the mailing addresses for proper U.S. Postal Service address formatting, spelling, and matching of city, state, and ZIP code
- Use of two tiers of locating staff, distinguished by proven experience and skill, with the upper-tier clerks reviewing cases lower-tier clerks were unable to locate

Review, editing, transcription, and data entry—Returned IHQs may require editing, and some providers return a copy of the original medical records rather than a completed IHQ. During the editing and transcription process, the PRC production team transcribes any medical records onto an IHQ, checks for data consistency, and converts data to specified codes in preparation for data entry. The data are then entered into the PRC database. Specific checks on data items are implemented, and cases with inconsistencies are flagged for manual review to determine if any corrections need to be made. Additional quality assurance steps include:

- Medical records and the IHQ responses are edited to conform with prespecified date, number, and name formats to ensure consistency in the PRC data
- IHQ data are double-keyed into the provider database, and discrepancies are manually reviewed to ensure accurate data entry

- All keyed data are examined for a set of predetermined data entry errors, including inconsistent name or sex; missing, invalid, or inconsistent vaccination dates; or inconsistent responses
- Electronic PRC data records with potential errors are compared with original paper IHQs to identify corrections as needed

The period 2005–2014 has seen an increased tendency by providers to send copies of medical records in lieu of returning completed IHQs. This trend has both positive and negative quality implications. Original medical records are assumed to be the gold standard for vaccination information, yet these data must be transcribed onto IHQs by PRC production staff, which carries the potential for error. However, transcription must be accomplished somehow, either by an employee at the medical provider's office completing the IHQ or by an NIS PRC staff member transcribing information from the medical record onto the IHQ. To improve the quality of the latter transcriptions, PRC staff members are trained to read and understand medical records and to transcribe them correctly, though the additional time needed to transcribe and apply quality assurance procedures may have implications for timeliness. Considering all of this, allowing providers to respond by sending medical records is viewed positively because it gives providers an alternative method of response and increases the provider cooperation rate.

Every quarter since 2005, for both NIS–Child and NIS–Teen, data from a 10% sample of IHQs are double-keyed into the IHQ database a second time, and the results are compared with the original double-keying as a basis for measuring the rate of data entry errors in the PRC. The error rate is defined as the number of fields for which the initial data entry does not match the second data entry, divided by the total number of fields with a nonblank value in either the initial or second data entry. The keying error rates in NIS–Child have declined steadily since 2005 and reached their lowest levels in 2014, averaging just 0.16% among all fields and 0.08% among numeric fields. The keying error rates have also steadily declined for NIS–Teen, reaching lows of 0.16% among all fields and 0.09% among numeric fields in 2013. Figure 13 and Figure 14 display the IHQ keying error rates since 2005 for NIS–Child and since 2006 for NIS–Teen.

Quality assurance for data processing

Following data collection, the household and provider data are reviewed, edited, and combined to create an analytic data file containing a record for each child with a completed household interview. This phase includes post-CATI cleaning and editing of the household-level data; cleaning, editing, and de-duplication (i.e., removal of duplicate vaccinations that occurs when the same vaccination is reported in two provider records) of the provider vaccination data; merging the household and provider data for the same child; "matching sheet" review to determine the best synthesized vaccination history

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2005–2014.
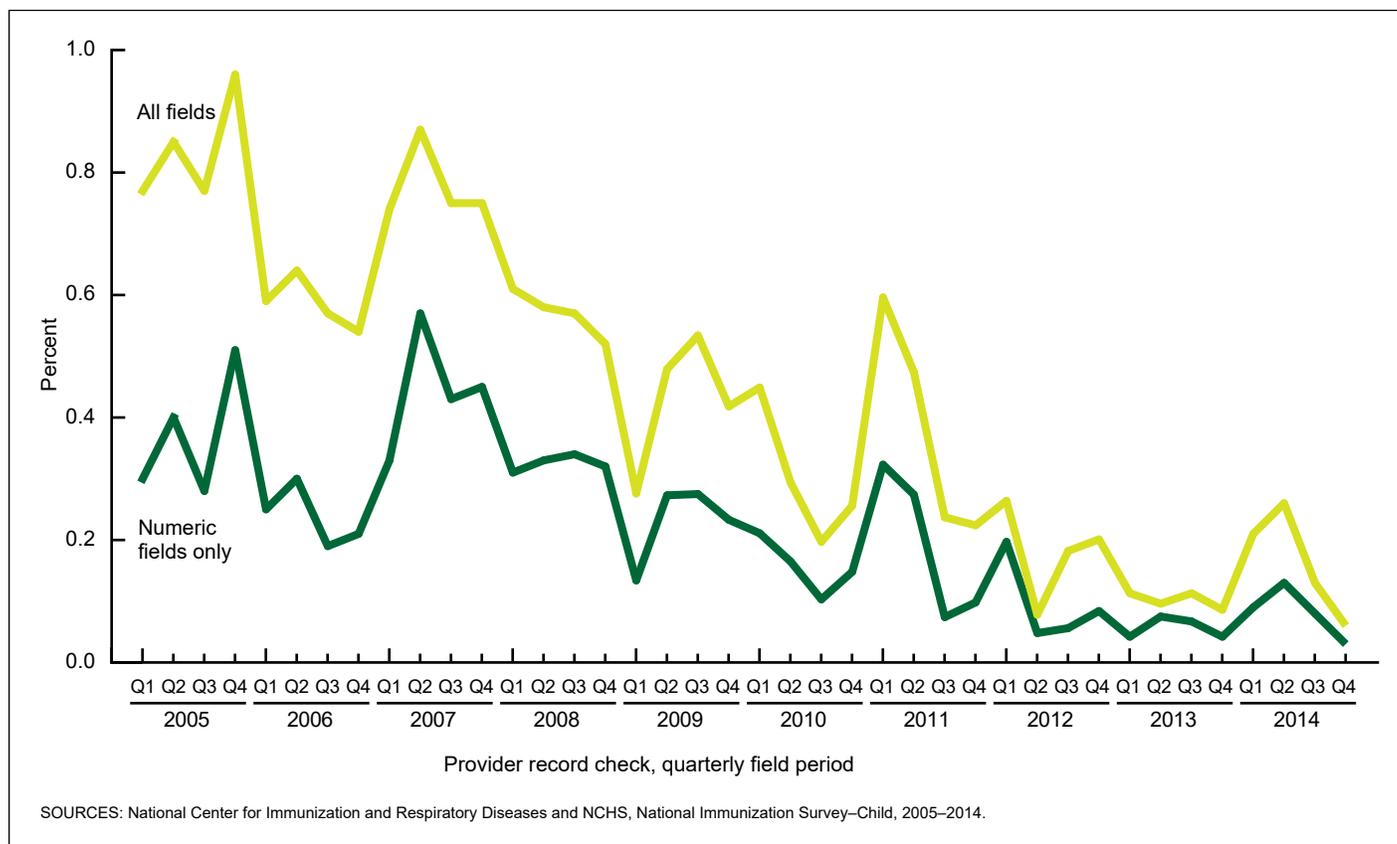
Figure 13. Immunization history questionnaire keying error rates for National Immunization Survey–Child, 2005–2014
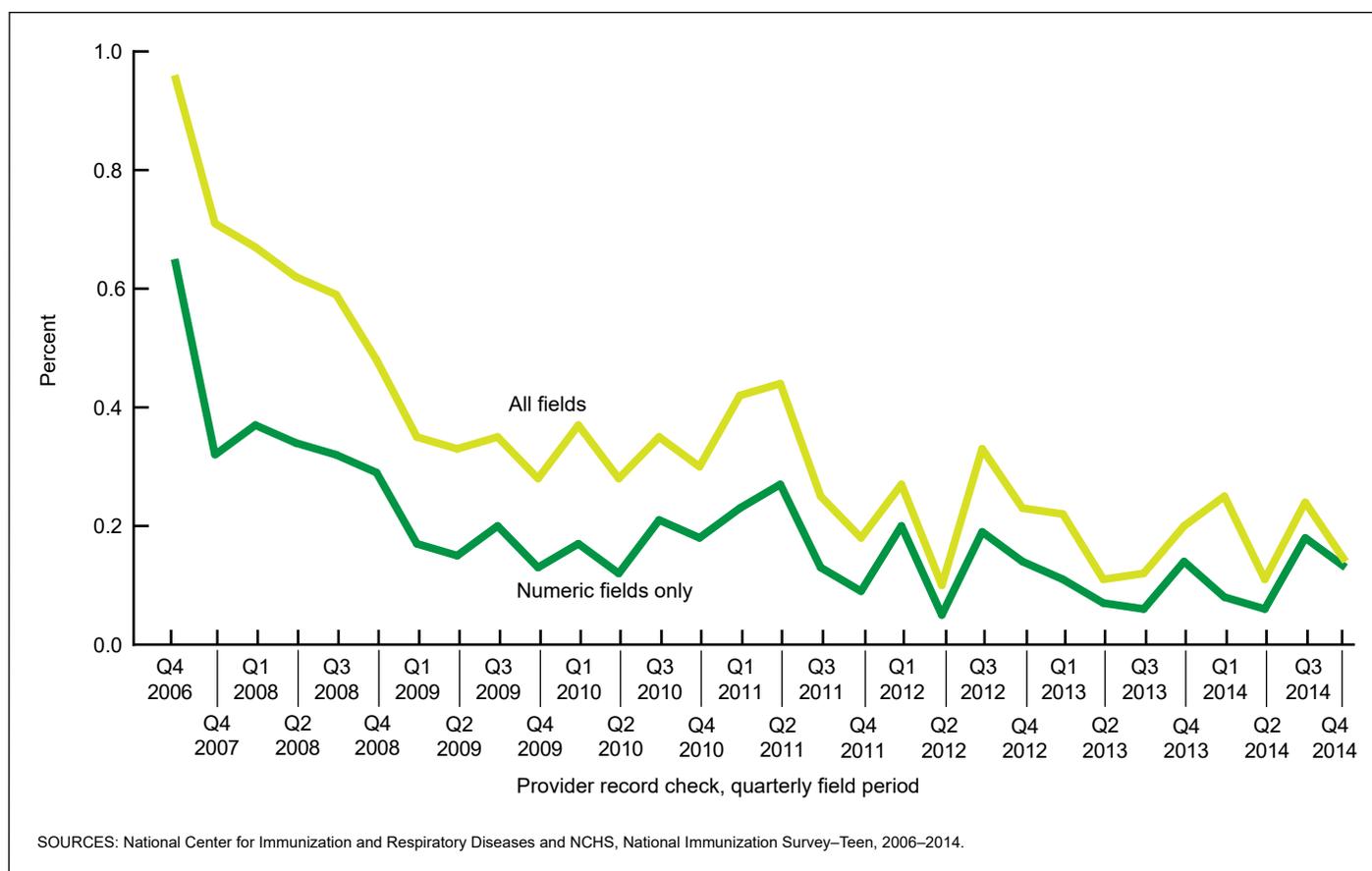
Figure 14. Immunization history questionnaire keying error rates for National Immunization Survey–Teen, 2006–2014

for each child; derivation of composite variables; and imputation of missing values.

To facilitate consistency and transparency in data processing, this work is organized into six distinct steps (see Table 21), each of which is thoroughly documented with detailed specifications. This approach ensures that these important steps occur in the proper order and in a timely manner. These standard steps clarify the process and increase efficiency as multiple members of the NIS data-processing team work with the survey data. Regular review and quality assurance occurs at each step of the process.

Post-CATI data editing and summarization (Step 1)—The post-CATI editing process produces final, cleaned data files for each quarter. After completion of household interviewing each quarter, the raw data are extracted from the CATI system and used to create two files: the sample file and the interview data file. The

sample file contains one record for each sample telephone number and summary information for telephone numbers and households. The interview data file contains one record for each eligible sample child or adolescent and all vaccination data the household respondent reported for the child or adolescent.

Following creation of these two files, a preliminary analysis of each file identifies out-of-range values and extraneous codes. Invalid values are replaced with either an appropriate data value or a missing value code. The eligibility statuses of the children and adolescents, based on date of birth and date of interview, are checked. Age-ineligible cases are deleted.

After the computer edits are run, frequency distributions of all variables in each file are produced and manually reviewed. Each variable's range of values is examined for any invalid values or unusual distributions. If blank values exist for a variable, they are checked to

determine whether they are allowable and whether they occur in excessive numbers. Skip-logic tests ensure that all data fields are populated correctly when they should be, and not populated when they should not be. Any problems are investigated and corrected as appropriate.

Computer programs check that cases exist in both files in a consistent manner. Checks also ensure that no duplicate households exist in the sample file and no duplicate children exist in the interview data file.

IHQ data processing (Step 2)—After the majority of the IHQs have been collected from providers and keyed, the provider data file is cleaned in a similar fashion to the household data file in terms of out-of-range values and consistency of the values of different associated variables. A computer program codes all "other shot" verbatim responses into the proper vaccine category (e.g., Engerix B counts as HepB, and Tetramune counts as DTP and Hib). The coding for a new quarter uses a database of coded

verbatim responses accumulated during all previous quarters. The provider data file is checked for duplicate records and exact duplicates are removed. If the IHQ contains a date of birth, sex, or name that differs from the household interview data, the IHQ is reexamined to determine whether it may have been filled out for an incorrect child. Provider data that appear to have been filled out for the wrong child are removed from the provider database. When two or more providers have reported IHQs for a given child or adolescent, decision rules are applied to the two reports to produce a single, consolidated, most complete vaccination history for the child, called the "synthesized provider-reported vaccination history." The official determination of whether the child or adolescent is UTD for recommended vaccines and vaccine series is based on this synthesized provider-reported vaccination history.

Matching sheet review (Step 3)— The matching sheet is a paper form (or corresponding electronic image) that presents the household and provider data

for a given child or adolescent in a format that is convenient for manual review by an editor. Children or adolescents with specific discrepancies between the household- and provider-reported data or between different provider IHQs are flagged for such review. The matching sheets are examined by an editor who determines whether a change in the vaccination data is warranted for the given child or adolescent. A supervisor reviews the results of the manual review. The three-step process of a) identifying discrepancies, b) flagging a child for review, and c) examining results manually and correcting is iterative, ensuring that a data edit to solve one problem does not cause another.

One of the most important elements of the matching sheet process is the set of editing limits used to evaluate vaccination dates. These editing limits identify reported vaccination doses that are too close to the child's birthdate or too close to each other based on the recommended vaccination schedule. Table 22 lists the 2014 editing limits for NIS–Child and NIS–Teen.

The editing limits designate which cases will be reviewed manually, but they do not necessarily specify the changes that should be made to the reported data, if any. Figure 15 shows the rate of change for NIS–Child to reported vaccinations due to matching sheet review by year from 2005 through 2014. Figure 16 presents the changes to vaccinations for NIS–Teen from 2006 through 2014. The percentage of children and adolescents with one or more changes to reported vaccinations varies from year to year due to shifts in the composition of the sample, variability in provider response errors, evolution in the use of different combination vaccines, and various other factors. Vaccine categories with only 1 recommended dose, such as measles-containing and varicella, typically exhibit fewer edits during the matching sheet process.

Derivation of composite variables (Step 4)—A number of composite variables are created and included in the NIS data files. Composite variables assist users and data analysts by eliminating duplication of effort, making data easier

¹DT is diphtheria and tetanus toxoids vaccine; DTP is diphtheria and tetanus toxoids and pertussis vaccine; and DTaP is diphtheria and tetanus toxoids and acellular pertussis vaccine.
SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2005–2014.
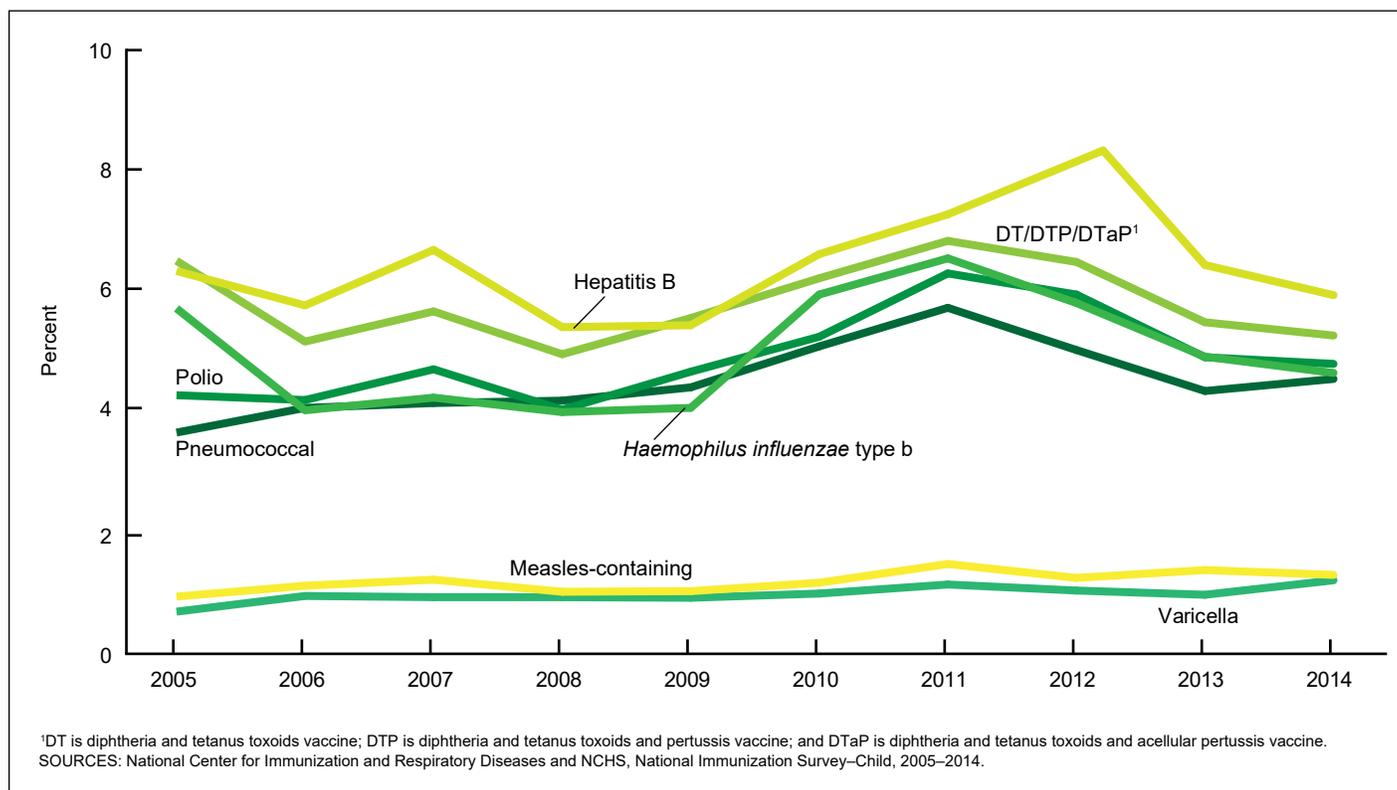
Figure 15. Trends in percentage of children with one or more changes to a vaccination among children with one or more valid immunization history questionnaires returned, by vaccine category, 2005–2014
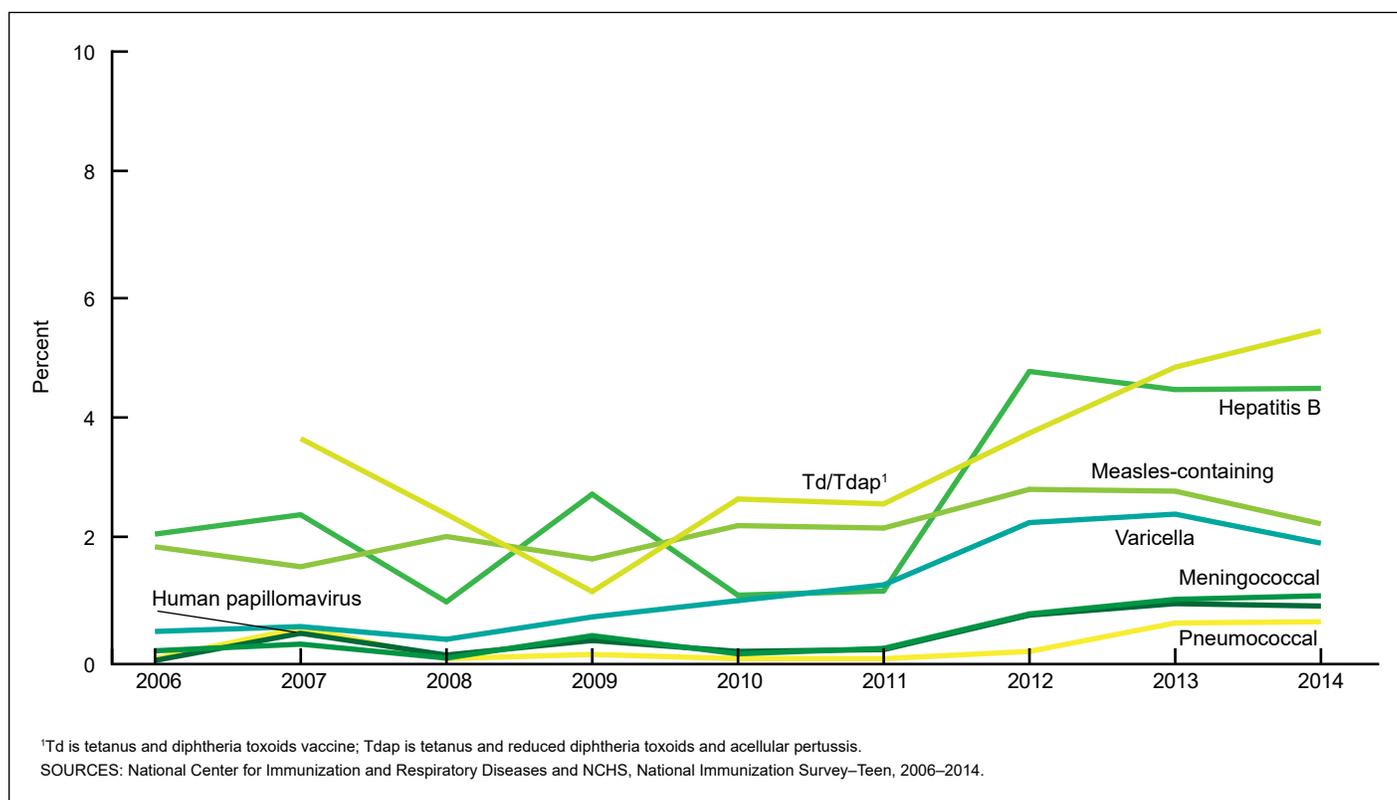
Figure 16. Trends in percentage of adolescents with one or more changes to a vaccination among adolescents with one or more valid immunization history questionnaires returned, by vaccine category, 2006–2014

to use, replicating analytic results, and increasing the timeliness and accessibility of data products. Composite variables include dose counts of individual vaccinations, indicators of vaccination status for individual vaccines and vaccine series, age, race and ethnicity of child or adolescent, race and ethnicity of the child's or adolescent's mother, household income, and a variety of other child- or adolescent- and household-level characteristics.

The quality of the derived composite variables is assured by a strict reliance on specifications, which document derivation and format of every composite variable that is derived. Tracking documents are used to highlight any deletions, additions, or modifications to the list of derived variables.

As the data-processing team derives the composite variables, an independent statistician ensures quality by producing a parallel set of composite variables for comparison. Frequencies of all derived variables are also reviewed and compared with distributions from previous years, and all composite variables are checked

for inconsistent or invalid values. If any issue is identified, the problem is corrected and the parallel test is rerun until no further issues are found. As an additional measure of quality assurance, each variable is checked once more as the final data files are produced.

Imputation of missing values (Step 5)—NIS uses a single imputation method to complete missing values in the socioeconomic and demographic variables used in the weighting process. Missing values of these variables are imputed for all children or adolescents with a completed household interview, using a sequential hot-deck method. Table 23 presents the quality assurance steps related to imputation of missing values.

Missing values are also imputed in HIM for the set of children with APD, once again using the sequential hot-deck method. Use of the reported and imputed values enables analysts to use standard, complete data methods of statistical analysis to study the associations between vaccination and health insurance variables without results being dependent

on variable patterns of data missingness.

Final data file production (Step 6)— After completing all phases of data collection and data processing, final data products are produced. For NIS, the main data product is an annual internal analytic data file containing one record for each child with a completed household interview, and it contains all household and provider data for all children and adolescents sampled in a given calendar year.

To improve the transparency and accessibility of the internal data file, it is accompanied by many supporting documents, including:

- A detailed data delivery memorandum outlining the methodology, data collection, weighting, and estimation procedure for NIS
- A codebook with variable information and frequencies for all variables on the data file
- SAS programs that researchers can use to read in the data file and apply formats and labels

- A report of all editing and corrective actions taken
- A record of all call attempts made to all sample cases and the outcome and disposition code for each call

This information is crucial to making NIS data accessible to researchers, so they can produce timely and accurate analyses of the vaccination statuses of children.

As a final check for consistency and accuracy, frequency distributions of all variables on the data file are compared with the corresponding frequency distributions from the prior year. Any increase or decrease of more than 5 percentage points in the proportion of respondents answering with a single response option, or a net change of more than 10 percentage points across all response options, is flagged for manual review and verification. Vaccination coverage rate estimates for all vaccines and vaccine series are compared with the corresponding rates in prior years.

The internal data file includes two survey weights for use in estimation: one weight for the set of children with completed household interviews and the other weight for the set of children with APD. After the weights are derived, a quality assurance review process brings together a team of statisticians who review summary statistics for the weights at each step and approve the final weights. Once the weights are appended to the data file, it is ready for analysis. Table 24 shows the quality assurance procedures used for the weighting process.

Confidentiality and Disclosure Avoidance

All information collected in NIS–Child and NIS–Teen is covered by strict assurances of confidentiality and may be used only for statistical purposes. For discussion of these assurances, refer to https://www.cdc.gov/nchs/about/policy/confidentiality.htm, Section 308(d) of the Public Health Service Act, 42 U.S. Code 242m(d), the Privacy Act of 1974 (5 U.S. Code 552a), and for NIS data collected through 2014, the Confidential Information Protection and Statistical Efficiency Act (5 U.S. Code).

The advance letter, introductory script for the CATI interview, and request for oral consent each assure respondents of the confidentiality of their responses and the voluntary nature of the survey. Informed consent is obtained from the person in the household most knowledgeable about the eligible child's immunization history (generally the parent or guardian of the child).

To ensure the privacy of the respondents and the confidentiality of their information, all CDC staff and contractor staff involved with NIS sign NCHS' confidentiality agreement and follow instructions to prevent disclosure.

NIS releases public-use data files to allow researchers to conduct analyses of U.S. childhood and adolescent vaccination data. To prevent identification of individual children and adolescents and the disclosure of information that would result from such identification, certain items reported in the survey are omitted from the public-use file.

Prior to release, the proposed contents of each public-use file undergo extensive review by NCHS' Disclosure Review Board to protect the confidentiality of survey participants and their data. To ensure confidentiality and reduce disclosure risk, several steps are taken (92), including removal of all household and personal identifiers that could be used to match children or adolescents to an exogenous file, either related or unrelated to NIS; elimination of screening, interview, and vaccination dates; collapsing, top-coding, or bottom-coding select sociodemographic variables; and examination of populations with rare combinations of demographic characteristics, with the possible reassignment of such sample cases to eliminate the possibility of disclosure. These steps ensure that the data can be made accessible to researchers everywhere while protecting participants' confidentiality.

Data Dissemination

NIS official estimates

Estimates of vaccination coverage for children aged 19–35 months at the national, state, and estimation-area levels were routinely released on the Web and are available from: https://www.cdc.gov/vaccines/imz-managers/coverage/childvaxview/index.html. National, state, and estimation-area level estimates for adolescents aged 13–17 are also available online from: https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/index.html. Child and adolescent vaccination coverage information is published periodically in CDC's *Morbidity and Mortality Weekly Report* (MMWR), available from: https://www.cdc.gov/vaccines/imz-managers/coverage/childvaxview/pubs-presentations.html and https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations.html.

Public-use data files

NIS–Child and NIS–Teen public-use files are available from: https://www.cdc.gov/vaccines/imz-managers/nis/data-tables.html. Each of the annual files is in ASCII file format and is accompanied by SAS and *R* input statements for reading the ASCII file, a data user's guide, a code book with variable information and frequencies, the household interview questionnaire, and the provider IHQ.

Evaluation of NIS Estimates and Methods

Introduction

Assessing the quality of NIS estimates is a critical and ongoing aspect of this surveillance program. Existing NIS methods were frequently evaluated to understand the causes and impacts of sampling and nonsampling errors on the vaccination coverage estimates, and new evidence-based methods were implemented wherever possible to improve data quality. Four of the major projects conducted since 2005 directed

at evaluation of the quality of the NIS estimates are described.

- Evaluation of NIS–Child data quality using immunization information systems (IIS)
- Assessment of representativeness of alternative sampling frames for NIS–Child
- Comparing NIS–Child vaccination coverage rates with those provided by the NHIS-PRC
- Assessment of total survey error (TSE)

Evaluation of NIS–Child Data Quality Using IIS

IIS are confidential, population-based, computerized databases that compile information about the doses of vaccines children have received from participating vaccination providers within a defined geographic area (93). Projects have been undertaken in collaboration with state and local area IIS to evaluate the relative completeness of NIS–Child and the IIS vaccination histories.

Within a given area, while both NIS–Child and IIS rely on provider-reported vaccination histories, they have different objectives. NIS–Child produces estimates at the national, state, and limited local-area levels using a standard methodology for monitoring vaccination coverage. IIS provide vaccination coverage estimates for state and local areas, provider practices, health plans, schools, and other populations. IIS are used by vaccination providers, schools, daycares, and other authorized organizations to determine vaccination UTD status for individuals residing in the jurisdiction. IIS include functions and features such as clinical decision support, reminder or recall services, vaccine ordering, and inventory management to support immunization providers, immunization programs, and other stakeholders in guiding public health actions related to improving vaccination rates and reducing vaccine-preventable disease.

Matching the provider-reported vaccination histories collected in NIS–Child and the IIS for a common sample of children provides insight into the quality of both sources of data.

Vaccinations included in the IIS but not in NIS–Child signal NIS–Child incompleteness, while vaccinations included in NIS–Child but not in the IIS signal IIS incompleteness.

The first match projects were conducted in 2002 and 2004 (94,95). Children in the NIS–Child sample for whom consent was obtained to contact their local IIS were matched to their respective IIS database. IIS vaccination histories for the matched children were then compared with the NIS–Child vaccination histories. The quality and completeness of the IIS vaccination histories were inconsistent and varied between different participating IIS. From 2008 through 2011, 19 additional match projects, patterned after the 2002 and 2004 projects, were conducted again to assess the quality and completeness of vaccination histories from NIS–Child and participating IIS. (No match projects were conducted in the 2005–2007 and 2012–2014 periods.) The 19 IIS were not selected as a representative sample of all IIS. Participation by an IIS in the match studies was by self-selection. The results from these studies are not necessarily generalizable to all IIS and across all years. To preserve the anonymity of the participating IIS, summary statistics for the set of match projects are presented, but the results for the specific participating IIS are not identified.

Table 25 provides information from the 19 match projects about the completeness of the IIS in terms of age-eligible children aged 19–35 months within the jurisdiction. (The 19 studies represent 15 distinct IIS [some studied in multiple years]. State or local area immunization program grantees or awardees requested that some of their Section 317 discretionary funding be used for this purpose.) Table 25 shows the percentages of NIS–Child children who were included in the IIS and whether the IIS had complete vaccination data for them. Across the 19 IIS, the percentage of children not matched to the IIS ranged from 0.0% to 31.8%. If NIS–Child is taken as the standard, these results suggest that some IIS did not include all age-eligible children in the jurisdiction, and some IIS achieved high

rates of adequate data for determining the vaccination status of those children.

Table 26 presents a comparison of NIS–Child, IIS, and synthesized vaccination coverage rates among children aged 19–35 months from the 19 studies (96–98). The synthesized estimates, denoted by NIS-IIS, reflect a combination of NIS–Child and IIS data, starting with the NIS–Child data as the base and treating the IIS vaccination data as an additional provider in determining APD and vaccination UTD status. Across the 19 IIS, Table 26 shows the minimum and maximum differences in vaccination coverage rates for the 4+DTaP (4 or more doses) vaccine and the 4:3:1:3:3:1 vaccine series. Compared with NIS–Child, the synthesized NIS-IIS rates were up to 11.9 percentage points higher for the 4:3:1:3:3:1 vaccination series and were up to 9.0 percentage points higher for the 4+DTaP vaccine. Compared with IIS, synthesized NIS-IIS rates were up to 51.9 percentage points higher for the 4:3:1:3:3:1 vaccination series and were up to 49.3 percentage points higher for the 4+DTaP vaccine. The results may be taken as evidence of possible under-determination of UTD status in both the NIS–Child data and the IIS data.

Assessment of Representativeness of Alternative Sampling Frames for NIS–Child

One of the strengths of NIS is that it is implemented consistently across the United States, allowing valid comparisons of estimates across time and areas. Despite this strength, the NIS–Child methodology has been challenged in recent years in two notable ways: a) the general environmental decline in response rates affecting all surveys, including NIS; and b) the rising proportion of CPO households. These two contextual challenges to representativeness raise concern about the validity of NIS estimates of vaccination coverage.

To assess the representativeness of the traditional landline RDD sampling frame, the following evaluations of

alternative sampling frames were sponsored:

- Assessment of cell-phone RDD samples in NIS–Child and NIS–Teen during 2009–2010 prior to implementation of a dual-frame design in 2011
- Assessment of an address-based sampling frame and multimode interviewing for NIS–Child in 2009
- Evaluation of the American Community Survey (ACS) as a sample frame in 2009 to screen for households with children aged 19–35 months and conducting the NIS–Child interviews for the eligible households
- Evaluation of the use of IIS as replacement or supplemental sampling frames for children

Assessment of cell-phone RDD samples in NIS–Child and NIS–Teen

In Q4/2010, a small national cell-phone sample was added to NIS–Child in preparation for a more complete implementation of a dual-frame design in 2011. Differences between the official 2010 NIS–Child estimates (based on the single-frame landline RDD design) and the 2010 piloted dual-frame estimates for specific vaccines and vaccine series were assessed and published (99,13). Differences in vaccination coverage rates for NIS–Child ranged from –1.2 to 2.2 percentage points, while differences for NIS–Teen ranged from –0.6 to 0.6 percentage points.

Official NIS vaccination coverage rates based on the dual-frame sampling design were released in 2011. For more information about the assessment prior to the adoption of the dual-frame design, see "Sampling Design, Questionnaire, and Response Rates."

Assessment of an address-based sampling frame and multimode interviewing

In 2009, researchers evaluated the use of the U.S. Postal Service's Delivery Sequence File (DSF) as an address-based sampling frame for NIS–Child in conjunction with multiple modes of household interviewing that included telephone, mail, and in-person approaches. The DSF is a computerized file that contains all delivery point addresses serviced by the U.S. Postal Service, with the exception of general delivery. The DSF provides an essentially complete listing of all households in the United States, regardless of telephone status (100). The ultimate goal of this study was to assess both the bias in NIS–Child statistics due to NIS–Child's omission of direct interviewing of CPO households at that time and the feasibility of an address-based sampling (ABS) multimode approach for NIS–Child.

The project used a national probability sample of addresses, including an oversample of addresses in Bexar County, Tex. An attempt was made to match all sample addresses to landline telephone numbers. In the event that a telephone number was available, a CATI interview was attempted. Otherwise, a brief screening form was mailed to the sample address, in which a request was made of the respondent to mail back a telephone number. If the screening form was returned, the case was contacted via CATI. Nonrespondents in CATI and nonrespondents to the screening form were mailed a self-administered version of the NIS–Child questionnaire, according to the Dillman method (101). In Bexar County only, in-person interviews were attempted if a sampled address was determined (via mail or telephone) to have age-eligible children in the household but had not completed the household interview or provided consent to contact the child's vaccination provider(s). A total of 520 household surveys were completed nationally, with 50.8% completed by phone, 44.4% completed by mail, and 4.8% completed via in-person interviews.

The ABS pilot survey achieved a much lower CASRO response rate (46.0%) than the 2009 NIS–Child (63.7%), and it achieved a similar unconditional rate of APD (68.2%) to the 2009 NIS–Child (68.7%). Table 27 contains the estimated UTD rates for children aged 19–35 months with APD for the 2009 NIS–Child and ABS pilot.

The sample size for the ABS pilot was sufficient to detect important differences. The vaccination coverage rates are generally about two to six percentage points higher in the 2009 NIS–Child. The only statistically significant difference between the vaccination coverage rates is for the 4:3:1:3:3:1:3 vaccine series.

Several aspects of the ABS multimode approach piloted in 2009 would be challenging for NIS–Child. There are sensitive but critical items on the NIS–Child questionnaire that were skipped more often in the paper-and-pencil-interview (PAPI) mode than in the CATI mode of the ABS pilot. PAPI item nonresponse rates were 0.7%, 2.9%, and 7.0% for child's sex, child's race, and respondent's relationship to child, respectively, compared with the CATI item nonresponse rates of 0% for the same items. For the CATI mode, interviewers had the opportunity to address respondents' questions and concerns in real time, resulting in no item nonresponse to these and other critical items. While not tested in this pilot, the addition of other surveys in the NIS family, such as NIS–Teen or NIS–Flu, to the overall interview, would increase the overall length and complexity of the PAPI household questionnaire, which in turn would likely reduce participants' willingness to respond. The study also established that the 2009 ABS pilot design would not be cost effective for NIS–Child, in part because of the substantial amount of screening that must be conducted to find households with age-eligible children.

Based on the limitations and the potential increase in costs identified in the 2009 ABS pilot and the general comparability of vaccination coverage rates between the ABS pilot and the 2009 NIS–Child, the telephone survey design for the household data-collection phase of NIS–Child was continued, and the coverage of CPO households was addressed by adding a cell-phone RDD sample (to the existing landline RDD sample) in a dual-frame approach.

Evaluation of NIS–Child using ACS

A pilot study was conducted in 2009 to evaluate the use of ACS as a sampling frame for NIS–Child. Conducted by the U.S. Census Bureau, ACS is a large ongoing survey that provides data about residents of the United States every year at national, state, and local levels. ACS is selected from a sampling frame that provides essentially complete coverage of all households in America, regardless of telephone status. The regular ACS interviews collect enough information to determine households that contain NIS-eligible children and adolescents. The 2009 NIS-ACS pilot study was conducted as a follow-on survey to ACS, through which a sample of ACS respondents identified to be in NIS–Child age-eligible households were asked to provide consent to participate in the NIS–Child household survey after completing the ACS survey.

The 2009 NIS-ACS pilot study was conducted in Florida, using a stratified random sampling design with three strata: Duval County, Dade County, and the rest of Florida. The Census Bureau selected a subsample of ACS respondents to achieve approximately 310 children with APD within each of these three areas, and Census Bureau interviewers conducted the in-person or telephone household interviews between August and October of 2009. The sample size for the pilot study was determined to ensure that meaningful differences in vaccination coverage rate estimates between the 2009 NIS-ACS and the 2009 NIS–Child could be statistically detected. The first mailing of IHQs occurred in October 2009 on behalf of the sampled children for whom permission to contact providers was obtained, and the closing of the provider portion of the pilot study occurred in June 2010.

Vaccination coverage was estimated for each of the nine recommended childhood vaccines, and the estimates from the 2009 NIS-ACS pilot were compared with estimates from the 2009 NIS–Child, as shown in Table 28. Vaccination coverage was statistically significantly higher in the NIS–Child sample for 1 or more varicella doses after

age 12 months and for seasonal influenza. For the 2009 ACS-NIS pilot study and the 2009 NIS–Child in Florida:

- The percentages of completed telephone interviews among households with age-eligible children were 77.7% and 81.6%, respectively
- The percentages of households giving permission to contact vaccination providers, among completed interviews, were 93.2% and 80.2%, respectively
- The percentages of sampled children with APD, among those with a completed interview and permission to contact vaccination providers, were 89.8% and 84.0%, respectively

The pilot study demonstrated that ACS could provide estimates of vaccination coverage comparable with estimates based on the NIS–Child telephone sampling frame, however, the ACS sampling frame did not provide sufficient numbers of children aged 19–35 months within each NIS–Child estimation area to achieve the NIS–Child precision requirement (i.e., 7.5% coefficient of variation for the estimator of the vaccination coverage rate when the true but unknown rate is 50% without use of an additional sampling frame). Another issue included the possibility that the ACS frame would not be available for NIS–Child, NIS–Teen, and NIS–Flu each data-collection year without interruption.

Based on the cited limitations in the size of the sample to deliver the necessary precision and the lack of guaranteed access to the ACS sample frame, NIS data collection using the dual-frame landline RDD and cell-phone RDD telephone survey design was continued.

Evaluation of the use of IIS as replacement or supplemental sampling frame

The 2008 NIS-IIS sampling frame evaluation was conducted in collaboration with two state IIS (to preserve anonymity, referred to as States A and B) to evaluate if the IIS list of children could replace or supplement the NIS–Child standard landline RDD sampling frame. The evaluation differed

from the NIS-IIS match projects described earlier. In the sampling frame study, an independent list sample of children's records was selected from each of the two participating IIS, and the list sample cases were fielded using the NIS–Child CATI household survey with the child's parent or guardian. Assuming parental consent was given during the household phone interview, the provider record check was conducted for the IIS sample of age-eligible children aged 19–35 months to obtain provider data just as in NIS–Child.

The IIS list sample for States A and B resulted in different proportions of nonlocatable cases (i.e., cases for which the state locating process did not yield a current address or telephone number): 29% and 14%, respectively. In addition, there were a substantial number of cases that were coded in the telephone center as nonworking or out-of-scope (16% in State A, 26% in State B), or as ineligible households (20% in State A, 18% in State B).

The yield rates (completed cases divided by the number of sample cases released and located for data collection) were similar for the two states, 15% and 19% for States A and B, respectively. Provider consent was greater than 80% for each state and APD were obtained for approximately 90% of the sample cases for which provider consent was obtained.

Table 29 presents differences in estimated vaccination coverage rates between the IIS and NIS–Child samples for the period Q1/2008–Q2/2008, based on provider-reported data. For State A, vaccination rates for the NIS–Child and IIS samples were within four percentage points of one another and differences were not significant. For State B, the vaccination rates were within three percentage points and differences were not significant.

Results from the 2008 NIS-IIS sampling frame evaluation suggest that the use of IIS as a replacement for the landline RDD telephone sampling frame, or the use of IIS in conjunction with the landline RDD frame in a multiframe sampling design, could be potentially feasible approaches for NIS–Child in the future. Major limitations of

the IIS frames include the substantial state-to-state variation in population coverage of young children and the limited availability of accurate contact information in IIS records, such as address and phone number (102). The population coverage, availability of accurate contact information, and the overall operational feasibility of using IIS as a supplemental sampling frame for NIS–Child continue to be explored using additional state IIS (97,98,103,104).

Comparing NIS–Child Vaccination Coverage Rates With Those Provided by NHIS-PRC

Reliance on household reports of childhood immunizations is subject to recall errors (105). To determine the accuracy of the household responses in NHIS, the National Immunization Provider Record Check Study (NIPRCS) was implemented starting in 1994. Its purpose was to evaluate the accuracy of household reports of children's immunization histories by comparing the household reports with the reports from the children's immunization providers, and to produce national estimates of vaccination coverage using both the household and provider reports. Documentation and data from the 1997–1999 NIPRCS are available from: https://www.cdc.gov/nchs/nhis/niprcs.htm.

Building on the work completed in NHIS-NIPRCS, during 2009 through Q3/2013, evaluations were conducted to compare the vaccination coverage rates of children enumerated in NHIS with the rates in NIS–Child (106). NHIS was based upon an area-probability sampling frame, which had essentially complete coverage of all households regardless of telephone status, and was conducted using face-to-face interviews. A provider record check (PRC) was conducted for children aged 19–35 months identified in the household interviews, using NIS-like methods and referred to as the NHIS-PRC. The NHIS-PRC reported here was conducted from 2009 through Q3/2013. Taking NHIS-PRC as the standard,

the comparison offers evidence about the validity of NIS–Child vaccination coverage estimates. Because of its relatively small sample size, however, the NHIS-PRC estimates were prepared and used for comparison purposes at the national level and not at the state or local-area levels.

Table 30 presents response rates for NIS–Child and NHIS for the period 2009–2013. NHIS sample child response rates and NIS–Child household-phase response rates are conceptually similar, although the NHIS rates refer to children under age 18 years while NIS–Child rates refer to children aged 19–35 months. NHIS sample child response rates were around 10 percentage points higher than the NIS–Child household-phase response rates for the landline sample and more than twice as high as NIS–Child for the cell-phone sample.

Both single-frame landline RDD sample and dual-frame landline and cell-phone RDD sample estimates derived from NIS–Child were compared with NHIS-PRC estimates. Vaccination coverage estimates for NIS–Child derived from the single-frame landline RDD sample and the NHIS-PRC for the 2-year period Q1/2009–Q4/2010 are presented in Table 31. NIS–Child single-frame landline estimates were one to three percentage points higher than NHIS-PRC estimates for three of seven individual vaccines and almost three percentage points greater for the 4:3:1:3:3:1:3 series.

Table 32 compares NIS–Child dual-frame landline and cell-phone sample vaccination coverage estimates with NHIS-PRC estimates for the 1-year period 2010. (The NIS–Child estimates combined the Q4/2010 national cell-phone RDD pilot sample with the standard Q1/2010–Q4/2010 landline RDD sample.) Differences were small and none of the differences were found to be statistically significant. The comparisons were generally consistent with the conclusion that the NIS–Child dual-frame estimators were not subject to differential bias compared with the NHIS-PRC estimators.

Assessment of TSE

Introduction

TSE is the sum of the errors that arise at every step of a survey, including both sampling and nonsampling errors, such as coverage, nonresponse, and measurement errors (107). In the assessment of TSE for NIS, the survey's total error is treated as a random variable with a statistical distribution conditional on the observed NIS. Analysis for the 2009–2012 NIS–Child and NIS–Teen was conducted to estimate the TSE distributions for estimated vaccination coverage rates for each data-collection year and to monitor any year-to-year changes in total error. As mentioned previously, the 2009–2010 surveys were based on the single-frame landline RDD design, while the 2011–2012 surveys were based on the dual-frame landline and cell-phone RDD design (108,109). The TSE methods are described briefly below, followed by a synopsis of the results of the TSE analysis for 2009–2012.

Methods

The TSE model framework may be summarized as follows: 1) specify a distribution function for each component of sampling and nonsampling error in the survey process, 2) derive estimates of the parameters of the component distributions from the best sources or analyses available, and 3) apply a Monte Carlo simulation approach to combine the components of error into a total error distribution for each vaccination coverage rate estimate examined (110,111). The mean of the TSE distribution is used as a summary measure of the total error in the vaccination coverage rate estimates. From a frequentist perspective, means found to be substantially different from zero signal the possibility of bias in the NIS estimators. The TSE models summarized in this report include two types of nonsampling error: incompleteness of the sampling frame and nonresponse.

† Zero percentage points fall outside of the 95% credible interval for total error.

¹The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more Hib doses of any type, 3 or more HepB doses, and 1 or more varicella doses given at age 12 months and over.

NOTES: DTaP is diphtheria and tetanus toxoids and acellular pertussis vaccine. DTP is diphtheria and tetanus toxoids and pertussis vaccine. DT is diphtheria and tetanus toxoids vaccine. MMR is measles, mumps, and rubella vaccine. Hib is *haemophilus influenzae* type b vaccine. HepB is hepatitis B.

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey–Child, 2009–2012.

Figure 17. Mean total survey error for the 4:3:1:3:3:1 vaccination series and 1 or more MMR and 4 or more DTaP vaccines, by survey year, 2009–2012

Results

Figure 17 displays the means of the TSE distributions for selected NIS–Child final weighted estimates for calendar years 2009 through 2012. The mean TSE estimates for all three vaccination coverage rates in 2010–2012 were around –2 to 2 percentage points, and 0 percentage points fell within the 95% credible interval for total error.

Figure 18 similarly displays the means of the TSE distributions for selected NIS–Teen vaccination coverage rate estimates. For 1 or more doses of Tdap and 1 or more doses of MenACWY, the mean error was smaller in 2011 and 2012 than in 2009 and 2010, but this finding did not appear to hold for 1 or more doses of HPV. The means of TSE distributions tended to be different from zero (i.e., the 95% credible interval fails to cover zero percentage points).

Conclusions

NIS–Child estimators appeared to lack bias in 2010–2012, but they appeared to be upward biased in 2009 relative to the available benchmarks used in the TSE analysis. NIS–Teen estimators appeared to benefit from the dual-frame landline and cell-phone RDD design, but they were biased by several percentage points in 2011 and 2012. The TSE analyses reported here were themselves subject to a multitude of sampling and nonsampling errors arising in the evaluation studies that form the basis for the analyses.

Recent TSE analysis of the 2012 NIS expanded in scope to include not only error due to incompleteness of the sampling frame and error due to nonresponse, but also classification error due to provider underreporting of vaccination status, using data from the NIS-IIS match studies described earlier (111).

Other Surveys in the NIS Family of Surveys

Introduction

Other surveys in the NIS family of surveys include NIS–Adult conducted in 2007, the National 2009 H1N1 Flu Survey (NHFS) conducted during the 2009–2010 influenza season, NIS–Kindergarten (NIS–K) conducted in 2013, and the ongoing NIS–Flu conducted every influenza season beginning with the 2010–2011 season.

NIS–Adult, 2007

The 2007 NIS–Adult was conducted to provide information related to vaccination coverage among adults aged 18 and over for vaccines recommended by the Advisory Committee on Immunization Practices,
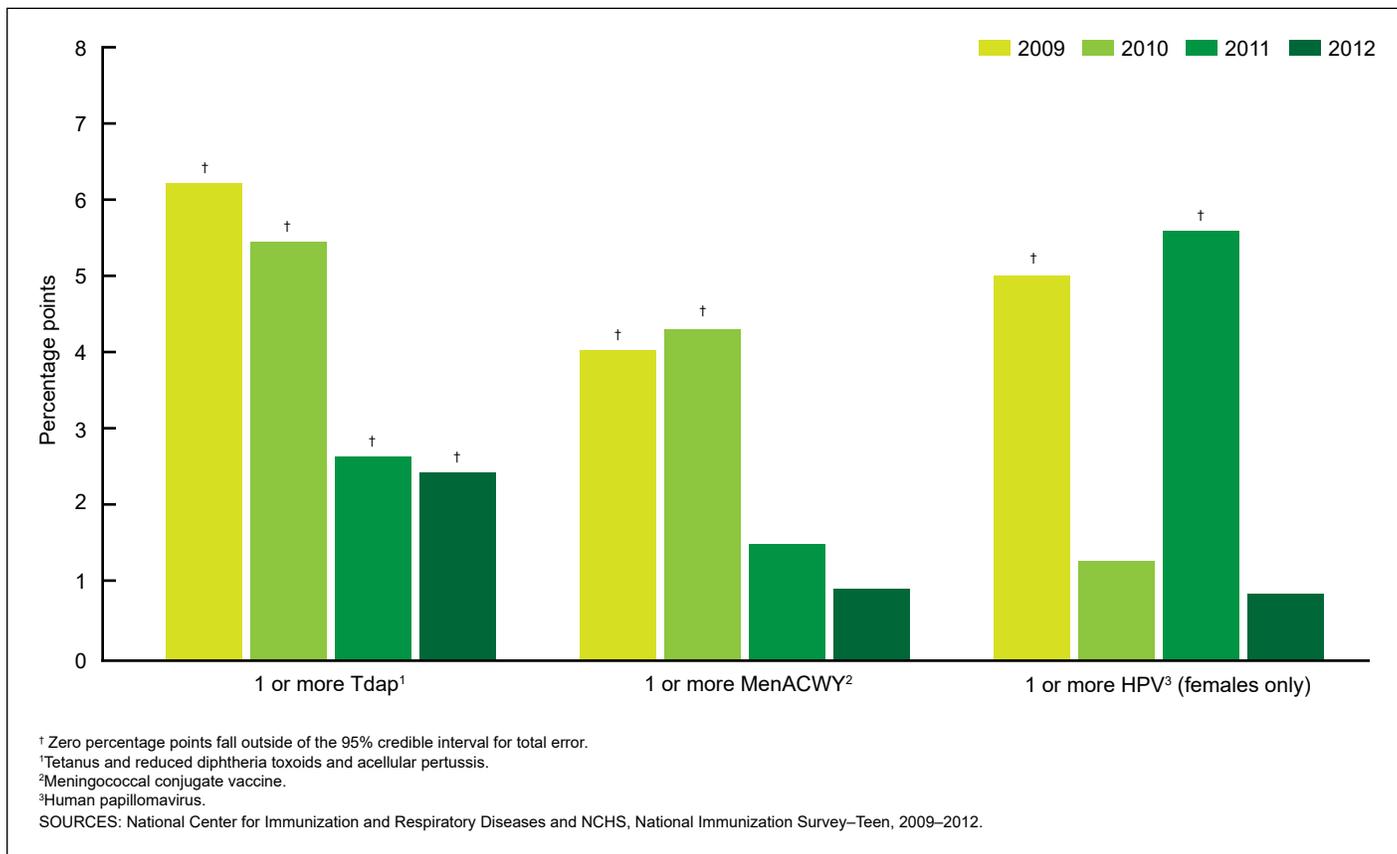
Figure 18. Mean total survey error for 1 or more Tdap and 1 or more meningococcal vaccines, and 1 or more HPV vaccines for females, by survey year, 2009–2012

including influenza, pneumococcal, tetanus-diphtheria, tetanus-diphtheria-acellular pertussis, hepatitis A, hepatitis B, and HPV vaccines. It built upon previous surveys, including, the Elderly Immunization Survey (conducted in 2003) and the National Adult Immunization Survey (conducted in 2004), which were limited to adults aged 65 and over and aged 50 and over, respectively (112,113). Target sample sizes for NIS–Adult were determined for nine race or ethnicity domains (Hispanic, non-Hispanic black, and other) by age group (18–49, 50–64, and 65 and over), with oversampling in the Hispanic and non-Hispanic black domains.

NIS–Adult data were collected using a landline telephone survey from May 3, 2007, through September 2, 2007. The survey utilized two distinct sampling frames: 1) household telephone numbers collected from NHIS-completed interviews from 2005 (except for the third quarter, July–September) and 2006 (only the first quarter, January–March),

and 2) an age-targeted list sample of household telephone numbers obtained from a vendor. All telephone numbers from the NHIS sample with nonmissing age and race or ethnicity information were included in the survey. The age-targeted sample supplemented the NHIS sample because the NHIS sample was not large enough to obtain the study target number of completed interviews.

One adult was selected for the survey per household and 7,055 interviews were completed. Key indicators appear in Table 33; 2,899 interviews were completed in the NHIS sample, 4,156 in the age-targeted sample, and 7,055 overall. Conditional on NHIS itself, the CASRO response rate in the NHIS sample was 33.5%, the response rate in the age-targeted sample was 29.4%, and the combined response rate over both samples was 30.5%. The relatively low response rate in the NHIS sample was the result of two factors: the time lag between the NHIS and NIS–Adult interviews and the oversampling of the

race or ethnicity domains.

Estimates from NIS–Adult have been published (114–119).

NHFS, 2009

The large screening samples used for NIS–Child provide a unique capability for responding to public health emergencies, such as the influenza A(H1N1)pdm09 pandemic from 2009 through 2010. The response to this emergency necessitated the generation of timely, valid estimates of influenza vaccination coverage with both the pandemic and seasonal influenza vaccines. For this reason, NHFS was developed, building upon the preexisting framework of NIS–Child. A standalone survey for adults and children was developed, and the resulting survey data were augmented by data from the preexisting NIS–Child, NIS–Teen, and National Survey of Children with Special Health Care Needs. Consequently, NHFS combined data from a new survey of

adults and children and from the usual NIS–Child and NIS–Teen (to which additional questions had been added). NHFS interviews were conducted from October 2009 through June 2010.

NHFS was designed to provide a) separate estimates of vaccination coverage rates for adults (18 and over) and children (6 months–17 years); b) national estimates of vaccination coverage rates and other statistics for the total population of adults and children, and by race and ethnicity, and for various priority domains on a weekly basis, in which the survey week was defined by the Saturday week-ending date; c) weekly estimates within 4 to 6 days following the end of the survey week; d) estimates of vaccination coverage rates and other statistics at the state level on a monthly basis; and e) estimates with the best possible survey response and the least possible nonresponse bias, within cost and timeliness constraints.

To achieve these objectives, a new rotation sampling design was developed. The standalone survey component used a dual-frame sampling design consisting of landline RDD and cell-phone RDD samples contacted to identify residential households. Within each household in the landline portion of the NHFS sample, one adult and one child (if present in the respondent's household) were randomly selected as the subject(s) of the survey. For each active personal cell-phone number (APCN) reached, the contacted adult was selected, while one child (if present in the respondent's household) was selected at random. For both landline and cell-phone samples, selected adults were interviewed about themselves, and a resident parent or guardian of the child, who was in most cases also the selected adult, was interviewed about the child.

The standalone survey component of NHFS used rolling weekly samples. A new sample was released weekly, with each sample undergoing active data collection for 5 weeks. Each sampled telephone number was called repeatedly during the 5-week period, until the number was resolved as nonresidential, confirmed as a refusal, or classified as a completed interview. Completed interviews obtained within a survey week

were used in generating the estimates for that survey week. Estimates for a survey month were based upon all completed interviews from survey weeks within the survey month.

The rotation design created for the NHFS sample, especially the use of the responses from five different weekly samples in the estimation for the current week, is unique. In traditional survey research, a single sample would be used to make estimates for a given time period. This approach for the NHFS would have meant that the survey would only use interviews achieved in the current week from members of the current week sample and would not benefit from the callback efforts possible with a more extended data-collection period. In planning this survey design, a model of the response mechanism in which the probability of response varies with the number of weeks since sample release was developed. The survey objectives and the response model drove the decision to use the rotating panel design.

Given the unique survey design of NHFS, a statistically appropriate method of weighting was developed and subsequently implemented. The data were weighted to adjust for nonresponse and for households that do not have a telephone; to account for overlap in the rotating panel design; and to match the age, sex, and race-ethnicity distribution of the population of children by state on a monthly basis.

Key indicators for NHFS, cumulative over all of the rolling weekly samples, as of the end of the influenza season are shown in Table 34. Completed interviews were achieved for 45,750 households in the landline sample, 11,080 households in the cell-phone sample, and 56,830 households in the combined sample. The CASRO response rates were 33.8%, 26.2%, and 32.0% in the landline, cell-phone, and combined samples, respectively.

The official release of estimates of pH1N1 influenza vaccination coverage in the 2009–2010 season have been published (120) and are available on CDC's FluVaxView website at: https://www.cdc.gov/flu/fluvaxview. Papers featuring NHFS data have been

written (120–124). More information about NHFS, including a public-use file and data user's guide, is available from: https://www.cdc.gov/nchs/nis/data_files_h1n1.htm.

NIS–Kindergarten, 2013

NIS–K was fielded in Q4/2013 using the NIS–Child sample to test the collection of school-related information from parents of children of kindergarten age (5–7 years) for whom vaccinations had been exempted and the reasons for exemption. The NIS–K household interview followed administration of the NIS–Child, NIS–Teen, and NIS–Flu screenings and interviews. Households with children aged 5–7 years were eligible to complete the NIS–K interview, and the survey made use of the household rosters collected in the existing NIS–Teen and NIS–Flu screeners to identify households with children aged 5–7. One age-eligible child was randomly selected to be the focus of NIS–K. A parental concerns module was also included in the survey to collect information about the respondent's perceptions of vaccines, concerns the respondent had when the child was vaccinated, influences on the decision to vaccinate, and delay and refusal to vaccinate. A PRC collected provider-reported vaccination histories for children with parental consent to contact vaccination providers.

Key indicators for NIS–K appear in Table 35. The survey included 2,348 completed interviews: 580 from the landline frame and 1,768 from the cell-phone frame. The overall CASRO response rates were 50.8% in the landline sample and 25.7% in the cell-phone sample. In the landline sample, 74.5% of respondents consented to participate in the PRC, and 70.6% gave consent from the cell-phone sample. The landline sample APD rate was 66.0% of children with completed interviews, and the cell-phone sample APD rate was 61.4% of children with completed interviews.

NIS–K was a pilot study with a limited sample size. Data have been used to estimate the percentage of children with exemptions, the risk of under-vaccination attributable to exemptions,

and the percentage of children whose parents were notified by schools that their child did not have all vaccinations required for kindergarten entry. Additional information about NIS–K is available (125).

NIS–Flu, 2010–2014

NIS–Flu is a national dual-frame (landline and cell phone) RDD survey of households with children aged 6 months–17 years. NIS–Flu includes three components: NIS–Child for children aged 19–35 months, NIS–Teen for adolescents aged 13–17, and the NIS–Child Influenza Module (NIS–CIM) for children aged 6–18 months and 3–12 years who are identified during screening interviews for NIS–Child and NIS–Teen. NIS–Flu was started in October 2010 to assess annual influenza vaccination coverage at the national, state, and selected local levels, including selected U.S. territories. Parents and guardians are asked if their children had an influenza vaccination, and if so, how many vaccine doses the child had received. For each reported dose, the month and year administered and the type of vaccination (injection or nasal spray) are recorded. Additional questions regarding the type of place vaccinations were received, as well as intent to vaccinate by the end of the influenza season among those not yet vaccinated, were asked. In recent influenza seasons, additional questions have been added to the questionnaires related to doctor or other health care professional recommendations for influenza vaccination, as well as parental preference regarding vaccine delivery method by injection or nasal spray.

NIS–Flu estimates are based on the parent- or guardian-reported data, not on provider-reported data. Influenza vaccination coverage estimates are calculated throughout the influenza season using Kaplan-Meier survival analysis to determine the cumulative influenza vaccination coverage (1 or more doses) during the July–May season using monthly interview data collected from October through June (126).

Table 36 displays the end-of-influenza-season cumulative key indicators for NIS–CIM. (Key indicators for the other components of NIS–Flu were discussed earlier in this report for NIS–Child and NIS–Teen.) For example, at the close of the 2013–2014 season, completed interviews had been obtained for 35,393 households in the landline sample, 44,413 in the cell-phone sample, and 79,805 in the combined sample, with CASRO response rates of 58.6%, 32.0%, and 40.1% in the landline, cell-phone, and combined samples, respectively.

For additional information on influenza vaccination coverage estimates from NIS–Flu, visit the FluVaxView website at: https://www.cdc.gov/flu/fluvaxview/. More information can be found in papers featuring NIS–Flu data (127,128).

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Table 1. Vaccines monitored by National Immunization Survey–Child in 2014

Vaccine recommended for routine administration[1]	Recommended dose[1]
Diphtheria and tetanus toxoids and acellular pertussis vaccine (DTaP)	4 doses
Poliovirus vaccine (Polio)	3 doses
Measles, mumps, and rubella vaccine (MMR)	1 dose
Haemophilus influenzae type b vaccine (Hib)	3 or 4 doses depending on the manufacturer of the vaccine
Hepatitis B vaccine (HepB)	3 doses
Varicella zoster vaccine (Var)	1 dose
Pneumococcal conjugate vaccine (PCV)	4 doses (infants and children who have received 1 or more doses of PCV7 should complete the immunization series with PCV13. A single supplemental dose of PCV13 is recommended for all children aged 14–59 months who have received 4 doses of PCV7 or another age-appropriate, complete PCV7 schedule.)
Hepatitis A vaccine (HepA)	2 doses
Rotavirus vaccine (RV)	2 or 3 doses depending on the manufacturer of the vaccine
Influenza vaccine (Flu)	1 or 2 doses annually

[1]See the 2014 recommended vaccination schedule at: https://www.cdc.gov/vaccines/schedules/downloads/past/2014-child.pdf.

Table 2. Vaccines monitored by National Immunization Survey–Teen in 2014

Recommended vaccine[1]	Recommended dose[1]
Tetanus-diphtheria-acellular-pertussis vaccine (Tdap)	1 dose
Meningococcal vaccine (MenACWY)	1 dose
Human papillomavirus vaccine (HPV)	3 doses
Measles, mumps, and rubella vaccine (MMR)	2 doses
Hepatitis B vaccine (HepB)	3 doses
Varicella zoster vaccine (Var)	2 doses
Hepatitis A vaccine (HepA)	2 doses
Pneumococcal polysaccharide vaccine (PPSV23)	Not routinely recommended for adolescents aged 13–17; recommended for adolescents with certain health or lifestyle conditions that put them at an increased risk for serious diseases. See Table 1 for recommended doses for younger children.
Influenza vaccine (Flu)	1 dose annually

[1]See the 2014 recommended vaccination schedule at https://www.cdc.gov/vaccines/schedules/downloads/past/2014-child.pdf.

Table 3. Major changes since 2005 in the protocol of National Immunization Survey–Child random-digit-dialing sample

Year or quarter/year	Description
2006	Began offering a token of appreciation to cases that had refused at any point in the interview after reporting there was a child under age 4 years in the household
2007	Introduced hybrid-dialing of landline telephone numbers, allowing cases to be called by predictive dialers until contact is established, and by preview dialers afterward
2007	Reduced the number of estimation areas from the original 78 immunization action plan areas to 56 core estimation areas, plus a varying number of rotating areas updated annually
2007	Eliminated the differentiation between "soft" and "hard" refusals
2008	Added a callback to minor-only households to confirm status
2008	Stopped coding "likely" households based on answering machine messages
2009	Stopped listening to entire answering machine messages, if not leaving a message
Q4/2010	Introduced an experimental national cell-phone sample as a complement to the landline sample, in which screening was conducted for cell-phone-only or cell-phone-mainly status
Q1/2011	Modified the sampling design to include a cell-phone sample stratified by estimation area
Q2/2011	Changed the determination of age eligibility from the date of birth falling in range on the date of screening to the date of birth falling in range at any point during the calendar quarter
Q2/2011	Removed screening for cell-phone-only or cell-phone-mainly status and instead interviewed all cell-phone respondents (a take-all design)
Q1/2012	Increased the size of the cell-phone sample; allocated sample size to the two random-digit-dialing sampling frames to minimize the cost of data collection, subject to a constraint on the coefficient of variation of the estimated vaccination coverage rate
Q1/2012	Removed Section A from household interview; as a result, could not use household shot-card data to determine adequate provider data status. Revised adequate provider data definition so children with at least one reported vaccination on a returned immunization history questionnaire were considered to have adequate provider data
Q1/2013	The dual-frame sample allocation was based on a projection of the most recent estimates of the population distribution forward to 2013. This method of projecting population estimates by telephone status forward resulted in a larger allocation to the cell-phone sample
Q2/2013	The household questionnaire was modified to accommodate the inclusion of Guam data collection in quarter 2 only
Q1/2014	An optimal allocation between sampling frames was not possible due to budget constraints, resulting in a smaller allocation to the cell-phone sample
Q1/2014	A prescreening process was introduced for the cell-phone sample to remove a portion of the nonworking cell-phone numbers prior to dialing. Ten percent of the cell-phone sample was designated as "holdout" sample, where numbers were dialed even if the prescreening process indicated they were nonworking. This holdout sample allows for continual monitoring of the effectiveness of the prescreening
Q1/2014	Prior to the first quarter of 2014, landline-sample telephone numbers that were ported to cell phones were not dialed and were treated as out of scope. Beginning with the first quarter of 2014, landline sample numbers identified as ported cell phones prior to being loaded for dialing are not finalized as out of scope but are instead dialed using the cell-phone dialing protocol. Numbers not identified as ported cell phones before being loaded for dialing but subsequently identified as ported cell phones continue to be finalized as out of scope
Q3/2014	The household questionnaire was modified to accommodate the inclusion of Puerto Rico data collection. A new Spanish-language immunization history questionnaire was used for Puerto Rico

Table 4. Population of children aged 19–35 months on July 1, 2013, for the 56 core estimation areas in National Immunization Survey–Child, by telephone status

Area name	Area number	Total children 19–35 months	Landline-only households		Landline and cell-phone households		Cell-phone-only households		Phoneless households	
			Proportion	Children 19–35 months	Proportion	Children 19–35 months	Proportion	Children 19–35 months	Proportion	Children 19–35 months
Total in the United States (excluding U.S. territories)	...	5,724,088	0.030	171,453	0.368	2,107,610	0.576	3,297,995	0.026	147,030
HHS Region 1										
Connecticut	1	56,042	0.061	3,415	0.531	29,763	0.394	22,107	0.014	757
Massachusetts.	2	104,130	0.038	3,988	0.543	56,572	0.403	41,972	0.015	1,598
Maine.	4	18,068	0.022	406	0.353	6,384	0.608	10,983	0.016	295
New Hampshire	5	19,233	0.007	140	0.504	9,694	0.475	9,130	0.014	269
Rhode Island	6	15,766	0.033	520	0.481	7,591	0.460	7,250	0.026	405
Vermont	7	8,294	0.051	422	0.563	4,666	0.385	3,190	0.002	16
HHS Region 2										
New Jersey	8	157,366	0.030	4,709	0.597	93,919	0.353	55,477	0.021	3,261
New York—rest of state	10	170,589	0.051	8,699	0.519	88,609	0.406	69,245	0.024	4,036
New York—City of New York	11	170,839	0.057	9,801	0.507	86,664	0.407	69,515	0.028	4,859
HHS Region 3										
District of Columbia	12	11,696	0.010	117	0.542	6,344	0.428	5,007	0.019	228
Delaware	13	16,545	0.004	66	0.576	9,537	0.406	6,710	0.014	232
Maryland	14	106,838	0.012	1,231	0.526	56,240	0.434	46,417	0.028	2,950
Pennsylvania—rest of state	16	174,120	0.019	3,240	0.505	87,993	0.447	77,757	0.029	5,130
Pennsylvania—Philadelphia County	17	34,576	0.028	981	0.352	12,166	0.592	20,452	0.028	977
Virginia.	18	150,476	0.030	4,570	0.471	70,941	0.475	71,540	0.023	3,425
West Virginia	19	28,465	0.047	1,337	0.319	9,085	0.594	16,913	0.040	1,130
HHS Region 4										
Alabama	20	84,627	0.034	2,905	0.301	25,484	0.638	54,030	0.026	2,208
Florida	22	310,138	0.026	8,172	0.327	101,368	0.611	189,364	0.036	11,234
Georgia	25	191,743	0.016	3,129	0.335	64,322	0.616	118,106	0.032	6,186
Kentucky	27	77,267	0.030	2,301	0.264	20,424	0.670	51,776	0.036	2,766
Mississippi	28	57,195	0.018	1,004	0.210	12,007	0.746	42,663	0.027	1,521
North Carolina	29	177,250	0.040	7,042	0.325	57,548	0.611	108,383	0.024	4,277
South Carolina.	30	82,621	0.018	1,476	0.294	24,251	0.660	54,570	0.028	2,324
Tennessee	31	115,714	0.028	3,275	0.293	33,848	0.649	75,121	0.030	3,470
HHS Region 5										
Illinois—rest of state	34	170,421	0.008	1,445	0.376	63,998	0.594	101,315	0.021	3,663
Illinois—City of Chicago.	35	59,237	0.009	505	0.360	21,327	0.606	35,904	0.025	1,501
Indiana.	36	120,179	0.041	4,907	0.328	39,370	0.591	71,064	0.040	4,838
Michigan	38	162,941	0.028	4,562	0.295	48,112	0.648	105,652	0.028	4,615
Minnesota	40	100,427	0.014	1,398	0.416	41,821	0.555	55,754	0.014	1,454
Ohio.	41	195,908	0.018	3,489	0.311	61,006	0.629	123,182	0.042	8,231
Wisconsin	44	98,363	0.027	2,679	0.333	32,721	0.614	60,395	0.026	2,568
HHS Region 6										
Arkansas	46	55,873	0.012	655	0.197	10,987	0.754	42,103	0.038	2,128
Louisiana.	47	89,448	0.027	2,422	0.292	26,148	0.649	58,033	0.032	2,845
New Mexico	49	39,405	0.021	822	0.175	6,890	0.756	29,802	0.048	1,891
Oklahoma	50	75,705	0.032	2,400	0.270	20,449	0.678	51,351	0.020	1,505
Texas—rest of state	51	431,653	0.041	17,785	0.276	119,064	0.661	285,300	0.022	9,504
Texas—El Paso County	53	20,871	0.091	1,894	0.143	2,976	0.708	14,776	0.059	1,225
Texas—City of Houston	54	67,752	0.040	2,684	0.270	18,310	0.667	45,224	0.023	1,534
Texas—Bexar County	55	38,417	0.054	2,066	0.274	10,514	0.650	24,986	0.022	851
HHS Region 7										
Iowa	56	54,442	0.025	1,351	0.346	18,820	0.594	32,364	0.035	1,907
Kansas.	57	57,727	0.014	796	0.308	17,806	0.660	38,095	0.018	1,030
Missouri.	58	108,467	0.019	2,087	0.300	32,534	0.648	70,281	0.033	3,565
Nebraska	59	36,625	0.026	959	0.338	12,385	0.618	22,652	0.017	629

See footnotes at end of table.

Table 4. Population of children aged 19–35 months on July 1, 2013, for the 56 core estimation areas in National Immunization Survey–Child, by telephone status—Con.

Area name	Area number	Total children 19–35 months	Landline-only households		Landline and cell-phone households		Cell-phone-only households		Phoneless households	
			Proportion	Children 19–35 months	Proportion	Children 19–35 months	Proportion	Children 19–35 months	Proportion	Children 19–35 months
HHS Region 8										
Colorado	60	96,605	0.019	1,813	0.331	31,981	0.631	60,948	0.019	1,863
Montana.	61	17,205	0.061	1,051	0.243	4,177	0.672	11,561	0.024	416
North Dakota	62	13,504	0.014	193	0.350	4,725	0.628	8,476	0.008	110
South Dakota.	63	16,347	0.018	301	0.356	5,823	0.599	9,799	0.026	424
Utah.	64	72,942	0.020	1,461	0.353	25,738	0.606	44,187	0.021	1,556
Wyoming	65	10,551	0.029	308	0.241	2,545	0.707	7,456	0.023	242
HHS Region 9										
Arizona	66	123,594	0.056	6,983	0.256	31,608	0.659	81,484	0.028	3,519
California	68	731,918	0.031	22,665	0.420	307,521	0.531	388,799	0.018	12,933
Hawaii	72	26,290	0.032	852	0.475	12,498	0.466	12,238	0.027	702
Nevada	73	52,403	0.038	1,981	0.378	19,788	0.569	29,827	0.015	807
HHS Region 10										
Alaska	74	13,751	0.026	352	0.465	6,394	0.498	6,851	0.011	154
Idaho	75	32,070	0.011	342	0.189	6,075	0.772	24,755	0.028	898
Oregon.	76	65,631	0.017	1,085	0.305	20,017	0.659	43,251	0.019	1,278
Washington	77	127,818	0.033	4,214	0.376	48,062	0.567	72,452	0.024	3,090

… Category not applicable.

NOTES: These population estimates were developed for National Immunization Survey–Child by Nadarajasundaram Ganesh at NORC at the University of Chicago using the methodology and data sources described in "National and State Vaccination Coverage Among Adolescents Aged 13–17 Years—United States, 2012;" see reference 19 in report. HHS is U.S. Department of Health and Human Services.

Table 5. Annual sample sizes and actual completed interviews from National Immunization Survey–Child, by estimation area: Landline random-digit-dialing sample, 2013

Area name	Area number	Released sample size (telephone numbers)	Number of completed household interviews	Number of children with complete household interviews[1]	Number of children with adequate provider data[1]
Total in the United States (excluding U.S. territories)	...	3,395,198	4,741	4,963	3,152
HHS Region 1					
Connecticut	1	98,244	153	160	110
Massachusetts.	2	63,970	121	128	76
Maine.	4	40,716	80	86	63
New Hampshire	5	48,175	67	68	48
Rhode Island	6	96,010	131	137	86
Vermont	7	58,372	95	100	68
HHS Region 2					
New Jersey	8	89,309	158	163	94
New York—rest of state	10	88,073	147	154	93
New York—City of New York	11	97,774	145	149	84
HHS Region 3					
District of Columbia	12	17,887	21	21	10
Delaware	13	72,059	105	111	69
Maryland	14	58,650	107	110	68
Pennsylvania—rest of state	16	56,104	116	123	78
Pennsylvania—Philadelphia County	17	76,575	75	81	35
Virginia.	18	65,179	111	117	73
West Virginia	19	60,583	114	121	84
HHS Region 4					
Alabama	20	69,659	59	59	32
Florida	22	95,273	92	98	55
Georgia	25	61,030	74	75	52
Kentucky	27	44,831	68	69	45
Mississippi	28	32,496	25	25	14
North Carolina	29	63,244	82	89	56
South Carolina.	30	69,361	72	77	49
Tennessee	31	53,379	63	66	44
HHS Region 5					
Illinois—rest of state	34	54,727	71	75	48
Illinois—City of Chicago.	35	65,934	87	93	50
Indiana.	36	44,647	65	67	44
Michigan	38	68,485	60	62	36
Minnesota	40	41,339	72	76	50
Ohio.	41	54,911	59	62	40
Wisconsin	44	45,994	75	77	60
HHS Region 6					
Arkansas	46	48,626	39	40	17
Louisiana.	47	69,667	68	71	37
New Mexico.	49	43,171	53	55	31
Oklahoma	50	62,376	82	85	58
Texas—rest of state.	51	60,608	71	72	48
Texas—El Paso County.	53	35,925	50	55	42
Texas—City of Houston.	54	126,481	91	96	55
Texas—Bexar County	55	53,038	55	56	35
HHS Region 7					
Iowa.	56	44,979	60	63	44
Kansas.	57	33,414	57	59	43
Missouri.	58	40,067	62	67	34
Nebraska	59	48,491	90	94	71
HHS Region 8					
Colorado	60	68,590	81	83	50
Montana.	61	47,364	51	52	44
North Dakota	62	32,623	85	89	61
South Dakota.	63	43,167	75	81	53
Utah.	64	25,949	47	50	32
Wyoming	65	67,537	82	86	49

See footnotes at end of table.

Table 5. Annual sample sizes and actual completed interviews from National Immunization Survey–Child, by estimation area: Landline random-digit-dialing sample, 2013—Con.

Area name	Area number	Released sample size (telephone numbers)	Number of completed household interviews	Number of children with complete household interviews[1]	Number of children with adequate provider data[1]
HHS Region 9					
Arizona	66	71,289	97	99	55
California	68	83,635	138	145	80
Hawaii	72	52,122	68	74	54
Nevada	73	58,565	109	119	79
HHS Region 10					
Alaska	74	58,613	142	144	94
Idaho	75	32,153	38	38	29
Oregon.	76	80,775	97	103	78
Washington	77	52,983	83	88	65

… Category not applicable.
[1]After removing children who became ineligible based on child's best date of birth.

NOTE: HHS is U.S. Department of Health and Human Services.

Table 6. Annual sample sizes and actual completed interviews from National Immunization Survey–Child, by estimation area: Cell-phone random-digit-dialing sample, 2013

Area name	Area number	Released sample size (telephone numbers)	Number of completed parental interviews	Number of children with completed parental interviews[1]	Number of children with adequate provider data[1]
Total in the United States (excluding U.S. territories)	...	4,537,972	16,818	17,499	10,459
HHS Region 1					
Connecticut	1	74,265	191	195	103
Massachusetts.	2	83,059	271	278	165
Maine.	4	79,616	255	266	161
New Hampshire	5	110,043	253	260	163
Rhode Island	6	97,755	212	223	121
Vermont	7	120,725	325	336	212
HHS Region 2					
New Jersey	8	87,886	302	311	171
New York—rest of state	10	78,059	240	250	133
New York—City of New York	11	108,478	318	331	158
HHS Region 3					
District of Columbia	12	215,873	353	369	213
Delaware	13	93,354	261	274	173
Maryland	14	20,113	346	362	219
Pennsylvania—rest of state	16	15,272	410	424	240
Pennsylvania—Philadelphia County	17	278,146	400	425	232
Virginia.	18	23,122	362	378	201
West Virginia	19	92,314	232	245	129
HHS Region 4					
Alabama	20	96,276	244	253	134
Florida	22	68,450	276	290	173
Georgia	25	38,258	204	213	126
Kentucky	27	71,538	228	236	145
Mississippi	28	89,589	288	297	166
North Carolina	29	69,213	329	341	206
South Carolina.	30	84,084	264	273	158
Tennessee	31	86,384	312	326	216
HHS Region 5					
Illinois—rest of state	34	95,581	452	469	279
Illinois—City of Chicago.	35	48,805	196	202	118
Indiana.	36	74,564	336	351	199
Michigan	38	80,417	270	280	176
Minnesota	40	42,928	233	239	145
Ohio.	41	99,875	348	358	209
Wisconsin	44	58,996	251	264	161
HHS Region 6					
Arkansas	46	81,825	267	279	171
Louisiana	47	116,860	322	343	187
New Mexico	49	81,019	335	344	224
Oklahoma	50	104,216	379	393	243
Texas—rest of state	51	9,651	510	527	324
Texas—El Paso County	53	74,743	294	309	199
Texas—City of Houston	54	95,474	241	252	149
Texas—Bexar County	55	126,280	321	338	193
HHS Region 7					
Iowa.	56	50,017	259	270	170
Kansas.	57	59,796	250	253	162
Missouri.	58	48,989	236	243	154
Nebraska	59	57,769	251	262	170
HHS Region 8					
Colorado	60	67,069	349	359	217
Montana.	61	74,047	262	273	176
North Dakota	62	110,350	393	413	242
South Dakota.	63	36,782	198	209	136
Utah.	64	35,691	307	322	217
Wyoming	65	76,659	218	231	147

See footnotes at end of table.

Table 6. Annual sample sizes and actual completed interviews from National Immunization Survey–Child, by estimation area: Cell-phone random-digit-dialing sample, 2013—Con.

Area name	Area number	Released sample size (telephone numbers)	Number of completed parental interviews	Number of children with completed parental interviews[1]	Number of children with adequate provider data[1]
HHS Region 9					
Arizona	66	70,108	325	342	199
California	68	47,112	350	366	203
Hawaii	72	51,006	318	328	189
Nevada	73	34,415	343	359	219
HHS Region 10					
Alaska	74	86,013	309	316	205
Idaho	75	47,112	299	307	204
Oregon.	76	51,006	277	290	197
Washington	77	34,415	243	252	157

... Category not applicable.
[1]After removing children who became ineligible based on child's best date of birth.

NOTE: HHS is U.S. Department of Health and Human Services.

Table 7. Content of the household interview questionnaire from National Immunization Survey–Child, 2013

Section	Content
S	Screening questions to determine eligibility, roster of eligible children, and availability of shot records
MR	Most knowledgeable respondent callback questions
A[1]	Vaccination history, asked if shot records are available
B	Vaccination history, asked if shot records are not available
C	Demographic and socioeconomic questions
D	Provider information and request for consent to contact the eligible child's vaccination providers
E	Health insurance coverage questions

[1]Section A was only administered to the sample in the U.S. territory of Guam.

Table 8. Key monitoring statistics for National Immunization Survey–Child: Landline random-digit-dialing sample excluding U.S. territories, 2005–2014

Key indicator	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
					Random-digit-dialing phase					
Total selected telephone numbers in released replicates.	4,465,261	5,037,830	4,539,367	5,710,803	6,310,629	7,077,661	8,423,688	5,683,234	3,395,198	10,501,675
Telephone numbers resolved before computer-assisted telephone interviewing.	1,873,070	2,186,906	1,987,635	2,493,844	2,934,598	3,259,819	3,934,335	2,758,947	2,017,511	6,149,489
Prefinalization rate.	41.90	43.40	43.80	43.70	46.50	46.10	46.70	48.50	59.40	58.60
Total telephone numbers released to computer-assisted telephone interviewing.	2,592,191	2,850,924	2,551,732	3,216,959	3,376,031	3,817,842	4,489,353	2,924,287	1,377,687	4,352,186
Advance letters mailed.	1,460,066	1,645,109	1,469,436	1,760,771	1,579,190	1,711,459	1,925,791	1,184,323	577,759	1,775,315
Advance letters rate.	56.30	57.70	57.60	54.70	46.80	44.80	42.90	40.50	41.90	40.80
Resolved telephone numbers[1].	3,721,224	4,197,242	3,763,013	4,698,087	5,228,200	5,897,725	6,992,832	4,780,039	2,825,547	8,683,951
Resolution rate.	83.30	83.30	82.90	82.30	82.80	83.30	83.00	84.10	83.20	82.70
Households identified	1,085,040	1,137,706	974,586	1,108,491	1,114,670	1,185,219	1,258,093	734,695	363,646	950,911
Working residential number rate	29.20	27.10	25.90	23.60	21.30	20.10	18.00	15.40	12.90	11.00
Households successfully screened for presence of age-eligible children.	1,006,435	1,029,073	879,207	1,000,840	1,030,376	1,084,421	1,141,212	666,273	330,986	876,761
Screener completion rate.	92.80	90.50	90.20	90.30	92.40	91.50	90.70	90.70	91.00	92.20
Households with no age-eligible children[2].	974,510	995,113	851,400	971,162	1,001,463	1,057,016	1,113,511	652,145	325,162	863,538
Ineligibility rate[2]	96.80	96.70	96.80	97.00	97.20	97.50	97.60	97.90	98.20	98.50
Households with age-eligible children[2]	31,925	33,960	27,807	29,678	28,913	27,405	27,701	14,128	5,824	13,223
Eligibility rate[2]	3.20	3.30	3.20	3.00	2.80	2.50	2.40	2.10	1.80	1.50
Households with age-eligible children with completed random-digit-dialing interviews	26,867	29,065	24,133	25,257	24,068	22,915	22,642	11,954	4,792	10,858
Interview completion rate.	84.20	85.60	86.80	85.10	83.20	83.60	81.70	84.60	82.30	82.10
CASRO response rate[3]	65.10	64.50	64.90	63.20	63.70	63.80	61.50	64.50	62.30	62.60
Age-eligible children with completed random-digit-dialing interviews[4].	27,627	29,880	24,807	25,948	24,809	23,605	23,406	12,325	4,963	11,198
					Provider-record-check phase					
Children with consent obtained to contact vaccination providers.	21,692	24,193	19,896	21,004	19,681	18,742	18,611	9,203	3,453	7,866
Consent rate	78.50	81.00	80.20	80.90	79.30	79.40	79.50	74.70	69.60	70.20
Immunization history questionnaires mailed to providers	27,023	30,073	25,170	26,081	25,164	25,407	24,512	11,812	4,240	9,625
Immunization history questionnaires or medical records returned by providers.	23,767	28,427	22,932	24,653	23,626	24,052	23,334	11,322	4,105	9,117
Immunization history questionnaire return rate	88.00	94.50	91.10	94.50	93.90	94.70	95.20	95.90	96.80	94.70
Children with adequate provider data	17,563	21,044	17,017	18,430	17,053	16,798	16,919	8,374	3,152	7,093
Adequate provider data rate	63.60	70.40	68.60	71.00	68.70	71.20	72.30	67.90	63.50	63.30

[1]Includes telephone numbers resolved before computer-assisted telephone interviewing.
[2]Prior to the first quarter of 2011 (Q1/2011), children were age eligible if they were aged 19–35 months on the day of the screening interview. Beginning in Q2/2011, children were age eligible if they were or would be aged 19–35 months on any day in the calendar quarter.
[3]CASRO is Council of American Survey Research Organizations. The response rate is the product of the resolution rate, screener completion rate, and interview completion rate.
[4]Excludes children with a completed random-digit-dialing interview who were later found to be age ineligible.

Table 9. Key monitoring statistics for National Immunization Survey–Child: Cell-phone random-digit-dialing sample excluding U.S. territories, 2011–2014

Key indicator	2011	2012	2013	2014
	Random-digit-dialing phase			
Total selected telephone numbers in released replicates	727,860	2,788,756	4,537,972	4,142,841
Resolved telephone numbers	341,797	1,460,642	2,439,654	2,432,314
Resolution rate.	47.00	52.40	53.80	58.70
Active personal cell-phone numbers identified	173,090	568,843	900,123	680,212
Active personal cell-phone numbers rate.	50.60	38.90	36.90	28.00
Active personal cell-phone numbers successfully screened[1]	132,033	440,389	713,754	534,254
Screener completion rate[1]	76.30	77.50	79.30	78.50
Number of screened households that were not eligible[2]	127,435	424,282	689,973	516,570
Ineligibility rate[2]	96.50	96.20	96.70	96.70
Number of screened households that were eligible[2]	4,598	16,707	23,781	17,684
Eligibility rate[2]	3.50	3.80	3.30	3.30
Households with age-eligible children with completed random-digit-dialing interviews	3,237	12,608	17,027	12,837
Interview completion rate.	70.40	75.50	71.60	72.60
CASRO response rate[3]	25.20	30.60	30.50	33.50
Age-eligible children with completed random-digit-dialing interviews[4].	3,335	13,009	17,499	13,233
	Provider-record-check phase			
Children with consent obtained to contact vaccination providers	2,502	9,276	11,744	8,853
Consent rate	75.00	71.30	67.10	66.90
Immunization history questionnaires mailed to providers	3,358	12,031	15,097	11,178
Immunization history questionnaires or medical records returned by providers.	3,150	11,525	14,491	10,472
Immunization history questionnaire return rate	93.80	95.80	96.00	93.70
Children with adequate provider data	2,225	8,313	10,459	7,800
Adequate provider data rate	66.70	63.90	59.80	58.90

[1]Prior to the second quarter of 2011 (Q2/2011), active personal cell-phone numbers (APCNs) were screened both for cell-phone status to identify cell-phone-only or cell-phone-mainly households and for age eligibility to identify cell phones used by adults in households with a child aged 19–35 months. In Q2/2011–Q4/2011, APCNs were screened only to identify adult cell phones in households with a child aged 19–35 months i.e., they were not screened for cell-phone status.
[2]Prior to Q2/2011, households were eligible if an adult used the cell phone, if the household was cell-phone only or cell-phone mainly, and if the household contained a child aged 19–35 months on the day of age-eligibility screening. Beginning Q2/2011, households were eligible if an adult used the cell phone and if the household contained a child that was or would be aged 19–35 months on any day in the calendar quarter.
[3]CASRO is Council of American Survey Research Organizations. The response rate is the product of the resolution rate, screener completion rate, and interview completion rate.
[4]Excludes children with a completed random-digit-dialing interview who were later found to be age ineligible.

Table 10. Annual household response rates for National Immunization Survey–Child: Combined landline and cell-phone random-digit-dialing samples excluding U.S. territories, 2011–2014

Key indicator	2011	2012	2013	2014
Estimated eligible households (HHs).	49,617	59,702	63,477	55,712
Observed eligible HHs among screened.	32,299	30,835	29,605	30,907
Estimated eligible HHs from unscreened	4,267	6,324	6,784	5,950
Estimated eligible HHs from unresolved	13,052	22,543	27,088	18,855
Completed HH interviews	25,879	24,562	21,819	23,695
HH response rate (percent)	52.20	41.20	34.40	42.50

Table 11. Item nonresponse rates for demographic variables subject to imputation in National Immunization Survey–Child: Landline random-digit-dialing sample, 2005–2014

Variable	Item nonresponse rate[1]									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Education of mother	0.7	0.7	0.7	0.8	0.8	0.9	0.8	0.8	0.8	1.1
Marital status of mother.	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Hispanic origin of child.	0.7	0.6	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5
Hispanic origin of mother.	0.5	0.5	0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.5
Age of mother	1.0	1.1	0.9	1.0	1.0	1.6	1.5	1.7	2.0	2.6
Number of landline telephone numbers in household	1.9	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Interruption in telephone service	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5
Length of interruption in landline telephone service	0.6	0.5	0.5	0.5	0.4	…	…	…	…	…
Number of cell phones used in the household	…	…	…	…	…	1.2	1.3	1.2	1.6	1.6
Number of cell phones usually used by child's parent or guardian	…	…	…	…	…	1.2	1.3	1.2	1.5	1.5
Single race of child	10.2	…	…	…	…	…	…	…	…	…
Race of child with multiple-race category	8.4	9.2	7.7	7.4	6.6	5.9	5.0	4.7	4.5	4.3
Single race of mother	9.2	9.8	8.5	7.9	7.2	6.5	5.8	5.6	5.6	5.4
Race of mother with multiple-race category	8.9	9.4	8.1	7.6	6.7	5.9	5.3	5.0	4.7	4.6
Sex of child	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
First-born status of child	2.9	3.2	3.0	3.1	3.4	3.0	2.9	3.1	3.6	3.1
Mobility status	0.6	0.5	0.5	0.5	0.5	0.7	0.5	0.6	1.0	0.9
True metropolitan statistical area status	…	…	…	…	…	0.7	0.7	1.0	1.2	1.1

… Category not applicable.
0.0 Quantity more than zero but less than 0.05.
[1]All rates exclude U.S. territories.

NOTES: Imputation of the number of cell phones in the household, the number of cell phones usually used by the parent or guardian, and the true metropolitan statistical area status began in 2010. Calculation of single race of child ended after 2005. Collection of length of telephone service interruption ended after 2009.

Table 12. Item nonresponse rates for demographic variables subject to imputation in National Immunization Survey–Child: Cell-phone random-digit-dialing sample, 2011–2014

Variable	Item nonresponse rate[1]			
	2011	2012	2013	2014
Education of mother	0.7	0.8	0.8	0.9
Marital status of mother.	0.3	0.4	0.4	0.5
Hispanic origin of child.	0.4	0.4	0.4	0.5
Hispanic origin of mother.	0.3	0.3	0.4	0.4
Age of mother	0.8	1.2	1.8	2.4
Number of cell phones used in the household	0.4	0.6	0.6	0.6
Number of cell phones usually used by child's parent or guardian	0.7	0.9	0.7	0.7
Race of child with multiple-race category	7.2	6.3	6.1	6.4
Single race of mother	8.0	6.9	7.2	7.5
Race of mother with multiple-race category	7.4	6.3	6.3	6.8
Sex of child	0.1	0.1	0.1	0.2
Firstborn status of child	2.1	2.2	2.6	2.8
Mobility status	0.4	0.6	1.0	1.1
True metropolitan statistical area status	1.1	1.1	1.5	1.7

[1]All rates exclude U.S. territories.

Table 13. Candidate predictor variables for fitting the response propensity model for whether a child has adequate provider data for National Immunization Survey–Child: 2005–2010, excluding U.S. territories

Name of variable	Description and category	Selected for final model					
		2005	2006	2007	2008	2009	2010
AGEGRP	Age of child (months) 19–23 24–29 30–35	Yes	No	Yes	No	No	Yes
CHILDNM	Number of children under age 18 years living in the household . . . . 1 child 2–3 children 4 or more children	No	Yes	Yes	Yes	Yes	Yes
C5	Relationship of the household respondent to the child (mother, father, or other) . . . . Mother (step, foster, or adoptive) or female guardian Father (step, foster, or adoptive) or male guardian Other and missing	Yes	Yes	Yes	Yes	Yes	Yes
EDUC1	Educational status of the mother. . . . . Less than 12 years 12 years More than 12 years, not college graduate College graduate	Yes	Yes	Yes	Yes	No	Yes
FRSTBRN	Firstborn status of child . . . . Yes No	No	Yes	Yes	Yes	No	Yes
INCPOV1	Poverty status . . . . Above poverty level, household income $75,000 or more Above poverty level, household income less than $75,000 At or below poverty level Unknown	Yes	Yes	Yes	Yes	Yes	Yes
MAGEGRP	Maternal age group . . . . 19 and under 20–29 30 and over	No	Yes	Yes	Yes	Yes	Yes
MARITAL	Marital status of the mother. . . . . Widowed, divorced, or separated Never married Married Deceased	No	No	No	No	Yes	No
MOBIL	Mobility status . . . . Moved, mother resided in a different state when child was born Did not move from different state	Yes	Yes	Yes	Yes	Yes	Yes
MSA	Relation of household's location to metropolitan statistical area (MSA). . . . . In central city of MSA In MSA, but not in central city Not in MSA	Yes	Yes	Yes	Yes	Yes	Yes
RACEKID	Race or ethnicity of the child . . . . Hispanic White only, non-Hispanic Black only, non-Hispanic American Indian or Alaska Native only, non-Hispanic Asian, Native Hawaiian or Pacific Islander only, non-Hispanic Other or multiple race, non-Hispanic	Yes	Yes	Yes	Yes	Yes	Yes
SEX	Sex of the child . . . . Male Female	No	No	No	No	Yes	No
SHOTCARD	Household's use of a "shot card" in reporting immunization status . . . . Shot card used during household interview Shot card not used during household interview	Yes	Yes	Yes	Yes	Yes	Yes

Table 14. Sample sizes and coefficient of variation of weights in National Immunization Survey–Child: 2005–2014, excluding U.S. territories

Weight	Summary statistic	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Final child-level interview weights (RDDWT)	Number of child records.	27,627	29,880	24,807	25,948	25,241	24,013	26,741	25,334	22,462	24,431
	National CV of weights	128.6	134.3	137.9	137.7	143.3	143.7	149.9	159.2	158.1	179.2
	Minimum estimation area CV of weights	31.0	39.9	22.6	33.9	25.3	35.2	59.9	45.1	46.8	55.0
	Median estimation area CV of weights	54.4	60.1	63.8	61.5	63.5	57.1	87.9	71.9	62.3	84.0
	Maximum estimation area CV of weights . . .	83.6	101.9	91.9	112.0	124.3	88.7	140.7	106.6	141.9	129.4
Final provider-phase weights (PROVWT)	Number of child records.	17,563	21,044	17,017	18,430	17,313	17,004	19,144	16,687	13,611	14,893
	National CV of weights	140.2	141.9	147.1	144.2	152.4	147.0	160.6	162.4	163.3	176.4
	Minimum estimation area CV of weights	29.8	37.7	30.7	36.9	30.6	36.7	60.0	48.4	47.1	63.4
	Median estimation area CV of weights	60.1	63.2	67.8	64.5	67.2	60.9	88.8	73.5	67.1	87.5
	Maximum estimation area CV of weights . . .	99.9	99.2	94.9	113.9	130.0	89.6	139.4	107.4	143.9	137.2

NOTE: CV is coefficient of variation and is expressed as a percentage.

Table 15. Candidate predictor variables for fitting the response propensity model for whether a child has adequate provider data for National Immunization Survey–Child: 2011–2014, excluding U.S. territories

Name of variable	Description and category	Selected for final model			
		2011	2012	2013	2014
AGEGRP	Age of child (months). 19–23 24–29 30–35	Yes	No	Yes	Yes
CHILDNM	Number of children under age 18 years living in the household . . . . 1 child 2–3 children 4 or more children	Yes	No	No	Yes
C5	Relationship of the household respondent to the child (mother, father, or other) . . . . Mother (step, foster, or adoptive) or female guardian Father (step, foster, or adoptive) or male guardian Other or missing	Yes	Yes	Yes	Yes
EDUC1	Educational status of the mother. . . . . Less than 12 years 12 years More than 12 years, not college graduate College graduate	Yes	Yes	Yes	Yes
FRSTBRN	Firstborn status of child . . . . Yes No	Yes	No	No	Yes
INCPOV1	Poverty status . . . . Above poverty level, household income $75,000 or more Above poverty level, household income less than $75,000 At or below poverty level Unknown	Yes	Yes	Yes	Yes
MAGEGRP	Maternal age group . . . . 19 and under 20–29 30 and over	Yes	No	Yes	Yes
MARITAL	Marital status of the mother. . . . . Widowed, divorced, or separated Never married Married Deceased	Yes	No	Yes	No
MOBIL	Mobility status . . . . Moved, mother resided in a different state when child was born Did not move from different state	No	Yes	Yes	No
MSA	Relation of household's location to metropolitan statistical area (MSA) . . . . In central city of MSA In MSA, but not in central city Not in MSA	Yes	Yes	Yes	No
RACEKID	Race or ethnicity of the child . . . . Hispanic White only, non-Hispanic Black only, non-Hispanic American Indian or Alaska Native only, non-Hispanic Asian, Native Hawaiian, or Pacific Islander only, non-Hispanic Other or multiple race, non-Hispanic	Yes	Yes	Yes	Yes
SEX	Sex of the child . . . . Male Female	No	No	No	No
SHOTCARD	Household's use of a "shot card" in reporting immunization status . . . . Shot card used during household interview Shot card not used during household interview	Yes	…	…	…
OWNER	Housing tenure . . . . Owned or being bought All other (including rented, other arrangements, don't know, or refused)	Yes	No	No	No
TEL_SAMPFRAME	Identifies whether the telephone number was selected from the landline or cell-phone sampling frame. . . . . Landline Cell phone	Yes	Yes	Yes	Yes
AGEGRP*TEL_SAMPFRAME	Interaction between AGEGRP and TEL_SAMPFRAME	Yes	No	Yes	Yes
C5*TEL_SAMPFRAME	Interaction between C5 and TEL_SAMPFRAME	Yes	Yes	Yes	Yes
MAGEGRP*TEL_SAMPFRAME	Interaction between MAGEGRP and TEL_SAMPFRAME.	No	No	Yes	No
RACEKID*TEL_SAMPFRAME	Interaction between RACEKID and TEL_SAMPFRAME	Yes	No	Yes	No

See footnotes at end of table.

Table 15. Candidate predictor variables for fitting the response propensity model for whether a child has adequate provider data for National Immunization Survey–Child: 2011–2014, excluding U.S. territories—Con.

Name of variable	Description and category	Selected for final model			
		2011	2012	2013	2014
FRSTBRN*TEL_SAMPFRAME	Interaction between FRSTBRN and TEL_SAMPFRAME	Yes	No	No	No
CHILDNM*TEL_SAMPFRAME	Interaction between CHILDNM and TEL_SAMPFRAME.	Yes	No	No	Yes
MARITAL*TEL_SAMPFRAME	Interaction between MARITAL and TEL_SAMPFRAME	No	No	Yes	No
EDUC1*TEL_SAMPFRAME	Interaction between EDUC1 and TEL_SAMPFRAME.	Yes	Yes	No	Yes
OWNER*TEL_SAMPFRAME	Interaction between OWNER and TEL_SAMPFRAME	Yes	No	No	No
MSA*TEL_SAMPFRAME	Interaction between MSA and TEL_SAMPFRAME	Yes	Yes	No	No

… Category not applicable.

Table 16. Key monitoring statistics for National Immunization Survey–Teen: Landline random-digit-dialing sample excluding U.S. territories, 2006–2014

Key indicator	Quarter 4, 2006	Quarter 4, 2007	2008	2009	2010	2011	2012	2013	2014
				Random-digit-dialing phase					
Total selected telephone numbers in released replicates.	341,512	398,683	2,481,132	3,275,206	3,365,921	4,266,170	3,676,083	2,369,873	4,892,189
Telephone numbers resolved before computer-assisted telephone interviewing	141,615	168,315	1,091,342	1,524,300	1,556,455	2,002,669	1,780,036	1,411,142	2,864,063
Prefinalization rate	41.50	42.20	44.00	46.50	46.20	46.90	48.42	59.55	58.54
Total telephone numbers released to computer-assisted telephone interviewing	199,897	230,368	1,389,790	1,750,906	1,809,466	2,263,501	1,896,047	958,731	2,028,126
Advance letters mailed.	118,189	132,870	756,176	809,385	803,790	952,525	758,603	412,432	819,058
Advance letters rate	59.10	57.70	54.40	46.20	44.40	42.10	40.01	43.02	40.38
Resolved telephone numbers[1]	281,465	327,674	2,040,314	2,707,821	2,798,198	3,538,211	3,086,732	1,978,048	4,039,413
Resolution rate.	82.40	82.20	82.20	82.70	83.10	82.90	83.97	83.47	82.57
Households identified	79,085	85,037	481,056	571,039	552,725	622,778	474,801	253,572	435,641
Working residential number rate	28.10	26.00	23.60	21.10	19.80	17.60	15.38	12.82	10.78
Households successfully screened for presence of age-eligible adolescents	64,387	69,289	403,134	485,138	471,817	527,203	403,165	218,237	379,759
Screening completion rate.	81.40	81.50	83.80	85.00	85.40	84.70	84.91	86.07	87.17
Households with no age-eligible adolescents	57,838	62,717	367,063	442,724	432,006	485,551	373,569	203,957	356,194
Ineligibility rate.	89.80	90.50	91.10	91.30	91.60	92.10	92.66	93.46	93.79
Households with age-eligible adolescents	6,549	6,572	36,071	42,414	39,811	41,652	29,596	14,280	23,565
Eligibility rate	10.20	9.50	8.90	8.70	8.40	7.90	7.34	6.54	6.21
Households with age-eligible adolescents with completed random-digit-dialing interviews	5,481	5,486	30,725	35,004	32,491	33,945	22,853	10,157	19,747
Interview completion rate.	83.70	83.50	85.20	82.50	81.60	81.50	77.22	71.13	83.80
CASRO response rate[2]	56.20	55.90	58.70	58.00	57.90	57.20	55.06	51.10	60.32
Age-eligible adolescents with completed random-digit-dialing interviews[3].	5,468	5,474	30,681	34,976	32,429	33,891	22,807	10,148	19,705
				Provider-record-check phase					
Adolescents with consent obtained to contact vaccination providers	4,192	4,114	23,561	26,125	23,738	25,048	16,628	6,931	12,684
Consent rate	76.70	75.20	76.80	74.70	73.20	73.90	72.91	68.30	64.37
Immunization history questionnaires mailed to providers	5,851	5,848	33,817	38,329	40,263	42,262	28,879	11,659	20,005
Immunization history questionnaires or medical records returned by providers	5,220	5,213	31,750	35,960	37,526	39,752	27,444	11,230	18,989
Immunization history questionnaire return rate	89.20	89.10	93.90	93.80	93.20	94.10	95.03	97.07	94.92
Adolescents with adequate provider data	2,882	2,947	17,835	20,066	19,257	20,848	14,133	6,039	11,243
Adequate provider data rate	52.70	53.80	58.10	57.40	59.40	61.50	61.97	59.51	57.06

[1]Includes telephone numbers resolved before computer-assisted telephone interviewing.
[2]CASRO is Council of American Survey Research Organizations. The response rate is the product of the resolution rate, screener completion rate, and interview completion rate.
[3]Excludes adolescents with a completed random-digit-dialing interview who were later found to be age ineligible.

Table 17. Key monitoring statistics for National Immunization Survey–Teen: Cell-phone random-digit-dialing sample excluding U.S. territories, 2011–2014

Key indicator	2011	2012	2013	2014
	Random-digit-dialing phase			
Total selected telephone numbers in released replicates	648,691	1,274,436	3,882,201	3,069,031
Resolved telephone numbers	304,091	663,110	2,092,383	1,808,334
Resolution rate.	46.90	52.03	53.90	58.92
Active personal cell-phone numbers identified	153,853	262,183	773,858	502,017
Active personal cell-phone numbers rate.	50.60	39.54	36.98	27.76
Active personal cell-phone numbers successfully screened[1]	107,967	185,065	565,564	365,720
Screener completion rate[1]	70.20	70.59	73.08	72.85
Number of screened households that were not eligible[2]	100,640	171,029	527,518	340,462
Ineligibility rate[2]	93.20	92.42	93.27	93.09
Number of screened households that were eligible[2]	7,327	14,036	38,046	25,258
Eligibility rate[2]	6.80	7.58	6.73	6.91
Households with age-eligible adolescents with completed random-digit-dialing interviews	4,984	9,007	22,495	18,368
Interview completion rate.	68.00	64.17	59.13	72.72
CASRO response rate[3]	22.40	23.57	23.29	31.22
Age-eligible adolescents with completed random-digit-dialing interviews[4].	4,976	8,985	22,448	18,342
	Provider-record-check phase			
Adolescents with consent obtained to contact vaccination providers.	3,346	6,100	14,579	11,228
Consent rate	67.20	67.89	64.95	61.21
Immunization history questionnaires mailed to providers	5,594	10,758	24,817	17,642
Immunization history questionnaires or medical records returned by providers	5,243	10,192	23,662	16,716
Immunization history questionnaire return rate	93.70	94.74	95.35	94.75
Adolescents with adequate provider data	2,716	5,066	12,225	9,584
Adequate provider data rate	54.60	56.38	54.46	52.25

[1]In the first quarter of 2011 (Q1/2011), active personal cell-phone numbers (APCNs) were screened both for cell-phone status to identify cell-phone-only or cell-phone-mainly households and for age eligibility to identify cell phones used by adults in households with an adolescent aged 13–17. Beginning with Q2/2011 and after, APCNs were screened only to identify adults in households with an adolescent aged 13–17 i.e., they were not screened for cell-phone status.
[2]In Q1/2011, households were eligible if an adult used the cell phone, if the household was cell-phone only or cell-phone mainly, and if the household contained an adolescent aged 13–17 on the day of age-eligibility screening. Beginning Q2/2011, households were eligible if an adult used the cell phone and if the household contained an adolescent aged 13–17 on the day of age-eligibility screening.
[3]CASRO is Council of American Survey Research Organizations. The response rate is the product of the resolution rate, screener completion rate, and interview completion rate.
[4]Excludes adolescents with a completed random-digit-dialing interview who were later found to be age ineligible.

Table 18. Annual household response rates for National Immunization Survey–Teen: Combined landline and cell-phone random-digit-dialing samples excluding U.S. territories, 2011–2014

Key indicator	2011	2012	2013	2014
Estimated eligible households (HHs).	81,600	79,727	116,462	91,581
Observed eligible HHs	48,979	43,632	52,326	48,823
Estimated eligible HHs from unscreened	10,665	11,108	16,324	12,881
Estimated eligible HHs from unresolved	21,956	24,988	47,812	29,877
Completed HH interviews	38,929	31,860	32,652	38,115
HH response rate (percent).	47.7	40.0	28.0	41.6

Table 19. Percentage of adolescents in the population within estimation area for National Immunization Survey–Teen, by telephone status, 2013

Area name	Area number	Adolescents in landline-only households as percentage of all adolescents in estimation area	Adolescents in dual-user households as percentage of all adolescents in estimation area	Adolescents in cell-phone-only households as percentage of all adolescents in estimation area	Adolescents in phoneless households as percentage of all adolescents in estimation area
HHS Region 1					
Connecticut	1	2.13	70.80	26.26	0.81
Massachusetts	2	2.53	77.87	18.68	0.93
Maine	4	2.17	62.03	34.45	1.36
New Hampshire	5	0.71	73.83	24.23	1.23
Rhode Island	6	2.79	67.05	28.11	2.05
Vermont	7	3.93	65.93	29.22	0.92
HHS Region 2					
New Jersey	8	1.15	78.84	18.78	1.23
New York—rest of state	10	1.55	72.04	24.93	1.48
New York—City of New York	11	2.29	64.98	30.69	2.04
HHS Region 3					
District of Columbia	12	4.32	63.95	29.95	1.78
Delaware	13	1.45	65.32	31.77	1.46
Maryland	14	0.56	66.58	31.38	1.48
Pennsylvania—rest of state	16	2.34	64.33	31.65	1.68
Pennsylvania—Philadelphia County	17	2.80	55.39	38.83	2.98
Virginia	18	1.40	65.09	31.91	1.61
West Virginia	19	2.23	52.17	43.25	2.36
Alabama	20	2.18	50.34	45.66	1.82
HHS Region 4					
Florida	22	2.68	47.15	47.68	2.49
Georgia	25	1.54	51.23	44.85	2.39
Kentucky	27	1.68	48.72	47.23	2.37
Mississippi	28	2.21	40.29	55.45	2.05
North Carolina	29	1.86	55.27	41.33	1.54
South Carolina	30	1.72	47.30	48.76	2.22
Tennessee	31	1.01	49.49	47.63	1.87
HHS Region 5					
Illinois—rest of state	34	0.85	58.70	39.11	1.34
Illinois—City of Chicago	35	1.84	55.01	41.46	1.69
Indiana	36	3.97	49.02	43.83	3.18
Michigan	38	2.73	53.05	42.34	1.88
Minnesota	40	1.24	62.07	35.54	1.15
Ohio	41	1.63	54.95	40.96	2.47
Wisconsin	44	1.54	55.45	41.08	1.93
HHS Region 6					
Arkansas	46	1.27	38.38	57.74	2.61
Louisiana	47	2.75	51.59	43.75	1.91
New Mexico	49	5.94	40.50	49.51	4.05
Oklahoma	50	0.98	47.64	50.27	1.10
Texas—rest of state	51	2.44	41.78	53.95	1.83
Texas—City of Houston	54	1.97	44.79	51.30	1.94
Texas—Bexar County	55	1.40	39.82	56.95	1.82
HHS Region 7					
Iowa	56	0.94	50.13	46.72	2.20
Kansas	57	2.69	49.35	46.05	1.91
Missouri	58	1.26	43.89	52.20	2.64
Nebraska	59	1.71	56.78	40.37	1.14
HHS Region 8					
Colorado	60	2.20	57.64	38.58	1.58
Montana	61	3.46	51.24	42.28	3.02
North Dakota	62	3.62	52.27	43.60	0.51
South Dakota	63	1.88	61.11	35.49	1.52
Utah	64	0.26	54.55	43.80	1.40
Wyoming	65	4.64	49.72	44.18	1.46

See footnotes at end of table.

Table 19. Percentage of adolescents in the population within estimation area for National Immunization Survey–Teen, by telephone status, 2013—Con.

Area name	Area number	Adolescents in landline-only households as percentage of all adolescents in estimation area	Adolescents in dual-user households as percentage of all adolescents in estimation area	Adolescents in cell-phone-only households as percentage of all adolescents in estimation area	Adolescents in phoneless households as percentage of all adolescents in estimation area
HHS Region 9					
Arizona	66	4.28	43.63	50.26	1.82
California	68	4.92	57.34	36.53	1.21
Hawaii	72	0.77	53.71	43.83	1.69
Nevada	73	4.32	55.05	39.04	1.59
HHS Region 10					
Alaska	74	1.82	79.39	18.10	0.69
Idaho	75	0.98	45.80	51.34	1.87
Oregon	76	2.17	53.08	43.30	1.46
Washington	77	2.47	57.33	38.88	1.32

NOTES: Data exclude all U.S. territories. HHS is U.S. Department of Health and Human Services.

SOURCE: Estimates derived by Nadarajasundaram Ganesh at NORC at the University of Chicago using statistical methods similar to those reported in "Wireless Substitution: State-level Estimates From the National Health Interview Survey, January 2007–June 2010;" see reference 41 in report.

Table 20. Topical modules conducted as part of National Immunization Survey–Child and –Teen

Topical module[1]	Sample sizes of children[2]	Period of administration (quarter/year)	Purpose
National Immunization Survey–Child			
Knowledge, Attitudes, and Practices	5,780 children with completed modules	Q1–Q4/2001	Provided data on parental concerns about childhood vaccinations. Conducted as a follow-up interview with parents who responded to the 2000–2001 NIS–Child, as well as a mail survey of 1,076 providers of the NIS–Child children to gather their attitudes and practices.
Health Insurance and Ability to Pay for Vaccines	30,741 children with completed modules, 24,596 with adequate provider data	Q3/2001–Q4/2002	Provided data on economic and health insurance-related barriers to vaccination and vaccination coverage levels and to evaluate vaccination coverage for Vaccines for Children-eligible children.
Parental Knowledge and Experiences	5,273 children with completed modules, 7,810 with adequate provider data	Q3/2001–Q4/2002	Provided data on parental concerns about vaccine safety and the impact of those concerns on vaccination practices.
Daycare, Breastfeeding Practices, and WIC[3]	9,908 children with completed modules, 4,179 with adequate provider data	Q3/2001–Q4/2002	Provided data to determine vaccination coverage among WIC[3]-eligible children.
Vaccine Shortage	2,840 children with completed modules, 2,247 with adequate provider data	Q2–Q4/2003	Provided data on the 2001–2005 shortages of the pneumococcal vaccine.
Vaccine Safety	2,936 children with completed modules, 2,287 with adequate provider data	Q2–Q4/2003	Provided data on how parents' concerns about vaccine safety might be addressed to increase vaccination coverage among children.
Influenza	30,682 children with completed modules, 20,599 with adequate provider data	Q1–Q4/2004	Provided data on influenza vaccination history.
Health Insurance[4]	Q1–Q4/2006: 24,712 children with completed modules, 20,890 with adequate provider data Q1–Q4/2007: 20,618 children with completed modules, 16,903 with adequate provider data Q1–Q4/2008: 21,650 children with completed modules, 18,254 with adequate provider data Q1–Q4/2009: 20,059 children with completed modules, 16,863 with adequate provider data Q1–Q4/2010: 18,996[5] children with completed modules, 16,591[5] with adequate provider data Q1–Q4/2011: 21,424 children with completed modules, 18,927 with adequate provider data Q1–Q4/2012: 18,607 children with completed modules, 16,503 with adequate provider data Q1–Q4/2013: 15,379 children with completed modules, 13,293 with adequate provider data Q1–Q4/2014: 17,050 children with completed modules, 14,629 with adequate provider data	Q1–Q4/2006–2014	Provided data to determine the degree to which NIS-sampled children are entitled to access vaccines through their state's Vaccine's for Children Program. These data helped identify children covered by private insurance, public insurance (Medicaid or state Children's Health Insurance Program), military insurance (TRICARE), or Indian Health Service.
Socioeconomic Status	8,768 children with completed modules, 7,450 with adequate provider data	Q1–Q2/2008	Provided data on socioeconomic status indicators related to racial, ethnic, and poverty disparities in vaccination coverage.
Parental Concerns	Q3/2008–Q4/2009: 29,509 children with completed modules, 24,875 with adequate provider data Q2–Q4/2011: 13,921 children with completed modules, 12,259 with adequate provider data	Q3/2008–Q4/2009; Q2–Q4/2011	Provided data on parents' attitudes about vaccines, decisions to delay or refuse vaccine administration, and reasons for delaying or refusing vaccines.

See footnotes at end of table.

Table 20. Topical modules conducted as part of National Immunization Survey–Child and –Teen—Con.

Topical module[1]	Sample sizes of children[2]	Period of administration (quarter/year)	Purpose
National Immunization Survey–Teen			
Health Insurance[4]	Q4/2006: 4,356 children with completed modules, 2,872 with adequate provider data Q4/2007: 4,232 children with completed modules, 2,928 with adequate provider data Q1–Q4/2008: 24,668 children with completed modules, 17,738 with adequate provider data Q1–Q4/2009: 26,945 children with completed modules, 19,921 with adequate provider data Q1–Q4/2010: 24,438[5] children with completed modules, 19,064[5] with adequate provider data Q1–Q4/2011: 29,243 children with completed modules, 23,324 with adequate provider data Q1–Q4/2012: 23,316 children with completed modules, 19,049 with adequate provider data Q1–Q4/2013: 22,127 children with completed modules, 17,986 with adequate provider data Q1–Q4/2014: 24,874 children with completed modules, 20,540 with adequate provider data	Q4/2006; Q4/2007; Q1–Q4/2008–2014	Provided data to determine the degree to which NIS–Teen-sampled children are entitled to access vaccines through their state's Vaccines for Children Program. These data helped identify teenagers covered by private insurance, public insurance (Medicaid or state Children's Health Insurance Program), military insurance (TRICARE), or Indian Health Service.
Parental Attitudes	10,808 children with completed modules, 8,490 with adequate provider data[5]	Q3–Q4/2010	A project sponsored by the American Recovery and Reinvestment Act of 2009, provided data on parents' perceptions about vaccines for their teenaged children, parents' satisfaction with their experience getting their teenagers vaccinated, and influences on parents' decision to vaccinate their teenaged children and delay or refuse vaccines.

[1]Data from these topical modules are not released for public use. However, access to the restricted data for special analyses may be available by submitting a proposal to the National Center for Health Statistics Research Data Center (available from: https://www.cdc.gov/rdc).
[2]Sample sizes exclude U.S. territories.
[3]Women, Infants, and Children Program
[4]Beginning in 2007, data were imputed to be nonmissing for all children with adequate provider data; the sample counts of children with a completed Health Insurance Module presented in this table are preimputation.
[5]Counts for 2010 exclude the 2010 National Immunization Survey cell-phone sample pilot study.

Table 21. Data-processing steps for National Immunization Survey–Child and –Teen, 2005–2014

Step	Description
1	Post-CATI[1] data editing and summarization
2	Immunization history questionnaire data processing
3	Matching sheet review
4	Derivation of composite variables
5	Imputation of missing values
6	Final data file production

[1]Computer-assisted telephone interview.

Table 22. Editing limits for vaccination date that trigger a matching sheet review: National Immunization Survey–Child and –Teen, 2014

Vaccine category	Vaccine type	Flag for review if:
National Immunization Survey–Child		
DTaP[1] and DTP[2]	DTaP	1st shot given before DOB plus 38 days 4th shot given before DOB plus 361 days Less than 24 days between 1st and 2nd shots Less than 24 days between 2nd and 3rd shots Less than 119 days between 3rd and 4th shots
Polio	IPV	1st shot given before DOB plus 38 days Less than 24 days between 1st and 2nd shots Less than 24 days between 2nd and 3rd shots
Measles-containing	All types	1st shot given before DOB plus 361 days Less than 24 days and not zero days between 1st meningococcal conjugate vaccination shot and 1st varicella shot
Hepatitis B	All types	3rd shot given before DOB plus 120 days 4th shot given before DOB plus 180 days Less than 24 days between 1st and 2nd shots Less than 52 days between 2nd and 3rd shots
Varicella	All types	1st shot given before DOB plus 180 days Less than 24 days and not zero days between 1st varicella shot and 1st meningococcal conjugate vaccination shot
National Immunization Survey–Teen		
Td and Tdap[3]	Td Td/Tdap unknown type Tdap	Any shot before 7 years Less than 4 weeks between 1st and 2nd shots Less than 8 weeks between 2nd and 3rd shots Any shot before 10 years
Hepatitis B	HepB–Hib[4] 0.5 ml Recombivax Engerix HepB only, unknown type HepB-containing, unknown type 1.0 ml Recombivax	Less than 24 days between 1st and 2nd shots 3rd shot given before DOB plus 120 days Less than 52 days between 2nd and 3rd shots 4th shot given before DOB plus 180 days Less than 4 months between 1st and 2nd shots
Measles-containing	All types	1st shot given before DOB plus 361 days Less than 4 weeks between 1st and 2nd shots
Varicella	All types	1st shot given before DOB plus 365 days Less than 4 weeks between 1st and 2nd shots
Meningococcal	MenACWY	Any shot before DOB plus 11 years Any shot before January 14, 2005
Hepatitis A	All types	1st shot given before DOB plus 365 days Less than 6 months between 1st and 2nd shots
HPV[5]	All types	1st shot given before DOB plus 9 years Less than 4 weeks between 1st and 2nd shots Less than 12 weeks between 2nd and 3rd shots Any shot before June 8, 2006

[1]Diphtheria and tetanus toxoids and acellular pertussis vaccine.
[2]Diphtheria and tetanus toxoids and pertussis vaccine.
[3]Tetanus and diphtheria toxoids vaccine.
[4]*Haemophilus influenzae* type b
[5]Human papillomavirus vaccine.

NOTE: DOB is date of birth.

Table 23. Quality assurance in imputation for National Immunization Survey–Child and –Teen, 2005–2014

Key step	Description	Quality assurance task
Assess the need for imputation	Identify the variables that need to be imputed for weighting or analysis purposes	Confer with weighting team to determine imputation needs
	View frequencies of these variables to understand distributions and level of missingness	Obtain group consensus on scope of imputation process
Determine class and sort variables to use in imputation of each variable	Create logistic-regression models for binary variables or cumulative-logistic or multinomial models for multilevel variables	Ensure that the correct model type is chosen based on variable of interest
	Identify necessary class variables	Choose class variables to ensure consistency in imputed values where necessary
	Create list of candidate sort variables	Document class and sort variables for records and future use
	Fit the model(s) via stepwise model selection to obtain the sort variables	Re-evaluate class and sort variables periodically
Impute missing values	Run the imputation SAS macro for each imputation	Statistician runs a parallel imputation and ensures that: Production and parallel imputed values agree; All variables that should have been imputed now have nonmissing values; The variable values for unimputed records did not change; The distribution of imputed values is similar to the distribution of unimputed values; New imputed values are within valid ranges; No case donated a value to more than four recipients

Table 24. Quality assurance in weighting for National Immunization Survey–Child and –Teen, 2005–2014

Key step	Description	Quality assurance task
Assess the need for weighting	Identify all weights required for analytical purposes	Confer with sampling team and analysis team to determine weighting needs
	Implement alternative weighting approaches to assess the potential pros and cons of each approach	Assess alternative weighting approaches; Obtain group consensus on scope of weighting process
Check and prepare all required weighting inputs	Derive population control totals for weighting	Compare current year's control totals with previous year's control totals to ensure no abrupt changes
	Derive true area of residence for each household with a completed interview	Ensure the availability of all required input variables for weighting and proper assignment of disposition codes to each released case
	Identify the list of required input variables for weighting	Document control total and true area derivation; Senior weighting statistician reviews all relevant work
Set up detailed weighting plan	Write a weighting plan that includes a description of each step of weighting	Weighting team meets to review each weighting step and check coherence of the whole plan; Identify any potential issues in the current plan and discuss with senior weighting statisticians
Produce weights	Implement weighting and produce weights	Weighting statistician implements weighting, documenting all outputs and logs and creating weighting summaries.
	Create weight summary files, summarizing key statistics for each weight variable	Senior weighting statistician runs a parallel check of weighting, ensuring that: Each weighting step is implemented according to the weighting plan; Each step has sufficient cases to warrant stable weighting adjustment; All cases that should have weights have nonmissing and correctly assigned weights; The summation of the final random-digit-dialing household weights and final provider-phase weights agree with the control totals for each calibration dimension; The weight variation is within valid and expected range
Produce weighted vaccine coverage rates	Generate weighted vaccine coverage rates using the current year's data	Weighting statistician compares current weighted vaccine coverage rates with similar vaccination coverage rates from prior years
Weighting quality control meeting	Weighting team meets with senior statisticians to discuss the weighting summaries	Review statistics of each weight and address any concerns

Table 25. Percentage of children in National Immunization Survey–Child also included in 19 immunization information systems, 2008–2011

Status of NIS–Child[1] children	Minimum percent	Maximum percent
Not matched in IIS	–	31.8
Matched in IIS, and IIS contains no vaccination data	–	17.2
Matched in IIS, and IIS vaccination data are too incomplete to determine child's up-to-date status	0.3	8.2
Matched in IIS, and IIS vaccination data are adequate to determine child's up-to-date status	61.4	98.5

– Quantity zero.

[1]NIS is National Immunization Survey.

NOTES: The 19 studies represent 15 distinct immunization information systems (IIS) (some studied in multiple years). Participation by an IIS in the NIS–IIS match studies was by self-selection. State or local area immunization program grantees and awardees requested that some of their grant or cooperative agreement funds be used for this purpose. The results from these studies are not generalizable across all IIS or across all years. Percentages are based on the set of children for whom consent was given to contact the IIS.

SOURCE: National Immunization Survey–Immunization Information Systems Match Study, 2008–2011.

Table 26. Minimum and maximum differences in vaccination coverage rates between National Immunization Survey–Child, 19 immunization information systems, and synthesized National Immunization Survey and immunization information systems, 2008–2011

Summary measure	Differences for 4:3:1:3:3:1 vaccination series (percentage points)			Differences for 4 or more doses of DTaP (percentage points)		
	NIS–Child-IIS	Synthesized NIS and IIS-NIS–Child	Synthesized NIS and IIS-IIS	NIS–Child-IIS	Synthesized NIS and IIS-NIS–Child	Synthesized NIS and IIS-IIS
Minimum	−8.2	−1.5	0.4	−6.6	−1.5	−2.4
Maximum	50.8	11.9	51.9	50.8	9.0	49.3

NOTES: DTaP is diphtheria and tetanus toxoids and acellular pertussis vaccine. NIS is National Immunization Survey. IIS is immunization information systems. The 19 studies represent 15 distinct IIS (some studied in multiple years). Participation by an IIS in the NIS–IIS match studies was by self-selection. State or local area immunization program grantees and awardees requested that some of their grant or cooperative agreement funds be used for this purpose. The results from these studies are not generalizable across all IIS or across all years.

Table 27. Estimated vaccination coverage rates (percent) and corresponding 95% confidence intervals for children aged 19–35 months: National Immunization Survey–Child and address-based sample pilot, 2009

Vaccine	National Immunization Survey—Child (n = 17,063)	Address-based sample pilot (n = 367)
4 or more DTaP[1]	83.9 (±1.0)	81.8 (±5.8)
3 or more polio[2]	92.8 (±0.7)	90.5 (±4.0)
1 or more MMR[3]	90.0 (±0.8)	89.4 (±4.1)
3 or more Hib[4]	83.6 (±1.0)	80.3 (±5.7)
3 or more HepB[5]	92.4 (±0.7)	89.1 (±4.5)
1 or more Var[6]	89.6 (±0.8)	90.5 (±3.8)
3 or more PCV[7]	92.6 (±0.7)	88.5 (±4.7)
4 or more PCV[8]	80.4 (±1.1)	79.0 (±5.7)
4:3:1 series[9]	81.5 (±1.1)	78.7 (±6.0)
4:3:1:3 series[10]	73.4 (±1.2)	69.8 (±6.6)
4:3:1:3:3 series[11]	71.9 (±1.2)	65.3 (±6.9)
4:3:1:3:3:1 series[12]	69.9 (±1.2)	63.7 (±7.0)†
4:3:1:3:3:1:3 series[13]	69.0 (±1.2)	61.2 (±7.0)†
4:3:1:3:3:1:4 series[14]	63.6 (±1.3)	57.0 (±7.2)
1+HepA series[15]	75.0 (±1.1)	73.2 (±6.4)
2+HepA series[16]	46.6 (±1.4)	48.0 (±7.3)

†Statistically different from National Immunization Survey–Child estimate at the 95% confidence level.
[1]Four or more doses of any diphtheria and tetanus toxoids and pertussis vaccines including diphtheria and tetanus toxoids, and any acellular pertussis vaccine (DTaP, DTP, or DT).
[2]Three or more doses of any poliovirus vaccine.
[3]One or more doses of measles-mumps-rubella vaccine.
[4]Three or more doses of *Haemophilus influenzae* type b vaccine.
[5]Three or more doses of hepatitis B vaccine.
[6]One or more doses of varicella at or after child's first birthday, unadjusted for history of varicella illness.
[7]Three or more doses of pneumococcal conjugate vaccine.
[8]Four or more doses of pneumococcal conjugate vaccine.
[9]Four or more doses of DTaP, 3 or more doses of poliovirus vaccine, and 1 or more doses of any MMR.
[10]Vaccine series 4:3:1 and 3 or more doses of Hib.
[11]Vaccine series 4:3:1:3 and 3 or more doses of HepB.
[12]Vaccine series 4:3:1:3:3 and 1 or more doses of varicella vaccine.
[13]Vaccine series 4:3:1:3:3:1 and 3 or more doses of PCV.
[14]Vaccine series 4:3:1:3:3:1 and 4 or more doses of PCV.
[15]One or more doses of hepatitis A vaccine.
[16]Two or more doses of hepatitis A vaccine.

NOTE: No correction for multiple statistical testing was employed.

Table 28. Vaccination coverage rates (percent) and corresponding 95% confidence intervals for children aged 19–35 months for each recommended childhood vaccine, by survey: National Immunization Survey–American Community Survey and Florida National Immunization Survey–Child, 2009

Vaccine	Florida National Immunization Survey–Child (n = 326)	National Immunization Survey–American Community Survey (n = 745)
4 or more DTaP (diphtheria and tetanus toxoids and acellular pertussis)	88.1 (±5.5)	80.8 (±5.5)
3 or more polio.	91.8 (±4.7)	90.7 (±3.8)
3 or more Hib (*Haemophilus influenzae* type b)	86.7 (±5.9)	88.8 (±4.0)
3 or more HepB (hepatitis B)	91.6 (±4.8)	91.9 (±3.3)
1 or more Var (varicella) after age 12 months	94.2 (±3.9)[1]	87.6 (±4.3)
4 or more PCV (pneumococcal)	76.4 (±7.3)	79.0 (±5.5)
2 or more HepA (hepatitis A)	39.7 (±8.3)	34.7 (±6.4)
RV[2]	41.6 (±8.3)	43.6 (±6.7)
Seasonal influenza	16.7 (±6.4)[1]	7.7 (±3.6)

[1]Estimated percentage is significantly different from corresponding percentage in the other survey, $p \leq 0.05$.
[2]Two or more doses of Rotarix (RVI) or 3 or more doses of RotaTeq (RV5).

Table 29. Differences in vaccination coverage rates (percent) and 95% confidence intervals for children aged 19–35 months between National Immunization Survey–Child and immunization information systems samples: Quarter 1–Quarter 2, 2008

	Differences[1] in vaccination coverage rates for National Immunization Survey–Child and immunization information systems	
Vaccine	State A	State B
4 or more DTaP (diphtheria and tetanus toxoids and acellular pertussis)	3.0 (± 10.7)	1.6 (± 8.3)
3 or more polio.	0.6 (± 9.0)	−1.5 (± 3.6)
1 or more MMR (measles, mumps, and rubella)	−1.2 (± 8.3)	2.1 (± 5.7)
3 or more Hib (*Haemophilus influenzae* type b)	−0.9 (± 6.0)	−1.1 (± 3.9)
3 or more HepB (hepatitis B).	−2.8 (± 5.6)	−0.2 (± 4.0)
1 or more Var (varicella).	2.6 (± 8.9)	1.6 (± 6.1)
4:3:1:3:3:1[2]	1.0 (± 11.1)	1.0 (± 9.1)

[1]No differences were statistically significant at the 0.05 level.
[2]The vaccine series of 4 or more DTaP/DTP/DT, 3 or more polio, 1 or more MMR, 3 or more Hib doses of any type, 3 or more HepB doses, and 1 or more varicella doses given at age 12 months and over. DTP is diphtheria and tetanus toxoids and pertussis vaccine; DT is diphtheria and tetanus toxoids vaccine.

Table 30. Comparison of response rates in National Immunization Survey–Child and National Health Interview Survey: 2009–2013, excluding U.S. territories

	National Immunization Survey–Child				National Health Interview Survey	
	Landline sample		Cell-phone sample			
Year	Household-phase response rate (percent)	Rate of children with adequate provider data (percent)	Household-phase response rate (percent)	Rate of children with adequate provider data (percent)	Sample child response rate (percent)	Rate of children with adequate provider data (percent)
2009.	63.7	68.7	…	…	73.4	58.2
2010.	63.8	71.2	25.9[1]	61.0	70.7	58.2
2011	61.5	72.3	25.2	66.7	74.6	63.6
2012.	64.5	67.9	30.6	63.9	69.7	59.2
2013.	62.3	63.5	30.5	59.8	69.0	59.7[2]

… Category not applicable.
[1]Results are for the fourth quarter 2010 (Q4/2010) national cell-phone random-digit-dialing pilot sample.
[2]Results are for Q1–Q3/2013. The National Health Interview Survey–Provider Record Check (NHIS–PRC) was not conducted in Q4/2013.

SOURCES: Household-phase response rates and rates of children with adequate provider data for National Immunization Survey–Child are available in the annual public-use files (https://www.cdc.gov/nchs/nis/data_files.htm). NHIS child response rates are available in Appendix II of the 2013 public-use file (ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2013/srvydesc.pdf). NHIS rates of children with adequate provider data are computed using the operational results of the NHIS–PRC.

Table 31. National vaccination coverage rates for children aged 19–35 months in National Immunization Survey–Child and National Health Interview Survey–Provider Record Check: Quarter 1–Quarter 4, 2009

Vaccine	NIS–Child[1] vaccination coverage rate (95% confidence interval), n = 33,851	NHIS–PRC vaccination coverage rate (95% confidence interval), n = 2,022	NIS–Child-NHIS–PRC percent difference in vaccination coverage rates (95% confidence interval)
4 or more DTaP (diphtheria and tetanus toxoids and acellular pertussis) doses	84.2 (± 0.7)	81.1 (± 2.2)	3.0 (± 2.3)[2]
3 or more polio doses	93.0 (± 0.5)	91.3 (± 1.6)	1.7 (± 1.7)[2]
1 or more measles-mumps-rubella doses	90.7 (± 0.6)	89.7 (± 1.7)	1.0 (± 1.8)
3 or more Hib (*Haemophilus influenzae* type b) doses	86.9 (± 0.7)	85.4 (± 2.0)	1.5 (± 2.1)
3 or more HepB (hepatitis B) doses	92.1 (± 0.5)	90.3 (± 1.7)	1.8 (± 1.7)[2]
1 or more Var (varicella) doses	90.0 (± 0.6)	89.6 (± 1.6)	0.4 (± 1.7)
3 or more PCV (pneumococcal) doses	92.6 (± 0.5)	91.7 (± 1.5)	1.0 (± 1.6)
4:3:1:3:3:1:3[3]	71.5 (± 0.9)	68.6 (± 2.5)	2.9 (± 2.7)[2]

[1]Single-frame landline random-digit-dialing estimates.
[2]Significant at the 0.05 level.
[3]The vaccine series of 4 or more DTaP/DTP/DT, 3 or more polio, 1 or more MMR, 3 or more Hib doses of any type, 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 3 or more PCV doses. DTP is diphtheria and tetanus toxoids and pertussis vaccine; DT is diphtheria and tetanus toxoids vaccine.

NOTES: NIS is National Immunization Survey. NHIS–PRC is National Health Interview Survey–Provider Record Check.

Table 32. National vaccination coverage rates for children aged 19–35 months in National Immunization Survey–Child and National Health Interview Survey–Provider Record Check: Quarter 1–Quarter 4, 2010

Vaccine	NIS–Child[1] vaccination coverage rate (95% confidence interval), n = 18,002	NHIS–PRC vaccination coverage rate (95% confidence interval), n = 978	NIS–Child-NHIS–PRC percent difference in vaccination coverage rates (95% confidence interval)
4 or more DTaP (diphtheria and tetanus toxoids and acellular pertussis) doses	82.6 (± 1.4)	83.4 (± 2.7)	−0.8 (± 3.0)
3 or more polio doses	93.3 (± 0.8)	93.4 (± 1.8)	0.0 (± 2.0)
1 or more measles-mumps-rubella (MMR) doses	90.4 (± 1.0)	90.2 (± 2.2)	0.3 (± 2.4)
3 or more Hib (*Haemophilus influenzae* type b) doses	91.2 (± 1.0)	91.7 (± 2.0)	−0.5 (± 2.2)
3 or more HepB (hepatitis B) doses	91.1 (± 1.0)	92.0 (± 1.9)	−1.0 (± 2.2)
1 or more Var (varicella) doses	89.9 (± 1.0)	89.3 (± 2.3)	0.6 (± 2.5)
3 or more PCV (pneumococcal) doses	92.5 (± 0.9)	92.4 (± 2.0)	0.1 (± 2.2)
4:3:1:3:3:1:3[2]	72.8 (± 1.5)	74.1 (± 3.2)	−1.2 (± 3.6)

0.0 Quantity more than zero but less than 0.05.
[1]Dual-frame landline and cell-phone random-digit-dialing estimates.
[2]The vaccine series of 4 or more DTaP/DTP/DT, 3 or more polio, 1 or more MMR, 3 or more Hib doses of any type, 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 3 or more PCV doses. DTP is diphtheria and tetanus toxoids and pertussis vaccine; DT is diphtheria and tetanus toxoids vaccine.

NOTES: NIS is National Immunization Survey. NHIS–PRC is National Health Interview Survey–Provider Record Check.

Table 33. Key indicators for National Immunization Survey–Adult: 2007, excluding U.S. territories

Key indicators	National Health Interview Survey sample	Age-targeted sample	Combined sample
Estimated eligible households (HHs)	8,666	14,119	23,157
Observed eligible HHs	3,743	5,793	9,536
Estimated eligible HHs from unresolved	2,820	5,059	8,244
Estimated eligible HHs from unscreened	2,103	3,267	5,377
Completed HH interviews	2,899	4,156	7,055
CASRO[1] HH response rate (percent)	33.5	29.4	30.5

[1]Council of American Survey Research Organizations.

Table 34. Key indicators for National H1N1 Flu Survey at end of influenza season: 2009, excluding U.S. territories

Key indicators	Landline sample	Cell-phone sample	Combined sample
Estimated eligible households (HHs)	135,170	42,358	177,527
Observed eligible HHs	105,481	19,827	125,308
Estimated eligible HHs from unresolved	29,235	19,236	48,470
Estimated eligible HHs from unscreened	454	3,295	3,749
Completed HH interviews	45,750	11,080	56,830
CASRO[1] HH response rate (percent)	33.8	26.2	32.0

[1]Council of American Survey Research Organizations.

Table 35. Key indicators for National Immunization Survey–Kindergarten: 2013, excluding U.S. territories

Key indicators	Landline sample	Cell-phone sample	Combined sample
Estimated eligible households (HHs)	1,142	6,871	8,013
Observed eligible HHs	820	2,698	3,518
Estimated eligible HHs from unresolved	197	3,124	3,321
Estimated eligible HHs from unscreened	125	1,048	1,174
Completed HH interviews	580	1,768	2,348
CASRO[1] HH response rate (percent)	50.8	25.7	29.3

[1]Council of American Survey Research Organizations.

Table 36. Key indicators for National Immunization Survey–Flu Child Influenza Module at end of influenza season: 2010–2014, excluding U.S. territories

Influenza season	Key indicators	Landline sample	Cell-phone sample	Combined sample
9/1/2011–6/30/2012	Estimated eligible households (HHs).........................	40,253	189,011	229,264
	Observed eligible HHs	25,242	53,020	78,262
	Estimated eligible HHs from unresolved	7,149	97,041	104,190
	Estimated eligible HHs from unscreened	7,862	38,950	46,812
	Completed HH interviews	22,459	49,930	72,389
	CASRO[1] HH response rate (percent)	55.8	26.4	31.6
9/1/2012–6/30/2013	Estimated eligible HHs....................................	43,138	652,485	695,623
	Observed eligible HHs	28,044	199,785	227,829
	Estimated eligible HHs from unresolved	7,840	376,693	384,533
	Estimated eligible HHs from unscreened	7,254	76,007	83,261
	Completed HH interviews	24,078	165,930	190,008
	CASRO[1] HH response rate (percent)	55.8	25.4	27.3
10/1/2013–6/30/2014	Estimated eligible HHs....................................	60,423	138,575	198,998
	Observed eligible HHs	41,934	55,900	97,834
	Estimated eligible HHs from unresolved	11,251	59,047	70,297
	Estimated eligible HHs from unscreened	7,238	23,628	30,866
	Completed HH interviews	35,393	44,413	79,805
	CASRO[1] HH response rate (percent)	58.6	32.0	40.1
10/1/2014–6/30/2015	Estimated eligible HHs....................................	38,775	124,472	163,247
	Observed eligible HHs	26,754	50,855	77,609
	Estimated eligible HHs from unresolved	7,336	53,087	60,424
	Estimated eligible HHs from unscreened	4,684	20,530	25,215
	Completed HH interviews	21,660	42,713	64,373
	CASRO[1] HH response rate (percent)	55.9	34.3	39.4

[1]Council of American Survey Research Organizations.

Recommended Immunization Schedules for Persons Aged 0 Through 18 Years
UNITED STATES, 2014

This schedule includes recommendations in effect as of January 1, 2014. Any dose not administered at the recommended age should be administered at a subsequent visit, when indicated and feasible. The use of a combination vaccine generally is preferred over separate injections of its equivalent component vaccines. Vaccination providers should consult the relevant Advisory Committee on Immunization Practices (ACIP) statement for detailed recommendations, available online at http://www.cdc.gov/vaccines/hcp/acip-recs/index.html. Clinically significant adverse events that follow vaccination should be reported to the Vaccine Adverse Event Reporting System (VAERS) online (http://www.vaers.hhs.gov) or by telephone (800-822-7967).

The Recommended Immunization Schedules for
Persons Aged 0 Through 18 Years are approved by the

Advisory Committee on Immunization Practices
(http://www.cdc.gov/vaccines/acip)

American Academy of Pediatrics
(http://www.aap.org)

American Academy of Family Physicians
(http://www.aafp.org)

American College of Obstetricians and Gynecologists
(http://www.acog.org)

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Figure 1. Recommended immunization schedule for persons aged 0 through 18 years – United States, 2014.
(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are in bold.

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19–23 mos	2–3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13–15 yrs	16–18 yrs
Hepatitis B[1] (HepB)	1st dose	←── 2nd dose ──→			←──────── 3rd dose ────────→											
Rotavirus[2] (RV) RV1 (2-dose series); RV5 (3-dose series)			1st dose	2nd dose	See footnote 2											
Diphtheria, tetanus, & acellular pertussis[3] (DTaP: <7 yrs)			1st dose	2nd dose	3rd dose		←──────── 4th dose ────────→					5th dose				
Tetanus, diphtheria, & acellular pertussis[4] (Tdap: ≥7 yrs)														(Tdap)		
Haemophilus influenzae type b[5] (Hib)			1st dose	2nd dose	See footnote 5		←── 3rd or 4th dose, See footnote 5 ──→									
Pneumococcal conjugate[6] (PCV13)			1st dose	2nd dose	3rd dose		←── 4th dose ──→									
Pneumococcal polysaccharide[6] (PPSV23)											See footnote 6					
Inactivated poliovirus[7] (IPV) (<18 yrs)			1st dose	2nd dose	←──────── 3rd dose ────────→							4th dose				
Influenza[8] (IIV; LAIV) 2 doses for some: See footnote 8					Annual vaccination (IIV only)							Annual vaccination (IIV or LAIV)				
Measles, mumps, rubella[9] (MMR)							←── 1st dose ──→					2nd dose				
Varicella[10] (VAR)							←── 1st dose ──→					2nd dose				
Hepatitis A[11] (HepA)							←──── 2- dose series, See footnote 11 ────→									
Human papillomavirus[12] (HPV2: females only; HPV4: males and females)														(3-dose series)		
Meningococcal[13] (Hib-MenCY ≥6 weeks; MenACWY-D ≥9 mos; MenACWY-CRM ≥ 2 mos)						See footnote 13								1st dose		Booster

Legend:

■ Range of recommended ages for all children

■ Range of recommended ages for catch-up immunization

■ Range of recommended ages for certain high-risk groups

■ Range of recommended ages during which catch-up is encouraged and for certain high-risk groups

□ Not routinely recommended

NOTE: The above recommendations must be read along with the footnotes of this schedule.

FIGURE 2. Catch-up immunization schedule for persons aged 4 months through 18 years who start late or who are more than 1 month behind —United States, 2014.

The figure below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. Always use this table in conjunction with Figure 1 and the footnotes that follow.

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to dose 2	Dose 2 to dose 3	Dose 3 to dose 4	Dose 4 to dose 5
Persons aged 4 months through 6 years					
Hepatitis B[1]	Birth	4 weeks	8 weeks and at least 16 weeks after first dose; minimum age for the final dose is 24 weeks		
Rotavirus[2]	6 weeks	4 weeks	4 weeks[2]		
Diphtheria, tetanus, & acellular pertussis [3]	6 weeks	4 weeks	4 weeks	6 months	6 months[3]
Haemophilus influenzae type b[5]	6 weeks	4 weeks if first dose administered at younger than age 12 months 8 weeks (as final dose) if first dose administered at age 12 through 14 months No further doses needed if first dose administered at age 15 months or older	4 weeks[5] if current age is younger than 12 months and first dose administered at < 7 months old 8 weeks and age 12 months through 59 months (as final dose)[5] if current age is younger than 12 months and first dose administered between 7 through 11 months (regardless of Hib vaccine [PRP-T or PRP-OMP] used for first dose); OR if current age is 12 through 59 months and first dose administered at younger than age 12 months; OR first 2 doses were PRP-OMP and administered at younger than 12 months. No further doses needed if previous dose administered at age 15 months or older	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 (PRP-T) doses before age 12 months and started the primary series before age 7 months	
Pneumococcal[6]	6 weeks	4 weeks if first dose administered at younger than age 12 months 8 weeks (as final dose for healthy children) if first dose administered at age 12 months or older No further doses needed for healthy children if first dose administered at age 24 months or older	4 weeks if current age is younger than 12 months 8 weeks (as final dose for healthy children) if current age is 12 months or older No further doses needed for healthy children if previous dose administered at age 24 months or older	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age	
Inactivated poliovirus[7]	6 weeks	4 weeks[7]	4 weeks[7]	6 months[7] minimum age 4 years for final dose	
Meningococcal[13]	6 weeks	8 weeks[13]	See footnote 13	See footnote 13	
Measles, mumps, rubella[9]	12 months	4 weeks			
Varicella[10]	12 months	3 months			
Hepatitis A[11]	12 months	6 months			
Persons aged 7 through 18 years					
Tetanus, diphtheria; tetanus, diphtheria, & acellular pertussis[4]	7 years[4]	4 weeks	4 weeks if first dose of DTaP/DT administered at younger than age 12 months 6 months if first dose of DTaP/DT administered at age 12 months or older and then no further doses needed for catch-up	6 months if first dose of DTaP/DT administered at younger than age 12 months	
Human papillomavirus[12]	9 years	Routine dosing intervals are recommended[12]			
Hepatitis A[11]	12 months	6 months			
Hepatitis B[1]	Birth	4 weeks	8 weeks (and at least 16 weeks after first dose)		
Inactivated poliovirus[7]	6 weeks	4 weeks	4 weeks[7]	6 months[7]	
Meningococcal[13]	6 weeks	8 weeks[13]			
Measles, mumps, rubella[9]	12 months	4 weeks			
Varicella[10]	12 months	3 months if person is younger than age 13 years 4 weeks if person is aged 13 years or older			

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Footnotes — Recommended immunization schedule for persons aged 0 through 18 years—United States, 2014

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.
For vaccine recommendations for persons 19 years of age and older, see the adult immunization schedule.

Additional information
- For contraindications and precautions to use of a vaccine and for additional information regarding that vaccine, vaccination providers should consult the relevant ACIP statement available online at http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.
- For purposes of calculating intervals between doses, 4 weeks = 28 days. Intervals of 4 months or greater are determined by calendar months.
- Vaccine doses administered 4 days or less before the minimum interval are considered valid. Doses of any vaccine administered ≥5 days earlier than the minimum interval or minimum age should not be counted as valid doses and should be repeated as age-appropriate. The repeat dose should be spaced after the invalid dose by the recommended minimum interval. For further details, see *MMWR, General Recommendations on Immunization and Reports / Vol. 60 / No. 2; Table 1. Recommended and minimum ages and intervals between vaccine doses* available online at http://www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.
- Information on travel vaccine requirements and recommendations is available at http://wwwnc.cdc.gov/travel/destinations/list.
- For vaccination of persons with primary and secondary immunodeficiencies, see Table 13, "*Vaccination of persons with primary and secondary immunodeficiencies*," in General Recommendations on Immunization (ACIP), available at http://www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.; and American Academy of Pediatrics. Immunization in Special Clinical Circumstances, in Pickering LK, Baker CJ, Kimberlin DW, Long SS eds. *Red Book: 2012 report of the Committee on Infectious Diseases. 29th ed.* Elk Grove Village, IL: American Academy of Pediatrics.

1. **Hepatitis B (HepB) vaccine. (Minimum age: birth)**
   Routine vaccination:
   At birth:
   - Administer monovalent HepB vaccine to all newborns before hospital discharge.
   - For infants born to hepatitis B surface antigen (HBsAg)-positive mothers, administer HepB vaccine and 0.5 mL of hepatitis B immune globulin (HBIG) within 12 hours of birth. These infants should be tested for HBsAg and antibody to HBsAg (anti-HBs) 1 to 2 months after completion of the HepB series, at age 9 through 18 months (preferably at the next well-child visit).
   - If mother's HBsAg status is unknown, within 12 hours of birth administer HepB vaccine regardless of birth weight. For infants weighing less than 2,000 grams, administer HBIG in addition to HepB vaccine within 12 hours of birth. Determine mother's HBsAg status as soon as possible and, if mother is HBsAg-positive, also administer HBIG for infants weighing 2,000 grams or more as soon as possible, but no later than age 7 days.
   Doses following the birth dose:
   - The second dose should be administered at age 1 or 2 months. Monovalent HepB vaccine should be used for doses administered before age 6 weeks.
   - Infants who did not receive a birth dose should receive 3 doses of a HepB-containing vaccine on a schedule of 0, 1 to 2 months, and 6 months starting as soon as feasible. See Figure 2.
   - Administer the second dose 1 to 2 months after the first dose (minimum interval of 4 weeks), administer the third dose at least 8 weeks after the second dose AND at least 16 weeks after the **first** dose. The final (third or fourth) dose in the HepB vaccine series should be administered no earlier than age 24 weeks.
   - Administration of a total of 4 doses of HepB vaccine is permitted when a combination vaccine containing HepB is administered after the birth dose.
   Catch-up vaccination:
   - Unvaccinated persons should complete a 3-dose series.
   - A 2-dose series (doses separated by at least 4 months) of adult formulation Recombivax HB is licensed for use in children aged 11 through 15 years.
   - For other catch-up guidance, see Figure 2.
2. **Rotavirus (RV) vaccines. (Minimum age: 6 weeks for both RV1 [Rotarix] and RV5 [RotaTeq])**
   Routine vaccination:
   Administer a series of RV vaccine to all infants as follows:
   1. If Rotarix is used, administer a 2-dose series at 2 and 4 months of age.
   2. If RotaTeq is used, administer a 3-dose series at ages 2, 4, and 6 months.
   3. If any dose in the series was RotaTeq or vaccine product is unknown for any dose in the series, a total of 3 doses of RV vaccine should be administered.
   Catch-up vaccination:
   - The maximum age for the first dose in the series is 14 weeks, 6 days; vaccination should not be initiated for infants aged 15 weeks, 0 days or older.
   - The maximum age for the final dose in the series is 8 months, 0 days.
   - For other catch-up guidance, see Figure 2.

3. **Diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine. (Minimum age: 6 weeks. Exception: DTaP-IPV [Kinrix]: 4 years)**
   Routine vaccination:
   - Administer a 5-dose series of DTaP vaccine at ages 2, 4, 6, 15 through 18 months, and 4 through 6 years. The fourth dose may be administered as early as age 12 months, provided at least 6 months have elapsed since the third dose.
   Catch-up vaccination:
   - The fifth dose of DTaP vaccine is not necessary if the fourth dose was administered at age 4 years or older.
   - For other catch-up guidance, see Figure 2.
4. **Tetanus and diphtheria toxoids and acellular pertussis (Tdap) vaccine. (Minimum age: 10 years for Boostrix, 11 years for Adacel)**
   Routine vaccination:
   - Administer 1 dose of Tdap vaccine to all adolescents aged 11 through 12 years.
   - Tdap may be administered regardless of the interval since the last tetanus and diphtheria toxoid-containing vaccine.
   - Administer 1 dose of Tdap vaccine to pregnant adolescents during each pregnancy (preferred during 27 through 36 weeks gestation) regardless of time since prior Td or Tdap vaccination.
   Catch-up vaccination:
   - Persons aged 7 years and older who are not fully immunized with DTaP vaccine should receive Tdap vaccine as 1 (preferably the first) dose in the catch-up series; if additional doses are needed, use Td vaccine. For children 7 through 10 years who receive a dose of Tdap as part of the catch-up series, an adolescent Tdap vaccine dose at age 11 through 12 years should NOT be administered. Td should be administered instead 10 years after the Tdap dose.
   - Persons aged 11 through 18 years who have not received Tdap vaccine should receive a dose followed by tetanus and diphtheria toxoids (Td) booster doses every 10 years thereafter.
   - Inadvertent doses of DTaP vaccine:
     - If administered inadvertently to a child aged 7 through 10 years may count as part of the catch-up series. This dose may count as the adolescent Tdap dose, or the child can later receive a Tdap booster dose at age 11 through 12 years.
     - If administered inadvertently to an adolescent aged 11 through 18 years, the dose should be counted as the adolescent Tdap booster.
   - For other catch-up guidance, see Figure 2.
5. ***Haemophilus influenzae* type b (Hib) conjugate vaccine. (Minimum age: 6 weeks for PRP-T [ACTHIB, DTaP-IPV/Hib (Pentacel) and Hib-MenCY (MenHibrix)], PRP-OMP [PedvaxHIB or COMVAX], 12 months for PRP-T [Hiberix])**
   Routine vaccination:
   - Administer a 2- or 3-dose Hib vaccine primary series and a booster dose (dose 3 or 4 depending on vaccine used in primary series) at age 12 through 15 months to complete a full Hib vaccine series.
   - The primary series with ActHIB, MenHibrix, or Pentacel consists of 3 doses and should be administered at 2, 4, and 6 months of age. The primary series with PedvaxHib or COMVAX consists of 2 doses and should be administered at 2 and 4 months of age; a dose at age 6 months is not indicated.
   - One booster dose (dose 3 or 4 depending on vaccine used in primary series) of any Hib vaccine should be administered at age 12 through 15 months. An exception is Hiberix vaccine. Hiberix should only be used for the booster (final) dose in children aged 12 months through 4 years who have received at least 1 prior dose of Hib-containing vaccine.

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.

5. **Haemophilus influenzae type b (Hib) conjugate vaccine (cont'd)**
    - For recommendations on the use of MenHibrix in patients at increased risk for meningococcal disease, please refer to the meningococcal vaccine footnotes and also to *MMWR* March 22, 2013; 62(RR02);1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

    Catch-up vaccination:
    - If dose 1 was administered at ages 12 through 14 months, administer a second (final) dose at least 8 weeks after dose 1, regardless of Hib vaccine used in the primary series.
    - If the first 2 doses were PRP-OMP (PedvaxHIB or COMVAX), and were administered at age 11 months or younger, the third (and final) dose should be administered at age 12 through 15 months and at least 8 weeks after the second dose.
    - If the first dose was administered at age 7 through 11 months, administer the second dose at least 4 weeks later and a third (and final) dose at age 12 through 15 months or 8 weeks after second dose, whichever is later, regardless of Hib vaccine used for first dose.
    - If first dose is administered at younger than 12 months of age and second dose is given between 12 through 14 months of age, a third (and final) dose should be given 8 weeks later.
    - For unvaccinated children aged 15 months or older, administer only 1 dose.
    - For other catch-up guidance, see Figure 2. For catch-up guidance related to MenHibrix, please see the meningococcal vaccine footnotes and also *MMWR* March 22, 2013; 62(RR02);1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

    Vaccination of persons with high-risk conditions:
    - Children aged 12 through 59 months who are at increased risk for Hib disease, including chemotherapy recipients and those with anatomic or functional asplenia (including sickle cell disease), human immunodeficiency virus (HIV) infection, immunoglobulin deficiency, or early component complement deficiency, who have received either no doses or only 1 dose of Hib vaccine before 12 months of age, should receive 2 additional doses of Hib vaccine 8 weeks apart; children who received 2 or more doses of Hib vaccine before 12 months of age should receive 1 additional dose.
    - For patients younger than 5 years of age undergoing chemotherapy or radiation treatment who received a Hib vaccine dose(s) within 14 days of starting therapy or during therapy, repeat the dose(s) at least 3 months following therapy completion.
    - Recipients of hematopoietic stem cell transplant (HSCT) should be revaccinated with a 3-dose regimen of Hib vaccine starting 6 to 12 months after successful transplant, regardless of vaccination history; doses should be administered at least 4 weeks apart.
    - A single dose of any Hib-containing vaccine should be administered to unimmunized* children and adolescents 15 months of age and older undergoing an elective splenectomy; if possible, vaccine should be administered at least 14 days before procedure.
    - Hib vaccine is not routinely recommended for patients 5 years or older. However, 1 dose of Hib vaccine should be administered to unimmunized* persons aged 5 years or older who have anatomic or functional asplenia (including sickle cell disease) and unvaccinated persons 5 through 18 years of age with human immunodeficiency virus (HIV) infection.
      Patients who have not received a primary series and booster dose or at least 1 dose of Hib vaccine after 14 months of age are considered unimmunized.

6. **Pneumococcal vaccines. (Minimum age: 6 weeks for PCV13, 2 years for PPSV23)**
    Routine vaccination with PCV13:
    - Administer a 4-dose series of PCV13 vaccine at ages 2, 4, and 6 months and at age 12 through 15 months.
    - For children aged 14 through 59 months who have received an age-appropriate series of 7-valent PCV (PCV7), administer a supplemental dose of 13-valent PCV (PCV13).

    Catch-up vaccination with PCV13:
    - Administer 1 dose of PCV13 to all healthy children aged 24 through 59 months who are not completely vaccinated for their age.
    - For other catch-up guidance, see Figure 2.

    Vaccination of persons with high-risk conditions with PCV13 and PPSV23:
    - All recommended PCV13 doses should be administered prior to PPSV23 vaccination if possible.
    - For children 2 through 5 years of age with any of the following conditions: chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy); diabetes mellitus; cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; solid organ transplantation; or congenital immunodeficiency:
      1. Administer 1 dose of PCV13 if 3 doses of PCV (PCV7 and/or PCV13) were received previously.
      2. Administer 2 doses of PCV13 at least 8 weeks apart if fewer than 3 doses of PCV (PCV7 and/or PCV13) were received previously.

6. **Pneumococcal vaccines (cont'd)**
      3. Administer 1 supplemental dose of PCV13 if 4 doses of PCV7 or other age-appropriate complete PCV7 series was received previously.
      4. The minimum interval between doses of PCV (PCV7 or PCV13) is 8 weeks.
      5. For children with no history of PPSV23 vaccination, administer PPSV23 at least 8 weeks after the most recent dose of PCV13.
    - For children aged 6 through 18 years who have cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma:
      1. If neither PCV13 nor PPSV23 has been received previously, administer 1 dose of PCV13 now and 1 dose of PPSV23 at least 8 weeks later.
      2. If PCV13 has been received previously but PPSV23 has not, administer 1 dose of PPSV23 at least 8 weeks after the most recent dose of PCV13.
      3. If PPSV23 has been received but PCV13 has not, administer 1 dose of PCV13 at least 8 weeks after the most recent dose of PPSV23.
    - For children aged 6 through 18 years with chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure), chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy), diabetes mellitus, alcoholism, or chronic liver disease, who have not received PPSV23, administer 1 dose of PPSV23. If PCV13 has been received previously, then PPSV23 should be administered at least 8 weeks after any prior PCV13 dose.
    - A single revaccination with PPSV23 should be administered 5 years after the first dose to children with sickle cell disease or other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma.

7. **Inactivated poliovirus vaccine (IPV). (Minimum age: 6 weeks)**
    Routine vaccination:
    - Administer a 4-dose series of IPV at ages 2, 4, 6 through 18 months, and 4 through 6 years. The final dose in the series should be administered on or after the fourth birthday and at least 6 months after the previous dose.

    Catch-up vaccination:
    - In the first 6 months of life, minimum age and minimum intervals are only recommended if the person is at risk for imminent exposure to circulating poliovirus (i.e., travel to a polio-endemic region or during an outbreak).
    - If 4 or more doses are administered before age 4 years, an additional dose should be administered at age 4 through 6 years and at least 6 months after the previous dose.
    - A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.
    - If both OPV and IPV were administered as part of a series, a total of 4 doses should be administered, regardless of the child's current age. IPV is not routinely recommended for U.S. residents aged 18 years or older.
    - For other catch-up guidance, see Figure 2.

8. **Influenza vaccines. (Minimum age: 6 months for inactivated influenza vaccine [IIV], 2 years for live, attenuated influenza vaccine [LAIV])**
    Routine vaccination:
    - Administer influenza vaccine annually to all children beginning at age 6 months. For most healthy, nonpregnant persons aged 2 through 49 years, either LAIV or IIV may be used. However, LAIV should NOT be administered to some persons, including 1) those with asthma, 2) children 2 through 4 years who had wheezing in the past 12 months, or 3) those who have any other underlying medical conditions that predispose them to influenza complications. For all other contraindications to use of LAIV, see *MMWR* 2013; 62 (No. RR-7):1-43, available at http://www.cdc.gov/mmwr/pdf/rr/rr6207.pdf.

    For children aged 6 months through 8 years:
    - For the 2013–14 season, administer 2 doses (separated by at least 4 weeks) to children who are receiving influenza vaccine for the first time. Some children in this age group who have been vaccinated previously will also need 2 doses. For additional guidance, follow dosing guidelines in the 2013-14 ACIP influenza vaccine recommendations, *MMWR* 2013; 62 (No. RR-7):1-43, available at http://www.cdc.gov/mmwr/pdf/rr/rr6207.pdf.
    - For the 2014–15 season, follow dosing guidelines in the 2014 ACIP influenza vaccine recommendations.

    For persons aged 9 years and older:
    - Administer 1 dose.

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.

9. **Measles, mumps, and rubella (MMR) vaccine. (Minimum age: 12 months for routine vaccination)**
   Routine vaccination:
   • Administer a 2-dose series of MMR vaccine at ages 12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 4 weeks have elapsed since the first dose.
   • Administer 1 dose of MMR vaccine to infants aged 6 through 11 months before departure from the United States for international travel. These children should be revaccinated with 2 doses of MMR vaccine, the first at age 12 through 15 months (12 months if the child remains in an area where disease risk is high), and the second dose at least 4 weeks later.
   • Administer 2 doses of MMR vaccine to children aged 12 months and older before departure from the United States for international travel. The first dose should be administered on or after age 12 months and the second dose at least 4 weeks later.
   Catch-up vaccination:
   • Ensure that all school-aged children and adolescents have had 2 doses of MMR vaccine; the minimum interval between the 2 doses is 4 weeks.

10. **Varicella (VAR) vaccine. (Minimum age: 12 months)**
    Routine vaccination:
    • Administer a 2-dose series of VAR vaccine at ages 12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 3 months have elapsed since the first dose. If the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid.
    Catch-up vaccination:
    • Ensure that all persons aged 7 through 18 years without evidence of immunity (see *MMWR* 2007; 56 [No. RR-4], available at http://www.cdc.gov/mmwr/pdf/rr/rr5604.pdf) have 2 doses of varicella vaccine. For children aged 7 through 12 years, the recommended minimum interval between doses is 3 months (if the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid); for persons aged 13 years and older, the minimum interval between doses is 4 weeks.

11. **Hepatitis A (HepA) vaccine. (Minimum age: 12 months)**
    Routine vaccination:
    • Initiate the 2-dose HepA vaccine series at 12 through 23 months; separate the 2 doses by 6 to 18 months.
    • Children who have received 1 dose of HepA vaccine before age 24 months should receive a second dose 6 to 18 months after the first dose.
    • For any person aged 2 years and older who has not already received the HepA vaccine series, 2 doses of HepA vaccine separated by 6 to 18 months may be administered if immunity against hepatitis A virus infection is desired.
    Catch-up vaccination:
    • The minimum interval between the two doses is 6 months.
    Special populations:
    • Administer 2 doses of HepA vaccine at least 6 months apart to previously unvaccinated persons who live in areas where vaccination programs target older children, or who are at increased risk for infection. This includes persons traveling to or working in countries that have high or intermediate endemicity of infection; men having sex with men; users of injection and non-injection illicit drugs; persons who work with HAV-infected primates or with HAV in a research laboratory; persons with clotting-factor disorders; persons with chronic liver disease; and persons who anticipate close, personal contact (e.g., household or regular babysitting) with an international adoptee during the first 60 days after arrival in the United States from a country with high or intermediate endemicity. The first dose should be administered as soon as the adoption is planned, ideally 2 or more weeks before the arrival of the adoptee.

12. **Human papillomavirus (HPV) vaccines. (Minimum age: 9 years for HPV2 [Cervarix] and HPV4 [Gardasil])**
    Routine vaccination:
    • Administer a 3-dose series of HPV vaccine on a schedule of 0, 1-2, and 6 months to all adolescents aged 11 through 12 years. Either HPV4 or HPV2 may be used for females, and only HPV4 may be used for males.
    • The vaccine series may be started at age 9 years.
    • Administer the second dose 1 to 2 months after the first dose (minimum interval of 4 weeks), administer the third dose 24 weeks after the first dose and 16 weeks after the second dose (minimum interval of 12 weeks).
    Catch-up vaccination:
    • Administer the vaccine series to females (either HPV2 or HPV4) and males (HPV4) at age 13 through 18 years if not previously vaccinated.
    • Use recommended routine dosing intervals (see above) for vaccine series catch-up.

13. **Meningococcal conjugate vaccines. (Minimum age: 6 weeks for Hib-MenCY [MenHibrix], 9 months for MenACWY-D [Menactra], 2 months for MenACWY-CRM [Menveo])**
    Routine vaccination:
    • Administer a single dose of Menactra or Menveo vaccine at age 11 through 12 years, with a booster dose at age 16 years.
    • Adolescents aged 11 through 18 years with human immunodeficiency virus (HIV) infection should receive a 2-dose primary series of Menactra or Menveo with at least 8 weeks between doses.
    • For children aged 2 months through 18 years with high-risk conditions, see below.
    Catch-up vaccination:
    • Administer Menactra or Menveo vaccine at age 13 through 18 years if not previously vaccinated.
    • If the first dose is administered at age 13 through 15 years, a booster dose should be administered at age 16 through 18 years with a minimum interval of at least 8 weeks between doses.
    • If the first dose is administered at age 16 years or older, a booster dose is not needed.
    • For other catch-up guidance, see Figure 2.
    Vaccination of persons with high-risk conditions and other persons at increased risk of disease:
    • Children with anatomic or functional asplenia (including sickle cell disease):
      1. For children younger than 19 months of age, administer a 4-dose infant series of MenHibrix or Menveo at 2, 4, 6, and 12 through 15 months of age.
      2. For children aged 19 through 23 months who have not completed a series of MenHibrix or Menveo, administer 2 primary doses of Menveo at least 3 months apart.
      3. For children aged 24 months and older who have not received a complete series of MenHibrix or Menveo or Menactra, administer 2 primary doses of either Menactra or Menveo at least 2 months apart. If Menactra is administered to a child with asplenia (including sickle cell disease), do not administer Menactra until 2 years of age and at least 4 weeks after the completion of all PCV13 doses.
    • Children with persistent complement component deficiency:
      1. For children younger than 19 months of age, administer a 4-dose infant series of either MenHibrix or Menveo at 2, 4, 6, and 12 through 15 months of age.
      2. For children 7 through 23 months who have not initiated vaccination, two options exist depending on age and vaccine brand:
         a. For children who initiate vaccination with Menveo at 7 months through 23 months of age, a 2-dose series should be administered with the second dose after 12 months of age and at least 3 months after the first dose.
         b. For children who initiate vaccination with Menactra at 9 months through 23 months of age, a 2-dose series of Menactra should be administered at least 3 months apart.
         c. For children aged 24 months and older who have not received a complete series of MenHibrix, Menveo, or Menactra, administer 2 primary doses of either Menactra or Menveo at least 2 months apart.
    • For children who travel to or reside in countries in which meningococcal disease is hyperendemic or epidemic, including countries in the African meningitis belt or the Hajj, administer an age-appropriate formulation and series of Menactra or Menveo for protection against serogroups A and W meningococcal disease. Prior receipt of MenHibrix is not sufficient for children traveling to the meningitis belt or the Hajj because it does not contain serogroups A or W.
    • For children at risk during a community outbreak attributable to a vaccine serogroup, administer or complete an age- and formulation-appropriate series of MenHibrix, Menactra, or Menveo.
    • For booster doses among persons with high-risk conditions, refer to *MMWR* 2013; 62(RR02);1-22, available at http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6202a1.htm.
    Catch-up recommendations for persons with high-risk conditions:
      1. If MenHibrix is administered to achieve protection against meningococcal disease, a complete age-appropriate series of MenHibrix should be administered.
      2. If the first dose of MenHibrix is given at or after 12 months of age, a total of 2 doses should be given at least 8 weeks apart to ensure protection against serogroups C and Y meningococcal disease.
      3. For children who initiate vaccination with Menveo at 7 months through 9 months of age, a 2-dose series should be administered with the second dose after 12 months of age and at least 3 months after the first dose.
      4. For other catch-up recommendations for these persons, refer to *MMWR* 2013; 62(RR02);1-22, available at http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6202a1.htm.

    For complete information on use of meningococcal vaccines, including guidance related to vaccination of persons at increased risk of infection, see *MMWR* March 22, 2013; 62(RR02);1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

Appendix II. Definitions of Terms

3:3:1—The vaccine series of 3 or more DTaP/DTP/DT doses, 3 or more polio doses, and 1 or more MMR doses.

4:3:1—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, and 1 or more MMR doses.

4:3:1:3—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, and 3 or more Hib doses of any type.

4:3:1:H (routine Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, and 4 or more doses of Hib of any type or 2 doses of Hib of Merck types followed by 1 or more doses of Hib of any type (routine recommendation).

4:3:1:H (shortage Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, and 3 or more doses of Hib of any type or 2 or more doses of Hib of Merck types (shortage recommendation).

4:3:1:3:3—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more Hib doses of any type, and 3 or more HepB doses.

4:3:1:H:3 (routine Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 4 or more doses of Hib of any type or 2 doses of Hib of Merck types followed by 1 or more doses of Hib of any type (routine recommendation), and 3 or more HepB doses.

4:3:1:H:3 (shortage Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more doses of Hib of any type or 2 or more doses of Hib of Merck types (shortage recommendation), and 3 or more HepB doses.

4:3:1:3:3:1—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more Hib doses of any type, 3 or more HepB doses, and 1 or more varicella doses given at age 12 months and over.

4:3:1:H:3:1 (routine Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 4 or more doses of Hib of any type or 2 doses of Hib of Merck types followed by 1 or more doses of Hib of any type (routine recommendation), 3 or more HepB doses, and 1 or more varicella doses given at age 12 months or over.

4:3:1:H:3:1 (shortage Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more doses of Hib of any type or 2 or more doses of Hib of Merck types (shortage recommendation), 3 or more HepB doses, and 1 or more varicella doses given at age 12 months and over.

4:3:1:3:3:1:3—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more Hib doses of any type, 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 3 or more PCV doses.

4:3:1:H:3:1:3 (routine Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 4 or more doses of Hib of any type or 2 doses of Hib of Merck types followed by 1 or more doses of Hib of any type (routine recommendation), 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 3 or more PCV doses.

4:3:1:H:3:1:3 (shortage Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more doses of Hib of any type or 2 or more doses of Hib of Merck types (shortage recommendation), 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 3 or more PCV doses.

4:3:1:3:3:1:4—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more Hib doses, 3 or more HepB doses of any type, 1 or more varicella doses given at age 12 months and over, and 4 or more PCV doses.

4:3:1:H:3:1:4 (routine Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 4 or more doses of Hib of any type or 2 doses of Hib of Merck types followed by 1 or more doses of Hib of any type (routine recommendation), 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 4 or more PCV doses.

4:3:1:H:3:1:4 (shortage Hib)—The vaccine series of 4 or more DTaP/DTP/DT doses, 3 or more polio doses, 1 or more MMR doses, 3 or more doses of Hib of any type or 2 or more doses of Hib of Merck types (shortage recommendation), 3 or more HepB doses, 1 or more varicella doses given at age 12 months and over, and 4 or more PCV doses.

Accurint—A company that maintains a database of public records and can conduct custom batch searches that determine the names and addresses of individuals associated with known phone numbers or vice versa.

Address-based sampling (ABS)—A method of probability sampling in which addresses are selected or derived from the U.S. Postal Service's Delivery Sequence File. The file is used primarily for surveys of households and people.

Adequate provider data—For the purposes of the National Immunization Survey, the idea that the information received from the child's providers is sufficient to determine whether the child is up to date (UTD) with the recommended vaccination schedule.

From 2005 through 2011, children aged 19–35 months with adequate provider data included those children for whom consent to contact providers was received and either (1) all identified vaccination providers returned the immunization history questionnaire (IHQ) or medical records or (2) some but not all of the identified vaccination providers returned the IHQ or medical records, at least one of these vaccination reports was received, and at least one of

the following additional criteria apply: a) the responding provider(s) reported the child as UTD with recommended doses of vaccines in the 4:3:1:3 series; b) the child was UTD for the 4:3:1:3 series when vaccinations given after the date of the household interview were counted; c) the responding provider(s) reported at least one measles-containing vaccination; or d) the responding provider(s) reported at least as many doses of the key recommended vaccines as the household respondent.

Beginning in 2012, the household questionnaire was shortened, eliminating the household report of vaccinations the children received, and the criteria for adequate provider data status was changed to include children for whom consent to contact providers was received and at least one provider returned the IHQ or medical records containing a history of at least one received vaccination. Since 2005, "zero-shot children" are considered to have adequate provider data; see definition.

Adolescent—Person aged 13–17 years.

American Community Survey—An ongoing statistical survey conducted by the U.S. Census Bureau that is sent to approximately 250,000 addresses monthly (or 3 million per year). It regularly gathers information previously collected in the now-defunct long form of the decennial census.

Area probability sample—A sample in which geographic areas are sampled with known probabilities. While an area probability sample design could conceivably provide for selecting areas that are themselves the units being studied, in survey research, an area probability sample is usually one in which areas are selected as part of a clustered or multistage design.

ASCII—American Standard Code for Information Interchange is an English-language text format for character encoding.

Attenuation estimator—Dual-frame estimator that combines the separate estimators from the landline sample and the cell-phone sample by minimizing the mean squared error for a specific vaccine of interest. The attenuation estimator is

biased, except when landline and cell-phone-only (CPO) children are similarly vaccinated, but it has a smaller mean squared error compared with the unbiased estimator.

Typically, when an attenuation estimator is used for the National Immunization Survey, the CPO sample size is relatively small, in fact, too small to encourage use of a direct sample-based estimator. Instead, the mean of the CPO domain is estimated by a weighted average of the means of the CPO sample and the landline sample (either the entire landline sample or the proxy CPO sample). Direct sample-based estimators are used for the landline-only and dual-user domains.

Balanced dual user—Household that has both landline and wireless telephone service, and receives an approximately equal amount of calls from either the landline or the cell phone. A household is classified as a balanced dual-user household if the respondent answered, "some received on cell phones and some received on regular phones," to the survey question, "Of all the telephone calls that you and your family receive, are nearly all received on cell phones, nearly all received on regular phones, or some received on cell phones and some received on regular phones?"

Bottom coding—The suppression of extremely low values by resetting these values to be equal to a predetermined minimum lower bound. This method is used to protect confidentiality and reduce disclosure risk of respondents with unique sociodemographic characteristics. For example, income-to-poverty ratio is bottom-coded to 0.5.

Cell-phone-mainly—A household that has both landline and wireless telephone service, but the respondent states that household residents are "not likely at all" or are "somewhat unlikely" to answer the landline phone if it rang. Households determined to be cell-phone-mainly selected one of these answers in response to the survey question, "Thinking just about the landline home phone, not your cell phone, if that telephone rang and someone were home, under normal circumstances how likely is it that it would be answered?"

Cell-phone-mostly—A household that has both landline and wireless telephone service, but reports that a few of their calls are received on their landline phone and most are received on their cell phone. Households classified as cell-phone-mostly answered, "all or almost all calls received on cell phones" in response to the survey question, "Of all the telephone calls that you and your family receive, are nearly all received on cell phones, nearly all received on regular phones, or some received on cell phones and some received on regular phones?"

Cell-phone-only—A household that only has wireless telephone service. A household was classified as cell-phone-only if respondents answered "no" to the survey question, "Do you have a landline telephone in your household?"

Census region—Groupings of states that subdivide the United States for the presentation of data. There are four census regions: Northeast, Midwest, South, and West. Each of the four census regions is divided into two or more census divisions.

Central city—The largest place in each metropolitan statistical area and consolidated metropolitan statistical area. In some cases, additional places are designated as central cities. A few primary metropolitan statistical areas do not have central cities. The largest central city, and in some cases, up to two additional central cities, are included in the metropolitan area (MA); there also are central cities that are not included in an MA. An MA central city does not include any part of a place that extends outside the MA boundary.

Child-level analytic file—A 4-quarter, child-level SAS data set with one record for each National Immunization Survey-eligible child for whom Section C of the household interview was completed. It contains all variables from the household interview and the provider record check, in addition to composite, geographic, and weighting variables.

Composite adjustment factor—A factor applied when integrating the landline-sample and cell-phone-sample estimated totals for the dual-user telephone domain, intended to yield a

combined estimate for the domain that achieves minimum mean squared error.

Computer-assisted telephone interviewing (CATI)—A telephone surveying technique in which the interviewer follows a script provided by a software application. It is a structured system of microdata collection by telephone that speeds up the collection and editing of microdata and permits the interviewer to educate the respondents on the importance of timely and accurate data. The software is able to customize the flow of the questionnaire based on the answers provided, as well as information already known about the participant.

Current Population Survey—The primary source of labor force statistics for the U.S. population. This survey is a source of numerous high-profile economic statistics, including the national unemployment rate, and it provides data on a wide range of issues relating to employment and earnings. It is sponsored jointly by the U.S. Census Bureau and the U.S. Bureau of Labor Statistics.

Delivery sequence file—A computerized file that contains all delivery point addresses serviced by the U.S. Postal Service, with the exception of general delivery.

DTaP—Diphtheria and tetanus toxoids and acellular pertussis vaccine.

DTP—Diphtheria and tetanus toxoids and pertussis vaccine.

DT—Diphtheria and tetanus toxoids vaccine.

Dual-frame sampling design— Refers to the utilization of two separate potentially overlapping sample frames to interview a population of interest. The most common dual-frame sampling design in use currently uses landline and cell phone random-digit-dialing telephone numbers to reach a representative sample of households.

Dual users—A household that has both landline and wireless telephone service. Dual users include landline mostly, balanced dual users, and cell-phone mostly.

For households sampled from the landline frame, households are classified as dual user if a respondent answered at least one to the survey question, "In total, how many working cell phones

do you and your household members have available for personal use? Please don't count cell phones that are used exclusively for business purposes."

For cases drawn from the cell-phone frame, the household is determined to be dual user if a respondent answered at least one to the survey question, "How many landline telephone numbers are residential numbers?"

Effective completed interviews—The number of completed interviews, adjusted for the effects of sample design and sample weighting on the variance of key survey estimates.

Estimation area—Geographic areas for which the National Immunization Survey produces vaccination estimates. There are 56 core estimation areas consisting of 50 states and 6 immunization grantee (or cooperative agreement awardee) areas comprising selected large urban areas, namely Chicago, Ill.; Houston, Tex.; New York, N.Y.; Philadelphia, Pa.; San Antonio, Tex.; and Washington, D.C. In addition to the core areas, additional areas become estimation areas depending on available funding.

Flu—Influenza.

H1N1 flu—H1N1, sometimes called "swine flu," is an influenza virus first detected in people in the United States in April 2009. This person-to-person virus spread worldwide, in much the same way that regular seasonal influenza viruses spread. In June 2009, the World Health Organization declared that a pandemic of H1N1 flu was underway.

Health Insurance Module—A section in the National Immunization Survey that asks questions about the extent and type of health insurance coverage the child has had since birth.

HepA—Hepatitis A.

HepB—Hepatitis B.

Hib—*Haemophilus influenzae* type b vaccine.

Hib routine recommendation—Four or more doses of Hib of any type or two or more doses of Hib of Merck types, followed by one dose of Hib of any type.

Hib shortage recommendation— Three or more doses of Hib of any type or two or more doses of Hib of Merck types.

HIPAA—The Health Insurance Portability and Accountability Act of 1996 provides health insurance protections for people and establishes security and privacy standards for the use of electronic health records and personal identifiers.

HPV—Human papillomavirus.

Immunization action plan— State-based programs sponsored by the Centers for Disease Control and Prevention in order to increase the rate of immunizations among young children.

Immunization history questionnaire—The questionnaire sent to the immunization provider(s) of a National Immunization Survey-sampled child to gather the child's immunization history, and information about the provider's facility for the provider record check phase of the National Immunization Survey.

Immunization information systems—Confidential, population-based, computerized databases that record all immunization doses administered by participating providers to persons residing within a given geopolitical area.

Item nonresponse—A missing response to a particular questionnaire item, whether by interview breakoff or by a "don't know" or "refused" response.

Landline-mostly—A household that has both landline and wireless telephone service, but reports that all or most of their calls are received on their landline telephone. A household is classified as a landline-mostly if the respondent answers "all or almost all calls received on regular phones" in response to the survey question, "Of all the telephone calls that you and your family receive, are nearly all received on cell phones, nearly all received on regular phones, or some received on cell phones and some received on regular phones?"

Landline only—A household that only has landline telephone service. Households sampled from the landline frame that answered "None" to the survey question, "In total, how many working cell phones do you and your household members have available for personal use? Please don't count cell phones that are used exclusively for business purposes," are considered to have a landline-only telephone status.

Language Line Services—A translation service that provided real-time translation of the National Immunization Survey computer-assisted telephone interview into languages other than English and Spanish.

MenACWY or MCV—Meningococcal conjugate vaccine or meningococcal-unknown type vaccine.

Metropolitan statistical area—Geographic entities (sometimes called "metro areas") defined by the Office of Management and Budget for use by federal statistical agencies collecting, tabulating, and publishing federal statistics. A metro area contains a core urban area of 50,000 or more population. Each metro area consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core.

MMR—Measles, mumps, and rubella vaccine.

Monte Carlo simulation—Methods (or experiments) referring to a class of computational algorithms that rely on repeated random sampling to compute their results. Monte Carlo methods are often used in computer simulations of physical and mathematical systems.

Marketing Systems Group—A company that provides products and services for the survey research industry. Examples of products and services include landline and cell-phone random-digit-dialing samples, address-based and list samples, sample or list enhancement services, and telephone screening services.

National Center for Health Statistics—An organizational component within the Centers for Disease Control and Prevention with the mission to provide statistical information that will guide actions and policies to improve the health of the American people.

National Center for Immunization and Respiratory Diseases—Organizational component within the Centers for Disease Control and Prevention with the mission to prevent disease, disability, and death through immunization and by control of respiratory and related diseases.

National Health Interview Survey (NHIS)—Conducted by the National Center for Health Statistics since 1957 to monitor the health of the country. NHIS collects data through personal household interviews on a broad range of health topics. Data are collected by the U.S. Census Bureau. Survey results have been instrumental in providing data to track health status, health care access, and progress toward achieving national health objectives.

National Health Interview Survey–Provider Record Check (NHIS–PRC)—Conducted as part of the National Immunization Survey (NIS) to examine sampling strategies to address concerns related to potential coverage and nonresponse bias. The project aims to explore the impact on estimated vaccination coverage rates of nonresponse and undercoverage of the NIS target populations.

National Immunization Program—An organizational component of the Centers for Disease Control and Prevention. The agency's name changed in 2006 to the National Center for Immunization and Respiratory Diseases.

National Immunization Survey (NIS)—A family of surveys sponsored by the National Center for Immunization and Respiratory Diseases. The surveys include NIS–Child, NIS–Teen, and NIS–Flu.

National Survey of Children with Special Health Care Needs—A module of the State and Local Area Integrated Telephone Surveys, which is conducted by the National Center for Health Statistics. This survey was designed to produce national and state-specific prevalence estimates of children with special health care needs (CSHCN), describe the types of services that they need and use, and assess aspects of the system of care for CSHCN. The Maternal and Child Health Bureau of the Health Resources and Services Administration provided funding for this survey. It was conducted in 2001, 2005–2006, and 2009–2010.

National H1N1 Flu Survey—A random-digit-dialing telephone survey conducted in 2009 and designed to produce timely, ongoing statistics on vaccination coverage of the population along with information concerning knowledge, attitudes, and behaviors related to the pH1N1 virus and its prevention.

NIS–Adult—National Immunization Survey Adult. A landline random-digit-dialing telephone survey of adults conducted during May, June, July, and August 2007.

NIS–CIM—National Immunization Survey–Child Influenza Module. A short flu vaccination questionnaire administered to the NIS screening sample from October through June each year for children aged 6–18 months and 3–12 years who are not eligible for NIS–Child or NIS–Teen.

NIS–Child—National Immunization Survey–Child. A list-assisted random-digit-dialing telephone survey followed by a mailed survey to children's immunization providers (the provider record check). The survey, which began data collection in April 1994, monitors childhood (ages 19–35 months) vaccination coverage in the United States and in U.S. territories.

NIS–Flu—National Immunization Survey–Flu. Combines the flu vaccination responses collected from NIS–Child (children aged 19–35 months), NIS–Teen (adolescents aged 13–17), and NIS–CIM ([child influenza module] children aged 6–18 months and 3–12 years). NIS–Flu data are used to assess annual flu vaccination coverage among children aged 6 months–17 years at the national, state, and selected local levels and in some U.S. territories. These estimates are based on data reported by the child's parent or guardian.

NIS–Teen—National Immunization Survey–Teen. Monitors vaccination coverage of adolescents aged 13–17. The survey uses a subsample of NIS–Child households, and the household and provider questionnaires were modeled after the corresponding NIS–Child instruments. NIS–Teen began data collection as an ongoing state-level survey in 2008.

Noncoverage—Occurs when the sampling frame does not fully cover the eligible population.

Nonresponse bias—Occurs in statistical surveys or censuses if the answers of respondents differ from the

potential answers of those who did not answer.

Parental concerns module— Added to the National Immunization Survey to assess and understand parents' perceptions related to vaccines administered to infants and toddlers, satisfaction with visits to providers, influences on decisions about vaccinating children, and influences on decisions by some to delay or refuse vaccinations altogether.

PCV—Pneumococcal vaccine.

Phoneless—A household that has no telephone service.

Polio—Poliovirus.

Ported number—A telephone number that has been transferred from one carrier to another, from one location to another, or from one service type to another. In this report, the term refers exclusively to a transfer between landline and cell-phone service.

Prefix area or exchange—Bank of 10,000 consecutive telephone numbers with suffix in the range 0000–9999.

Provider—Doctor, nurse, or health care provider responsible for the child's health and vaccinations.

Provider-phase weight—A set of survey weights applied to all children or adolescents for whom adequate provider data were obtained. The provider-phase weight allows for estimation of vaccination status and other variables obtained from the National Immunization Survey provider record check.

Provider record check (PRC)— Follow-on mail survey of vaccination providers identified by household respondents. The PRC survey is mailed to vaccination providers to obtain the vaccination history for the National Immunization Survey-eligible children for which consent to contact the provider was obtained from the parents or guardians in the household telephone interview.

Proxy cell-phone-only—A household that has a landline telephone and has similar (as identified via a logistic regression model) characteristics as a cell-phone-only household.

Random-digit dialing (RDD)— Method for selecting people in telephone statistical surveys by generating telephone numbers at random, using telephone exchange information. RDD has the advantage that it includes unlisted numbers that would be missed if the numbers were selected from a phone directory. In populations where there is a high telephone-ownership rate, it can be a cost-efficient way to obtain complete coverage of a geographic area.

RDD-phase weight—A set of survey weights applied to all children or teenagers for whom a completed household interview was obtained. The RDD-phase weight allows for estimation of variables obtained from the National Immunization Survey household interview.

Realization rate—An alternative measure of potential bias in surveys that does not suffer from the limitations encountered by the response rate. It takes into account the potential bias from nonresponse as well as frame undercoverage. It is defined as the ratio of the unadjusted survey estimate of the size of the target population to the true size of that population, as obtained from an external source.

Resolution rate—For a random-digit-dialing sample, the number of selected telephone numbers resolved as residential or nonresidential as a proportion of the total number of telephone numbers in the sample.

Response rate—Often response rates in survey research are calculated by dividing the number of completed interviews by the number of individuals who were selected to participate in the research. However, this method is too simplistic and does not do justice to the complexity of research design, sampling process, and the practical difficulties of contacting and assessing potential survey participants. As a result, the Council of American Survey Research Organizations (CASRO) proposed a method to better consider the various situations encountered in survey research. This method formed the basis for the development of a standard for the calculation of response rates by the American Association for Public Opinion Research.

Generally, the response rate is defined as the number of completed interviews divided by the number of cases eligible to take the survey. Specifically, the CASRO response rate for the National Immunization Survey is the product of the resolution rate, screener completion rate, and the interview completion rate.

RV—Rotavirus vaccine.

Screener completion rate—For a random-digit-dialing sample, the number of households screened as eligible or ineligible as a proportion of the total resolved residential telephone numbers in the sample.

Screener nonrespondent— Households or people for whom the screener portion of the survey that determines eligibility for the National Immunization Survey was not completed.

Section 317 Program—A discretionary program funded by Congress to support immunization infrastructure (activities to increase and sustain immunization coverage rates in the population) and vaccine purchase for underinsured children and adults. This grant (cooperative agreement) award program is administered by the Centers for Disease Control and Prevention and implemented by 64 grantees: 50 states, 8 territories (the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Northern Mariana Islands, the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, and American Samoa), and 6 urban areas (Chicago, Houston, Bexar County [San Antonio], New York City, Philadelphia County, and Washington, D.C.).

Socioeconomic status module— Assesses the contributions of socioeconomic status indicators to racial and ethnic and poverty disparities in vaccination coverage.

State and Local Area Integrated Telephone Survey—Collects important health care data at the state and local levels. The National Center for Health Statistics developed this data-collection mechanism, which uses the large National Immunization Survey screening sample. Survey modules fielded with this mechanism supplement national data-collection strategies by providing in-depth state and local area data to meet various program and policy needs.

Synthesized estimates—Estimates for children computed using adequate provider data from the National Immunization Survey or adequate provider data from a state or local immunization information system.

TD or Tdap—Tetanus and diphtheria toxoid vaccine (Td); tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap); or tetanus-unknown vaccine at or after age 10 years.

Teen-level analysis file—Annual file created for NIS–Teen, using processing and estimation procedures similar to those used to produce NIS–Child child-level analysis file, including matching sheet review, creation of up-to-date variables, imputation, and weighting.

Telephone Consumer Protection Act of 1991—A list of rules for telemarketers to follow when contacting consumers via telephone. This includes 1) limiting calls to between 8 a.m. and 9 p.m., 2) adhering to do-not-call lists and keeping this list indefinitely, and 3) having a clearly written policy available.

Telephone hundred bank—A group of 100 consecutive telephone numbers. Each bank is grouped by area code, three-digit prefix, and the first two digits of the suffix.

Telephone status—Refers to whether the household has no telephone service, only landline telephone service, only cell-phone service, or has both landline and cell telephone service. For those with both types of service, telephone status can be further separated based on whether calls are answered mostly using the landline, mostly the cell phone, or nearly equal for both (see definition for "balanced dual user"). The Figure in this appendix depicts the spectrum of telephone statuses diagram.

Top coding—The suppression of extremely high values by resetting these values to be equal to a predetermined maximum upper bound. Top coding is a method used to protect confidentiality and reduce disclosure risk of respondents with unique sociodemographic characteristics. For example, respondents with very high reported income are top-coded.

Topical modules—Additional sets of questions to the National Immunization Survey (NIS) to learn more about parents' concerns about vaccines and financial barriers to becoming vaccinated. Topical modules that have been administered since 2004 as part of the NIS–Child household interviews include the Health Insurance Module, the Parental Concerns Module, and the Socioeconomic Status Module. The Health Insurance Module has been incorporated into the core NIS survey since 2006.

Total survey error—Includes all forms of survey error, including sampling variability, interviewer effects, frame errors, response bias, and nonresponse bias.

Undercoverage—The existence of members of the population that do not appear in the sampling frame and cannot be selected for the interview (e.g., no-phone households).

Unit nonresponse—A missing response for all questionnaire items due to noncontact or refusal to participate in the survey.

Unresolved telephone number—A selected telephone number for which it is not possible to determine, through initial contact attempts, whether it is residential or nonresidential.

UTD—A child or teenager is up to date (UTD) if recommendations from the Advisory Committee for Immunization Practices for vaccinations for the child or teenager are met.

Vaccines for Children (VFC) Program—Provides financially entitled children with publicly purchased vaccines at no cost at the offices and clinics of vaccination providers who are enrolled in the VFC Program. Children aged 18 years and under are entitled to receive VFC vaccines if they are a) eligible for Medicaid, b) not covered by any health insurance that pays for doctor visits and hospital stays ("uninsured"), c) American Indian or Alaska Native, or d) covered by private health insurance that does not cover the costs of all recommended vaccines aside from copays, deductibles, and vaccination administration fees ("underinsured") and are vaccinated at a federally qualified health center or a rural health center.

Var—Varicella.

Working residential number rate—For a random-digit-dialing sample, the number of residential telephone numbers as a proportion of the total number of resolved telephone numbers in the sample.

*Zero-bank*—A group of telephone hundred banks with no listed residential number.

SOURCES: National Center for Immunization and Respiratory Diseases and NCHS, National Immunization Survey.
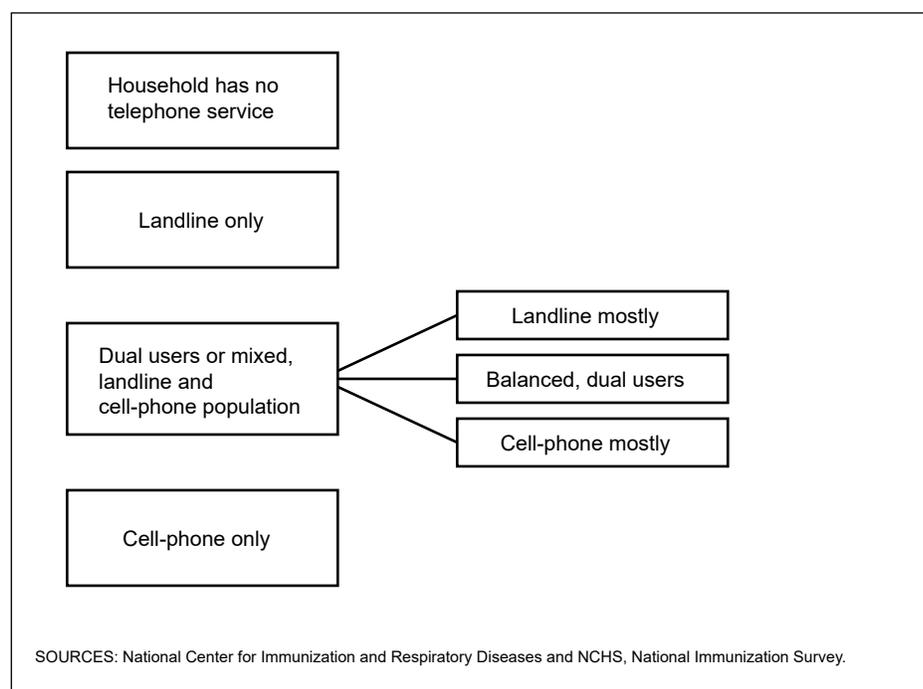
Figure. Spectrum of telephone statuses

Zero-shot child—A child is considered to be "zero-shot" if 1) the household respondent reported zero vaccinations for the child and identified zero providers; or 2) the household respondent reported zero vaccinations for the child and identified one or more providers, all of the identified providers returned immunization history questionnaires or medical records, and none of the providers reported any vaccinations for the child.

Vital and Health Statistics
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Reports include analyses by cause of death and demographic variables, and geographic and trend analyses. The last Series 20 report was published in 2007; these reports are now included in Series 3.

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Reports include analyses by health and demographic variables, and geographic and trend analyses. The last Series 21 report was published in 2006; these reports are now included in Series 3.

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