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Modeling Receipt of Influenza A(H1N1)pdm09 Vaccinations among U.S. Children during the 2009-2010 Flu Season: Findings from the 2010 National Health Interview Survey

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Abstract

Objective—Using 32 weeks of data from the 2010 National Health Interview Survey, factors associated with receipt of influenza A(H1N1)pdm09 vaccinations among U.S. children during October 2009 through February 2010 are examined.

Methods—Logistic models estimated receipt of first dose by January 1, 2010 for all children aged 4.5 months through 17 years and receipt of second dose by February 1, 2010 for children aged 6 months through 9 years who received a first dose, using demographic characteristics and measures of family structure, parental education, family income, access to health care, and chronic condition status. All analyses were weighted to yield nationally representative results for the U.S. child population.

Results—Receipt of a seasonal influenza vaccination in the 12 months prior to October 2009 as well as race/ethnicity, family structure, and various measures representing family socioeconomic status were statistically significant correlates of receipt of the first pH1N1 dose, while children's asthma and chronic condition status were not.

Conclusion—In the event of future pandemics, public health officials may utilize these findings to target particular segments of the U.S. child population that may have been underserved during the 2009 influenza pandemic.

Keywords

pH1N1 vaccination; children; United States; family structure; seasonal flu vaccination

Introduction

The emergence of the influenza A(H1N1)pdm09 virus (hereafter referred to as pH1N1) in the spring of 2009 led the World Health Organization (WHO) to declare a pandemic [1]. An estimated 60 million Americans (20% of the U.S. population) were infected with pH1N1 from April 2009 through February 2010; roughly 270,000 pH1N1-related hospitalizations and 12,000 pH1N1-related deaths occurred during this same time period [2].

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In the fall and winter of 2009-2010, few Americans knew the course that the pandemic would take. The crisis was widely covered by U.S. media and included numerous calls by federal and state public health officials to obtain pH1N1 vaccinations promptly. To what extent did Americans respond to these messages from public health officials to obtain pH1N1 vaccinations? In particular, how quickly did American parents obtain pH1N1 vaccinations for their children? The latter is a compelling question because early findings by public health agencies suggested that younger persons were at higher risk of contracting the pH1N1 virus than older persons. Moreover, children and adolescents play an important role in the transmission of influenza to healthy individuals, such that vaccinating healthy children can reduce the spread and costs of possible pandemics [3-9].

Previous papers have addressed these questions, but many were based on regional data obtained from hospitals or immunization registries [10-12]. While some of these datasets contained sizable numbers of observations, the number of explanatory variables available for analysis was often limited, plus results could not be generalized to the U.S. child population. This paper extends earlier research by using the 2010 National Health Interview Survey (NHIS), which contains a nationally representative sample of children, to estimate receipt of pH1N1 vaccinations by January 1, 2010 among noninstitutionalized children in the U.S.

Background

While seasonal influenza typically strikes elderly persons the hardest, early analyses by the Centers for Disease Control and Prevention (CDC) indicated that the median age of persons with laboratory-confirmed pH1N1 infections in the U.S. as of July 31, 2009, was 12 years, the highest infection incidence was among persons aged 5-24 years, and the incidence of hospitalization was highest among children aged 4 years or younger [1]. Consequently, CDC's Advisory Committee on Immunization Practices (ACIP) recommended in late July 2009 that initial vaccination efforts target several sub-populations, including persons aged 6 months-24 years, and that children under 10 years of age needed two doses at least 21 days apart to induce immunity to the virus, whereas older children required one dose [1]. Distribution of pH1N1 vaccine in the U.S. began on October 5, 2009, with state public health departments receiving initial vaccine supplies in amounts proportional to their populations [13].

Methods

Data, analytic sample, and key measures

Data from the 2010 NHIS were used for this analysis. Conducted by the CDC's National Center for Health Statistics (NCHS), NHIS collects information about the health and health care of the civilian noninstitutionalized population of the U.S. from a representative sample of households across the country. Information on all family members was typically collected during face-to-face interviews with one or more members present at the time of interview. One child (0-17 years of age) per family was randomly selected as the sample child, and more in-depth information regarding this child was collected from a knowledgeable adult proxy respondent, typically a parent, residing in the household. Previous reports of influenza

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vaccination coverage have yielded comparable estimates regardless of whether data were based on one randomly selected child or all children in the family [14]. The final response rate for the 2010 NHIS Sample Child file was 70.7% [15].

Several questions about receipt of pH1N1 vaccinations were added to the NHIS Sample Child questionnaire fielded in January 2010. Interviewers asked whether the sample child had received a pH1N1 flu vaccination (either by shot or nasal spray) since October 2009. If so, the interviewer asked how many vaccinations the sample child had received, and then asked the month and year of the first dose. If a second dose was received, the interviewer asked the month and year of that dose. Sample children without a valid year regarding the first and/or second pH1N1 vaccination were excluded from the analyses (n = 22).

Age eligibility for this analysis was determined by the sample child's age on October 5, 2009, rather than his or her age at interview to insure that all cases in the analysis were at least 6 months old sometime during the first 3 months that the vaccine was available (348 cases were excluded because they were too young to receive the vaccine). For those sample children with complete birthdate information (i.e., month, day, and year), all children who were 4.5 months or older on October 5, 2009 were included in the analysis; for sample children without complete birthdate information, age at interview was used but sample children under 1 year of age were excluded (n = 19).

The pH1N1 questions were dropped from the NHIS instrument in late July 2010, when a single vaccine containing immunizations against both seasonal and pH1N1 influenzas was widely available. The analysis was thus restricted to the first 32 weeks of 2010 when the survey specifically asked about receipt of pH1N1 vaccinations. Consequently, the sample child case weight was adjusted by a factor of 1.625 (52 divided by 32) to obtain results that are generalizable to the U.S. child population in 2010. Sufficient information regarding month and year of the first pH1N1 does was obtained for 96% of sample children included in the NHIS during January-July, 2010.

Outcome measures

Given that the vaccine first became available on October 5, 2009, a model was developed to estimate receipt of a first vaccination among age-eligible children by January 1, 2010. This guarantees that all sample children would have had the same opportunity to obtain vaccinations in the final months of 2009, *before* their family was interviewed in 2010. For children under 10 years of age who received their first dose by January 1, a second model estimated which children received their second dose by February 1, 2010, assuming a 3-4 week interval between the first and second doses [16], although previous research suggests that the second dose was likely delayed for most children [17]. Some interviews for the 2010 survey year may have been conducted before children could receive their second dose by February 1. However, interviewing for the 2010 NHIS did not begin until January 18, so the number of cases was likely small. January interview dates for all children under age 10 who received their first vaccinations in December were examined, and censoring was a possibility in only 5-6 cases.

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Explanatory measures

Demographic variables in the analysis included the child's age, sex, race/ethnicity, and family structure. Child's age on October 5, 2009 was collapsed into one of two age groups: 4.5 months through 9 years versus 10 years through 17 years to distinguish younger from older children, reflecting the ACIP recommendations. Regarding race/ethnicity, children were categorized as Hispanic, non-Hispanic black, non-Hispanic other (e.g., Asian, Native American or Alaska Native, or Native Hawaiian or Other Pacific Islander children), and non-Hispanic white in order to test for immunization disparities by race or ethnicity [10-11; 18].

Family structure was measured by seven mutually exclusive variables reflecting parental marital status as well as type of relationship (e.g., biological, adoptive, step) between all children 0-17 years of age living in the family at the time of the interview and any parents present (see Table 1), in a manner consistent with previous studies that have used detailed family structure indicators to examine children's living arrangements and health outcomes [19-21].

Because the NHIS defines children as family members who are 0-17 years of age and adults as family members who are aged 18 or older, adult children aged 18 or older in the NHIS are considered related adults regardless of their relationship to their parents [15].

Several explanatory variables also measured characteristics and resources of the parents or family, including parental education (less than high school diploma; high school diploma or General Educational Development high school equivalency diploma (GED); some college; and college degree), region (Northeast, Midwest, South, and West), and place of residence. Regarding parental education, education of the parent with the higher level of education was utilized, regardless of that parent's age, to reflect the parent's ability to interact with and understand the health care system (per social capital theory). If the child's parents did not reside in the household or if education of resident parent(s) was missing, then parental education was unknown (n = 268). Place of residence identified families residing in a central city, a suburb, or in a non-metro area at the time of interview. Region and place of residence have been utilized in previous research as proxy indicators of provider supplies [22].

Measures of family resources were also included in the models, such as income; health insurance coverage; receipt of a well-child checkup (i.e., a general checkup received when the sample child was not sick or injured) in the past 12 months; receipt of special education; and receipt of supplemental nutrition benefits for Women, Infants, and Children, or WIC. Poverty ratios in the 2010 NHIS Imputed Income files were utilized to eliminate missing income information; these ratios were based on the family's income from all sources and before taxes in the previous calendar year relative to the appropriate 2009 poverty threshold defined by the U.S. Census Bureau [23]. The imputed ratios were collapsed into one of four mutually exclusive variables: strictly below the federal poverty threshold (less than 1.00); 1.00 to less than 2 times the federal poverty threshold; 2.00 to less than 4 times the federal poverty threshold; and 4.00 times the poverty threshold or more.

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Health insurance coverage was measured at the time of interview and was indicated by three variables: children with private coverage, any public coverage (e.g., Medicaid, State Children's Health Insurance Program, military health plans, etc.), and those without any health insurance coverage. Indicators of participation in special education and receipt of benefits from the special supplemental nutrition program for Women, Infants, and Children (WIC), at any time during the previous year were also included because there is evidence suggesting that some states took advantage of existing local assistance programs and school systems in order to increase vaccinations [18; 24].

Researchers at CDC [25] found that 58% of children hospitalized with the pH1N1 virus during April 2009 to February 2010 had at least one underlying condition; 33% of these children had asthma, 11% had neurological/developmental disabilities, 8% had moderately severe developmental delay conditions, 6% had seizure disorders, 5% had chronic lung conditions, 5% had blood disorders (including sickle cell anemia), 3% had cerebral palsy, and 1% had diabetes. It is therefore likely that children with underlying chronic conditions might be more likely to receive pH1N1 vaccinations simply because they are sicker and need more medical attention. Chronic condition status was derived from a series of questions that asked whether a doctor or other health professional had ever said that the sample child had mental retardation; any other developmental delay; Down syndrome; cerebral palsy; muscular dystrophy; cystic fibrosis; sickle cell anemia; autism; diabetes; arthritis; congenital heart disease; another heart condition; and, in the past 12 months, anemia or seizures. Children with none of these conditions were distinguished from those with one, or two or more such conditions. Children who had ever been diagnosed with asthma and still had it when interviewed were included in a separate measure apart from chronic condition status due to the large percentage of children with asthma who were hospitalized for pH1N1 [25].

Lastly, the NHIS does not ask questions that ascertain respondents' trust in health services, immunizations, or the public health system, so previous behavior – children's receipt of a seasonal flu vaccination sometime during the year before the H1N1 vaccination became available – served as a proxy for parental trust in the safety and benefits of flu immunizations, which may in turn have translated into a greater willingness to heed warnings of public health officials regarding the pH1N1 pandemic and the importance of timely vaccination(s) for their children [26]. Therefore, the models included a measure of receipt of a seasonal flu vaccination in the past year but before October, 2009 when pH1N1 vaccinations became available.

Statistical analyses

Two logistic regression models were fitted to estimate receipt of a first pH1N1 vaccination before January 1, 2010 (among all U.S. children aged 4.5 months through 17 years), and then receipt of a second vaccination before February 1, 2010 (among U.S. children aged 4.5 months through 9 years who had a first vaccination by January 1, 2010). Note that these models are based on 5,601 and 972 observations, respectively, after cases with missing information were removed.

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Unweighted analyses using methodology described by Allison tested for multicollinearity issues [27; see p. 60-63]; none were detected. All analytic results in the tables were conducted using SUDAAN 11.0 to account for the complex sample design of the NHIS [28]. Because receipt of pH1N1 vaccinations was not a rare event – nearly 29% of U.S. children had received a pH1N1 vaccination by January 1, 2010 – relative risk ratios rather than odds ratios were estimated [29-30], using the procedures described in Bieler, et al. [31].

Analytic Results

Table 2 shows unweighted frequencies, counts of cases with missing information, and weighted population percentages for all analytic variables.

Adjusted relative risk ratios (ARR) and 95% confidence intervals derived from the first model predicting receipt of a first pH1N1 vaccination by January 1, 2010, are shown in Table 3.

Younger children (4.5 months through 9 years on October 5, 2009) were 29% more likely than older children aged 10-17 years to have received a pH1N1 vaccination by January 1, 2010 (ARR = 1.29), while children in cohabiting and extended families were 33% and 18%, respectively, less likely than children in nuclear families to have received a pH1N1 vaccination by this date. Non-Hispanic black children were 25% less likely than non-Hispanic white children to have received a vaccination by January 1, 2010, while non-Hispanic other children were 22% more likely than non-Hispanic white children to have received a vaccination. Children in families where the more educated parent did not attend any college decreased the likelihood that a child received a first pH1N1 vaccination by 18-28%. Children living in the West were 19% less likely than children in the Northeast to have received a vaccination by January 1, 2010; no other regional differences were detected.

Children living in families that were less than 4 times the federal poverty threshold) were 23-31% less likely to receive the first pH1N1 vaccination by January 1, 2010. However, receipt of WIC benefits and public health insurance coverage offset these income effects, increasing the likelihood of a first pH1N1 vaccination by 19% and 23%, respectively. Receipt of a seasonal flu vaccination before October, 2009 also increased the likelihood that a child received a first pH1N1 vaccination by 39%. Note that uninsured children and those with private health insurance were equally likely to have received a vaccination by January 1, 2010 (although note that the ARR for uninsured children was 0.79).

Children with asthma or one or more chronic conditions were not any more likely to have received a pH1N1 vaccination by January 1, 2010 than children without these conditions. (Preliminary analyses that included asthma as a chronic condition yielded the same finding.) Other explanatory variables such as children's general health, disability status, having respiratory allergies and hay fever were also examined, but these were not retained in the analysis because they added no explanatory information to the model.

Risk ratios obtained from the second logistic model are shown in Table 4.

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Four variables were significantly associated with receipt of a second pH1N1 vaccination among younger children by February 1, 2010. Children living in single parent, unmarried biological or adoptive, or blended families were less likely than children in nuclear families to have received a second vaccination (ARR = 0.60, ARR = 0.44, and ARR = 0.60, respectively). Also, children who received a seasonal flu vaccination before October, 2009 were more likely than children who did not receive a seasonal flu vaccination in this time period to receive a second pH1N1 vaccination by February 1, 2010 (ARR = 1.34).

Discussion

This paper examined immunization behavior in response to the appearance of a new influenza virus in the summer and fall of 2009, and examined what factors were correlated with a child's vaccination within 3 months of the emergency vaccine's availability. Models predicted receipt of a first dose by January 1, 2010, for all children aged 6 months through 17 years – this dose would have insured full immunity for children over age 10 and partial immunity for younger children. A second model predicted receipt of a second dose by February 1, 2010, among younger children who had received a first dose.

Consistent with previous research [10-12; 18], this study found disparities in children's access to first pH1N1 vaccinations, and among younger children receiving their second vaccination. In particular, non-Hispanic black children and children living in different types of non-nuclear families were less likely to receive timely vaccinations, as were children living in families with lower income and with a parent (or parents) who had not attended college. However, receipt of WIC benefits and public health insurance coverage were positively associated with pH1N1 vaccinations, thus offsetting these disparities to some extent.

Children with asthma or chronic conditions were not any more likely to have received a pH1N1 vaccination than healthy children – this is a somewhat surprising finding that is at odds with previous research [12]. However, children's health status and receipt of a well-child checkup in the past year were both strongly related to receipt of a seasonal flu vaccination by January 1, 2010 (results not shown but available upon request), and receipt of a seasonal flu vaccination before October, 2009 was associated with timely receipt of both first and second pH1N1 vaccinations. While fewer than 7% of children had received a seasonal flu vaccination by October, 2009, nearly 35% had received one by January 1, 2010. Thus, the lack of any direct relationship between receipt of a pH1N1 vaccination and children's health may be explained, in part, by receipt of a seasonal flu vaccination, which ultimately underscores the importance that existing immunization programs may play during a pandemic.

Limitations of the data

Cross-sectional survey data based on respondent assessments are typically subject to data limitations, such as recall problems and not understanding the interviewer's questions. In addition, adult respondents were not asked to consult immunization records for the child. Previous research has shown that immunization estimates based only on parental reports of

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children's vaccinations are higher than estimates based on provider records of immunizations, which are considered more reliable [32-33].

With the exception of the indicator for age, other explanatory variables in the analyses reflected characteristics at the time of interview, which occurred after the immunization(s). Furthermore, the 2010 NHIS did not ask whether the sample child had been diagnosed with the pH1N1 virus, so that these children could not be excluded. In addition, the survey did not obtain any information regarding parents' perceptions of the effectiveness or safety of the vaccine, the likelihood that their child might contract the pH1N1 virus, or the health risks that this flu virus might pose for their child [34]. These represent unmeasurable factors that parents might take into consideration when deciding whether to have their child vaccinated.

Also, the analysis assumes that vaccine supplies were uniformly available throughout the U.S. as of October 5, 2009, but this may not have been the case. Some states and counties may have encountered shortfalls and rationed supplies, but the NHIS did not ask whether respondents experienced delays in obtaining H1N1 vaccinations for their children.

Conclusion

While the U.S. Public Health system was able to vaccinate 40.2% (29.1 million) of children during October 2009 and May 2010 [35], this is still well below the immunization numbers that would be necessary to protect healthy children from a highly contagious virus [10; 36-37]. Fortunately, the pH1N1 virus in the U.S. peaked in October 2009 [38], which was about the same time that the vaccine became widely available, so that final morbidity and mortality rates were not as high as public health officials had at first feared. The 2009-2010 pH1N1 pandemic nevertheless serves as an important learning experience that can provide officials with additional insights to help them prepare for the next pandemic, which may be more severe.

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References

1. Centers for Disease Control and Prevention. Use of Influenza A (H1N1) 2009 Monovalent Vaccine: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2009. MMWR Recommendations and Reports. Aug 28.2009 58:RR-10.
2. Centers for Disease Control and Prevention. [Accessed Nov. 2, 2011] CDC Estimates of 2009 H1N1 Influenza Cases, Hospitalizations and Deaths in the United States, April 2009 – March 13, 2010. Apr 19. 2010 http://www.cdc.gov/H1N1flu/estimates/April_March_13.htm
3. Brownstein JS, Kleinman KP, Mandl KD. Identifying Pediatric Age Groups for Influenza Vaccination Using a Real-Time Regional Surveillance System. American Journal of Epidemiology. 2005; 162:686–693. [PubMed: 16107568]
4. Chao DL, Halloran ME, Longini IM Jr. School Opening Dates Predict Pandemic Influenza A (H1N1) Outbreaks in the United States. Journal of Infectious Disease. 2010; 202(6):877–880.

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5. Jordan R, Connock M, Albon E, Fry-Smith A, Olowokure B, Hawker J, et al. Universal vaccination of children against influenza: Are there indirect benefits to the community? A systematic review of the evidence. Vaccine. 2006; 24(8):1047–1062. [PubMed: 16298026]
6. Li S, Leader S. Economic burden and absenteeism from influenza-like illness in healthy households with children (5-17 years) in the U.S. Respiratory Medicine. 2007; 101:1244–1250. [PubMed: 17156991]
7. Loeb M, Russell ML, Moss L, Fonseca K, Fox J, Earn DJ, et al. Effect of Influenza Vaccination of Children on Infection Rates in Hutterite Communities. JAMA. 2010; 303(10):943–950. [PubMed: 20215608]
8. Weycker D, Edelsberg J, Halloran ME, Longini IM Jr, Nizam A, Ciuryla V, et al. Population-wide benefits of routine vaccination of children against influenza. Vaccine. 2005; 23(10):1284–1293. [PubMed: 15652671]
9. Yang Y, Sugimoto JD, Halloran ME, Basta NE, Chao DL, Matrajt L, et al. The Transmissibility and Control of Pandemic Influenza A (H1N1) Virus. Science. 2009; 326(5953):729–733. [PubMed: 19745114]
10. Stockwell MS, Martinez RA, Hofstetter A, Natarajan K, Vawdrey DK. Timeliness of 2009 H1N1 vaccine coverage in a low-income pediatric and adolescent population. Vaccine. 2011 doi; 10.1016/j,vaccine.2011.03.062.
11. Boulton MJ, Grossman AM, Potter R, Vranesich PA, Clayton J. Assessing the Relationship between Seasonal and H1N1 Influenza Vaccination Status in Michigan Children, 2009-2010. Public Health Reports. Jul-Aug;2011 126(Suppl 2):70–77. [PubMed: 21812171]
12. Brien S, Kwong JC, Buckeridge DL. The determinants of 2009 pandemic A/H1N1 influenza vaccination: A systematic review. Vaccine. 2012; 30:1255–1264. [PubMed: 22214889]
13. Centers for Disease Control and Prevention. Interim Results: State-Specific Influenza A (H1N1) 2009 Monovalent Vaccination Coverage --- United States, October 2009--January 2010. MMWR. Apr 2.2010 59:363–368. [PubMed: 20360670]
14. Lu P, Santibanez TA, Williams WA, Zhang J, Ding H, Bryan L, et al. Surveillance of Influenza Vaccination Coverage – United States, 2007-08 through 2011-12 Influenza Seasons. MMWR Surveillance Summaries. Oct.2013 62(4):1–28.
15. National Center for Health Statistics. 2010 NHIS survey description. National Center for Health Statistics; Hyattsville, MD: 2011. at: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/srvydesc.pdf [Accessed Jan. 3, 2012]
16. Borse RH, Shrestha SS, Fiore AE, Atkins CY, Singleton JA, Furlow C, et al. Effects of vaccine program against pandemic influenza A(H1N1) virus, United States, 2009-2010. Emerging Infectious Disease. 2013; 19(3):439–448.
17. Hofstetter AM, Natarajan K, Martinez RA, Rabinowitz D, Vawdrey DK, Stockwell MS. Influenza vaccination coverage and timeliness among children requiring two doses, 2004-2009. Preventive Medicine. 2013:165–170. [PubMed: 23219757]
18. Uscher-Pines L, Maurer J, Harris KM. Racial and Ethnic Disparities in Uptake and Location of Vaccination for 2009-H1N1 and Seasonal Influenza. American Journal of Public Health. 2011; 101(7):1252–1255. [PubMed: 21566026]
19. Ziol-Guest KM, Dunifon RE. Complex Living Arrangements and Child Health: Examining Family Structure Linkages with Children's Health Outcomes. Family Relations. 2014; 63:424–437.
20. Bramlett MD, Blumberg SJ. Family Structure and Children's Physical and Mental Health. Health Affairs. 2007; 26(2):549–558. [PubMed: 17339685]
21. Blackwell DL. Family structure and children's health in the United States: Findings from the National Health Interview Survey, 2001–2007. National Center for Health Statistics. Vital Health Stat. 2010; 10:1–166.
22. Chiri G, Warfield ME. Unmet Need and Problems Accessing Core Health Care Services for Children with Autism Spectrum Disorder. Maternal and Child Health Journal. 2012; 16:1081–1091. [PubMed: 21667201]
23. National Center for Health Statistics. Multiple Imputation of Family Income and Personal Earnings in the National Health Interview Survey: Methods and Examples. 2011 at: http://www.cdc.gov/nchs/data/nhis/tecdoc_2010.pdf.

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24. Schuller KA, Probst JC. Factors associated with influenza vaccination among US children in 2008. Journal of Infection and Public Health. 2013; 6:80–88. [PubMed: 23537820]
25. Centers for Disease Control and Prevention. [Accessed Nov. 2, 2011] 2009 H1N1 Flu: Underlying Health Conditions among Hospitalized Adults and Children. Feb.. 2010 at: http://www.cdc.gov/H1N1flu/eip_underlying_conditions.htm
26. Holte JH, Mæstad O, Jani JV. The decision to vaccinate a child: An economic perspective from southern Malawi. Social Science and Medicine. 2012; 75:384–391. [PubMed: 22571892]
27. Allison, PD. Theory and Application. Second edition. SAS Institute; Cary, NC: 2012. Logistic Regression Using SAS.
28. Shah, BV.; Barnwell, BG.; Bieler, GS. SUDAAN User's Manual. Release 7.5. Research Triangle Institute; Research Triangle Park, NC: 1997.
29. Hilbe, JM. Logistic Regression Models. CRC Press, Taylor & Francis Group; Boca Raton, FL: 2009.
30. Vittinghoff, E.; Glidden, DV.; Shiboski, SC.; McCulloch, CE. Regression Methods in Biostatistics: Linear, Logistic, Survival, and Repeated Measures Models. Second edition. Springer; New York: 2012.
31. Bieler GS, Brown GG, Williams RL, Brogan DJ. Estimating Model-Adjusted Risks, Risk Differences, and Risk Ratios from Complex Survey Data. American Journal of Epidemiology. 2010; 171(5):618–623. [PubMed: 20133516]
32. Brown C, Clayton-Boswell H, Chaves SS, Prill MM, Iwane MK, Szilagyi PG, et al. Validity of parental report of influenza vaccination in young children seeking medical care. Vaccine. 2011; 29(51):9488–9492. [PubMed: 22015394]
33. Lu P, Dorell C, Yankey D, Santibanez TA, Singleton JA. A comparison of parent and provider reported influenza vaccination status of adolescents. Vaccine. 2012; 30(22):3278–3285. [PubMed: 22445809]
34. Santibanez TA, Singleton JA, Santibanez SA, Wortley P, Bell BP. Socio-demographic differences in opinions about 2009 pandemic influenza A (H1N1) and seasonal influenza vaccination and disease among adults during the 2009-2010 influenza season. Influenza and Other Respiratory Viruses. 2013; 7(3):383–392. [PubMed: 22568588]
35. U.S. Department of Health and Human Services (DHHS). [Accessed Jan. 19, 2012] Final estimates for 2009–10 Seasonal Influenza and Influenza A (H1N1) 2009 Monovalent Vaccination Coverage – United States, August 2009 through May, 2010. 2010. 2010at: http://www.pandemicflu.gov/planning-preparedness/hospital/vcoverage0910.html
36. Plans-Rubio P. The vaccination coverage required to establish herd immunity against influenza viruses. Preventative Medicine. 2012; 55:72–77.
37. U.S. Department of Health and Human Services (DHHS). [Accessed Sept. 12, 2012] Healthy People 2020 Objectives. 2012. at: http://www.healthypeople.gov/2020/topicsobjectives2020/pdfs/HP2020objectives.pdf
38. Jhung MA, Swerlow D, Olsen SJ, Jernigan D, Biggerstaff M, Kamimoto L, et al. Epidemiology of 2009 Pandemic Influenza A (H1N1) in the United States. Clinical Infectious Diseases. 2011; 52(Suppl 1):13–26.

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Table 1

Family structure variables and definitions

Single parent family	One or more children living with a single adult (male or female, related or unrelated to the child(ren))
Unmarried biological/adoptive family	One or more children living with two parents who are not married to one another and are each biological or adoptive parents to all children in the family
Blended family	One or more children living with a biological or adoptive parent and an unrelated step-parent who are married to one another
Cohabiting family	One or more children living with a biological or adoptive parent and an unrelated adult who are cohabiting with one another
Extended family	One or more children living with at least one biological or adoptive parent and a related adult who is not a parent (e.g., grandparent, adult sibling)
Other family	One or more children living with related or unrelated adults who are not biological or adoptive parents (e.g., children being raised by their grandparents; foster children)
Nuclear family	One or more children living with two parents who are married to one another and are each biological or adoptive parents to all children in the family

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Table 2

Unweighted frequencies (based on interviews from January-June, 2010) and weighted percentages (with standard errors) of children aged 6 months-17 years with selected characteristics at time of interview (unless otherwise noted); National Health Interview Survey, 2010

Selected characteristic	Unweighted frequencies (n = 6,501)	Weighted percent (SE)
Had pH1N1 vaccination by Jan. 1, 2010 (among *all* children)		
Yes	1,729	28.8 (0.79)
No	4,524	71.2 (0.79)
Missing	248	
Had 2nd pH1N1 dose by Feb. 1, 2010 (among children aged 6 months-9 years receiving a first dose)		
Yes	348	34.6 (1.86)
No	732	65.4 (1.86)
Age on Oct. 5, 2009 (see text)		
4.5 months-9 years	3,480	56.6 (0.77)
10-17 years	3,021	43.4 (0.77)
Sex		
Female	3,133	49.4 (0.77)
Male	3,368	50.6 (0.77)
Family structure		
Single parent	1,223	17.5 (0.62)
Nuclear	2,526	42.9 (0.86)
Unmarried biological/adoptive	143	2.3 (0.36)
Blended	397	7.9 (0.45)
Cohabiting	252	3.9 (0.30)
Extended	1,700	21.8 (0.61)
Other	257	3.8 (0.29)
Missing	3	
Race/ethnicity		
Hispanic	2,008	23.2 (0.71)
Non-Hispanic white, single race	2,770	54.3 (0.89)
Non-Hispanic black, single race	1,081	14.0 (0.57)
Non-Hispanic other single race or multiple race	642	8.5 (0.50)
Parental education (of the resident parent with more education)		
Less than high school diploma	948	13.2 (0.62)

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Selected characteristic	Unweighted frequencies (n = 6,501)	Weighted percent (SE)
High school diploma or GED	1,352	20.9 (0.67)
Some college	1,944	31.5 (0.77)
College degree (at least a BA or BS)	1,989	34.5 (0.93)
Missing	268	
Region		
Northeast	967	15.3 (0.69)
Midwest	1,355	23.4 (0.85)
South	2,374	35.7 (0.87)
West	1,805	25.6 (0.81)
Residence		
Central city	2,326	32.0 (1.12)
Suburbs	3,262	52.8 (1.25)
Non-metro	913	15.2 (0.91)
Child received special education		
Yes	456	7.1 (0.39)
No	6,038	93.0 (0.39)
Missing	7	
Child's family received WIC benefits (at any time during previous year)		
Yes	1,015	17.3 (0.72)
No	5,276	82.7 (0.72)
Missing	210	
Health insurance coverage		
Private	3,294	53.9 (0.91)
Public	2,556	37.6 (0.87)
Uninsured	628	8.5 (0.45)
Missing	23	
Poverty status (in previous year)		
Under (< 1.00 times) the federal poverty threshold	1,389	21.5 (0.78)
1.00 to < 2.00 times the federal poverty threshold	1,592	24.2 (0.70)
2.00 to < 4.00 times the federal poverty threshold	1,827	28.4 (0.81)
4.00 and over times the federal poverty threshold	1,694	26.0 (0.85)
Child had well-child checkup in past 12 months		
Yes	5,030	78.7 (0.65)

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Selected characteristic	Unweighted frequencies (n = 6,501)	Weighted percent (SE)
No	1,424	21.3 (0.65)
Missing	47	
Child still had asthma		
Yes	667	9.9 (0.42)
No	5,819	90.1 (0.42)
Missing	15	
Doctor/health professional said child had 1 or more selected chronic conditions (see text)		
No conditions	5,984	92.1 (0.38)
1 condition	383	6.1 (0.34)
2 or more conditions	119	1.8 (0.21)
Missing	15	
Child had a seasonal flu vaccine before October, 2009 in the past year		
Yes	410	6.7 (0.39)
No	5,674	93.3 (0.39)
Missing	417	

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Table 3

Adjusted risk ratios and confidence intervals (in parentheses) from a logistic regression model estimating a pH1N1 vaccination before Jan. 1, 2010, among all U.S. children aged 6 months-17 years; National Health Interview Survey, 2010

Selected characteristic	Risk ratios estimating a first pH1N1 vaccination before Jan. 1, 2010, among all U.S. children
Age on Oct. 5, 2009 (see text)	
4.5 months through 9 years	1.29* (1.16-1.44)
10-17 years (ref)	1.00
Sex	
Female	1.09 (0.99-1.21)
Male (ref)	1.00
Family structure	
Single parent	0.89 (0.75-1.05)
Unmarried biological/adoptive	0.93 (0.70-1.24)
Blended	0.82 (0.66-1.03)
Cohabiting	0.67* (0.49-0.92)
Extended	0.82* (0.70-0.94)
Other	0.72 (0.40-1.29)
Nuclear (ref)	1.00
Race/ethnicity	
Hispanic	0.97 (0.84-1.13)
Non-Hispanic black, single race	0.75* (0.63-0.91)
Non-Hispanic other, single race or multiple race	1.22* (1.03-1.45)
Non-Hispanic white, single race (ref)	1.00
Parental education (of resident parent with more education)	
Less than high school diploma	0.72* (0.57-0.92)
High school diploma or GED	0.82* (0.68-1.00)
Some college	0.89 (0.77-1.02)
College degree (BA or BS) (ref)	1.00
Region	
South	0.90 (0.76-1.08)
Midwest	0.95 (0.78-1.15)
West	0.81* (0.66-0.99)
Northeast (ref)	1.00
Residence	
Central city	1.08 (0.96-1.21)

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Selected characteristic	Risk ratios estimating a first pH1N1 vaccination before Jan. 1, 2010, among all U.S. children
Non-metro	1.15 (0.97-1.36)
Suburbs (ref)	1.00
Child received special education	
Yes	1.14 (0.92-1.40)
No (ref)	1.00
Child's family received WIC benefits	
Yes	1.19* (1.04-1.37)
No (ref)	1.00
Health insurance coverage	
Public	1.23* (1.07-1.43)
Uninsured	0.79 (0.62-1.02)
Private (ref)	1.00
Poverty status (in previous year)	
Under (< 1.00 times) the federal poverty threshold	0.75* (0.59-0.96)
1.00 to < 2.00 times the federal poverty threshold	0.69* (0.57-0.84)
2.00 to < 4.00 times the federal poverty threshold	0.77* (0.66-0.90)
4.00 and over times the federal poverty threshold (ref)	1.00
Child had well-child checkup past 12 months	
Yes	1.13 (0.98-1.31)
No (ref)	1.00
Still had asthma	
Yes	1.13 (0.97-1.33)
No (ref)	1.00
Doctor/health professional said SC had one or more selected chronic conditions	
2 or more conditions	1.11 (0.74-1.66)
1 condition	1.11 (0.92-1.35)
No conditions (ref)	1.00
Had a seasonal flu vaccine before Oct., 2009 in the past year	
Yes	1.39* (1.17-1.65)
No (ref)	1.00
Number of observations in analysis	5,601
−2 * Normalized Log likelihood for full model (degrees of freedom)	6388.47 (31)

*Percent is significantly different from reference category (ref) at 0.05 level

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Table 4

Adjusted risk ratios and confidence intervals (in parentheses) from a logistic regression model estimating a second pH1N1 vaccination before Feb. 1, 2010, among U.S. children under age 10 who had a first vaccination by Jan. 1, 2010; National Health Interview Survey, 2010

Selected characteristic	Risk ratios estimating a second pH1N1 vaccination before Feb. 1, 2010, among children who had a first vaccination by Jan. 1, 2010
Sex	
Female	1.00 (0.86-1.17)
Male (ref)	1.00
Family structure	
Single parent	0.60* (0.42-0.86)
Unmarried biological/adoptive	0.44* (0.22-0.88)
Blended	0.60* (0.37-0.97)
Cohabiting	0.57 (0.27-1.18)
Extended	0.85 (0.67-1.07)
Other	0.20 (0.02-1.79)
Nuclear (ref)	1.00
Race/ethnicity	
Hispanic	0.84 (0.68-1.05)
Non-Hispanic black, single race	0.78 (0.56-1.10)
Non-Hispanic other, single race or multiple race	0.90 (0.69-1.16)
Non-Hispanic white, single race (ref)	1.00
Parental education (of resident parent with more education)	
Less than high school diploma	0.67 (0.44-1.03)
High school diploma or GED	0.91 (0.70-1.20)
Some college	0.97 (0.78-1.21)
College degree (BA or BS) (ref)	1.00
Region	
South	0.84 (0.67-1.07)
Midwest	0.96 (0.75-1.21)
West	0.80 (0.61-1.04)
Northeast (ref)	1.00
Residence	
Central city	1.06 (0.90-1.26)
Nonmetro	1.12 (0.89-1.41)
Suburbs (ref)	1.00
Child received special education	

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Selected characteristic	Risk ratios estimating a second pH1N1 vaccination before Feb. 1, 2010, among children who had a first vaccination by Jan. 1, 2010
Yes	1.03 (0.73-1.46)
No (ref)	1.00
Child's family received WIC benefits	
Yes	1.08 (0.88-1.34)
No (ref)	1.00
Health insurance coverage	
Public	1.21 (1.00-1.49)
Uninsured	1.26 (0.96-1.67)
Private (ref)	1.00
Poverty status (in previous year)	
Under (< 1.00 times) the federal poverty threshold	0.96 (0.68-1.34)
1.00 to < 2.00 times the federal poverty threshold	1.07 (0.80-1.42)
2.00 to < 4.00 times the federal poverty threshold	0.84 (0.66-1.07)
4.00 and over times the federal poverty threshold (ref)	1.00
Child had well-child check-up past 12 months	
Yes	1.05 (0.82-1.35)
No (ref)	1.00
Still had asthma	
Yes	1.06 (0.82-1.37)
No (ref)	1.00
Doctor/health professional said SC had one or more selected chronic conditions	
2 or more conditions	0.67 (0.32-1.47)
1 condition	1.04 (0.77-1.39)
No conditions (ref)	1.00
Had a seasonal flu vaccine before Oct., 2009 in the past year	
Yes	1.34* (1.11-1.62)
No (ref)	1.00
Number of observations in analysis	972
−2 * Normalized Log likelihood for full model (degrees of freedom)	1257.10 (30)

* Percent is significantly different from reference category (ref) at 0.05 level