

# Parental-Reported Full Influenza Vaccination Coverage of Children in the U.S.



Yusheng Zhai, MSPH,<sup>1</sup> Tammy A. Santibanez, PhD,<sup>2</sup> Katherine E. Kahn, MPH,<sup>1</sup> Anup Srivastav, PhD<sup>1</sup>

**Introduction:** Depending upon influenza vaccination history, children aged 6 months–8 years need one or two doses of influenza vaccine to be considered fully vaccinated. The objectives of this study were to quantify the percentage of children aged 6 months–8 years who were fully vaccinated against influenza based on parental report, overall, by state, and by sociodemographic characteristics, and to examine sociodemographic characteristics associated with being fully vaccinated.

**Methods:** Data from the National Immunization Survey-Flu for the 2012–2013 and 2013–2014 influenza seasons were analyzed in 2015 using the Kaplan–Meier method to produce vaccination coverage estimates. Wald chi-square tests were used to test for bivariate associations, and Cox proportional hazards models were used to test for demographic characteristics independently associated with the child being fully vaccinated.

**Results:** The percentages of children aged 6 months–8 years who were fully vaccinated during the 2012–2013 and 2013–2014 influenza seasons were 41.0% and 45.2%, respectively. Full vaccination varied widely by state and was more likely for children requiring only one dose. Based on the statistical models, children likely to be fully vaccinated were older, non-black, had a mother with an education > 12 years, or lived in a high-income household.

**Conclusions:** Most children in the U.S. are not fully vaccinated against influenza. Reminder systems and interventions that reduce or remove barriers to children receiving their second doses of influenza vaccine may improve full influenza vaccination coverage among all children.

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## INTRODUCTION

Influenza infections are associated with significant morbidity and mortality in children.<sup>1</sup> Furthermore, children have been found to play a large role in transmission of influenza into their household.<sup>2</sup> Household contacts of influenza-positive children have been found to have more missing work or school days and more medical visits.<sup>3</sup> Influenza vaccination is the most effective strategy to prevent people from getting influenza and influenza-related complications.<sup>4</sup>

The Advisory Committee on Immunization Practices (ACIP) recommends annual influenza vaccination for all people aged  $\geq 6$  months.<sup>4</sup> Two doses, administered a minimum of 4 weeks apart, is recommended for many children aged 6 months–8 years to ensure they obtain the optimum immune response and protection from influenza disease.<sup>5,6</sup> The ACIP definition of which children

aged <9 years require two doses to be considered fully vaccinated has varied from season to season.<sup>7–17</sup> Two approaches were recommended by ACIP for the 2012–2013 and 2013–2014 influenza seasons.<sup>15,16</sup> According to the first approach, during the 2012–2013 and 2013–2014 seasons, children aged 6 months–8 years needed only one dose if they had received a total of two or more doses of seasonal vaccine since July 1, 2010, whereas children who had not received two or more doses of

From the <sup>1</sup>Leidos, Inc., Atlanta, Georgia; and <sup>2</sup>Immunization Services Division, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

Address correspondence to: Yusheng Zhai, MSPH, National Center for Immunization and Respiratory Diseases (NCIRD), Centers for Disease Control and Prevention, 1600 Clifton Road, NE, Mail Stop A-19, Atlanta GA 30329-4027. E-mail: xds3@cdc.gov.  
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seasonal vaccine since July 1, 2010, required two doses. The second approach involves taking into account a child's vaccination history prior to July 1, 2010, when it is available.

Although parent-reported influenza vaccination coverage with one or more dose has been routinely reported for children aged 6 months–17 years since the 2010–2011 season using the National Immunization Survey Flu (NIS-Flu) and during the 2009–2010 season using the National H1N1 Flu Survey, national estimates of full vaccination coverage among all children aged 6 months–8 years have not been reported.<sup>18</sup> Full vaccination coverage based upon provider-reported vaccinations among children aged 6–23 months has been published using data from NIS-Child.<sup>19</sup> These estimates, however, cannot be produced for one influenza season before the start of the following influenza season owing to the time required to obtain provider data.<sup>19</sup> Relying upon parental report of influenza vaccination status allows for timely production of estimates, as is done for the estimates of influenza vaccination coverage with one or more dose reported annually on FluVaxView.<sup>18</sup> Some estimates of full influenza vaccination coverage based upon pediatric outpatient visits and on an HMO population have been reported.<sup>20,21</sup> Likewise, estimates have been published based upon Immunization Information Systems (IIS) for select states and local areas that have well-developed registries, and at least one study has examined full influenza vaccination coverage using a hospital-based immunization registry.<sup>22–24</sup> However, full vaccination coverage among children aged 6 months–8 years by state and sociodemographic characteristics has not yet been evaluated using a national sample. Identifying differences in full influenza vaccination coverage would be useful to immunization programs for targeting interventions and could help guide public health action to improve full influenza vaccination coverage. The objectives of this study were to quantify the percentage of children aged 6 months–8 years who were fully vaccinated against influenza, based on parental report, overall, by state, and by sociodemographic characteristics and to examine sociodemographic characteristics associated with being fully vaccinated.

## METHODS

### Data Sample

Data from NIS-Flu for the 2012–2013 and 2013–2014 influenza seasons were analyzed in 2015. NIS-Flu is a national list-assisted, random-digit-dialed, dual-frame (landline and cellular telephones) survey of households with children aged 6 months–17 years.<sup>25</sup> NIS-Flu includes three components: NIS-Child for children aged 19–35 months, NIS-Teen for children aged 13–17 years, and the NIS-Child Influenza Module for children aged 6–18 months and 3–12 years who are identified during screening households for

NIS-Child and NIS-Teen.<sup>25–30</sup> The Council of American Survey Research Organizations response rates for the 2012–2013 and 2013–2014 influenza seasons ranged from 52.2% to 63.4% for landline and 18.1% to 33.5% for cellular telephones.<sup>31</sup> NIS-Flu included a total of 107,550 and 130,409 children with completed interviews for the 2012–2013 and 2013–2014 seasons, respectively. This study restricted analyses to children aged 6 months–8 years (as of November 1 for each season, consistent with how age is defined for official Centers for Disease Control and Prevention estimates of one or more dose) and excluded children with missing vaccination status (3.7% in 2012–2013 and 2.7% in 2013–2014). The resulting sample sizes were 51,620 children for the 2012–2013 season and 65,848 children for the 2013–2014 season.

### Measures

Vaccination coverage estimates were based on interviews conducted October–June and included vaccinations received July–May of the respective influenza season. The main outcome measure was full vaccination. Estimates of coverage with one or more dose were also calculated.

Influenza vaccination status was assessed by asking the parent or guardian if the survey-selected child in the household had received an influenza vaccination since July 1 and, if so, how many vaccinations and in which month and year the child received the first dose and in which month and year the child received the second dose if applicable. To assess history of vaccination, required to determine whether one or two doses were needed to be fully vaccinated, additional questions were asked. For the 2012–2013 season survey, the parent was asked, *Did [selected child] receive any flu vaccinations during the last two flu seasons? This would be from July 1, 2010 to end of June 2012.* If yes was selected, the following question was asked, *How many flu vaccinations did [selected child] receive in the past two flu seasons, which were from July 1, 2010 to end of June 2012?* Similar questions were asked for the 2013–2014 season. Note that for the 2013–2014 season the survey question was in reference to the last two influenza seasons (back to July 2011) and not the last three seasons (back to July 2010). Children for whom the number of doses needed to be fully vaccinated could not be determined owing to missing responses to the vaccination history questions (11.3% of vaccinated children in 2012–2013 and 9.7% of vaccinated children in 2013–2014) were considered as needing two doses to be fully vaccinated. This approach reflects ACIP recommendations, which have a vaccination history response of *don't know* equated to *no* in the vaccination decision algorithm.<sup>17</sup> The full vaccination estimates are based upon the Kaplan–Meier analyses with the event being time (in months) of receipt of the dose that would make the child fully vaccinated (Dose 1 for those who needed only one dose and Dose 2 for those who needed two doses). For children reported to have been vaccinated but had a missing month and year of vaccination for their first (or only) dose (12.5% for the 2012–2013 season and 16.3% for the 2013–2014 season), month and year were imputed from donor pools matched for week of interview, age group, region of residence, and race/ethnicity using hot deck imputation. Likewise, for children reported to have received two doses of influenza vaccine but had a missing month and year of vaccination for their second dose (2.6% for the 2012–2013 season and 2.9% for the 2013–2014 season), the month and year were imputed. For children reported to have not been fully vaccinated, they were

censored on the month of interview. For all vaccination outcome measures, Kaplan–Meier survival analysis was used to obtain the cumulative vaccination coverage estimates as detailed in previous reports.<sup>32</sup>

Respondent-reported demographic characteristics included in this study were child's gender, age, and race/ethnicity; mother's education level; household poverty level; number of children aged <18 years in the household; and Metropolitan Statistical Area (MSA). The income/poverty level variable was defined based on total family income in the past calendar year, and the U.S. Census poverty thresholds for that year specified for the applicable family size and number of children aged <18 years.<sup>33</sup>

## Statistical Analysis

Wald chi-square tests followed by post hoc pairwise comparison *t*-tests were used to test the associations between influenza vaccination status and demographic characteristics. Comparisons of influenza vaccination coverage estimates between the 2012–2013 and 2013–2014 seasons were performed with *t*-tests assuming large df. Cox proportional hazards models were used to determine demographic characteristics independently associated with the child being fully vaccinated, and hazard ratios are reported. Proportional hazard assumptions were tested using time dependent covariates. All analyses were weighted to population totals and to adjust for households having multiple telephone lines, unit non-response, and non-coverage of non-telephone households. All estimates, along with 95% CIs, were calculated using SAS, version 9.3, and SUDAAN, version 11.01, to account for the complex survey design. All tests were two-sided with a significance level of 0.05.

## RESULTS

Demographic characteristics of the study sample and the percentages requiring one versus two doses to be fully vaccinated are presented in [Table 1](#). Overall, approximately two thirds of children required two doses to be fully vaccinated (2012–2013, 62.0%; 2013–2014, 58.3%). These percentages were much higher for younger children, with >80% of children aged 6–23 months (2012–2013, 83.6%; 2013–2014, 81.2%) requiring two doses ([Table 1](#)).

The percentages of children aged 6 months–8 years who received one or more dose of influenza vaccination during the 2012–2013 and 2013–2014 influenza seasons were 65.9% and 67.2%, respectively, whereas the percentages of children fully vaccinated were 41.0% and 45.2%, respectively ([Table 2](#)). State variability in full vaccination coverage was large, ranging from 28.0% in Oklahoma to 60.5% in Rhode Island during the 2012–2013 season and 31.1% in Idaho to 64.9% in Rhode Island during the 2013–2014 season ([Table 3](#)).

In bivariate analyses, full vaccination status varied by sociodemographic characteristics ([Table 2](#)). In both seasons, the percentage of fully vaccinated children aged 6–23 months was lower than those of children aged 2–4

years and 5–8 years. Hispanic, non-Hispanic white, and other/multiple race children had higher full vaccination coverage than non-Hispanic black children. Children of mothers who were college graduates had higher full vaccination coverage than children of mothers with lower education levels. Children living in households above poverty with a household income >\$75,000 had the highest full vaccination coverage. Children in households with two children had higher full vaccination coverage than children in households with one or three or more children and children living in a non-MSA had lower full vaccination coverage than children living in an MSA. Among children who needed only one dose to be fully vaccinated, 90.6% in 2012–2013 and 93.2% in 2013–2014 received one or more doses and therefore were fully vaccinated. Among children who needed two doses to be fully vaccinated, the one or more dose coverage rate was 50.9% in 2012–2013 and 48.9% in 2013–2014, whereas the corresponding full vaccination coverage rates were 10.7% and 10.9%. Additional details of the associations with full coverage as well as associations with one or more dose coverage are shown in [Table 2](#).

Results of the multivariable Cox proportional hazard models are shown in [Table 4](#) and were similar to results from the bivariate analyses. Generally, the models showed that the children most likely to be fully vaccinated were those who were aged >6–23 months, non-black, had a mother with an education >12 years, or lived in a high-income household ([Table 4](#)).

## DISCUSSION

The results of this study indicate that only approximately two of every five children aged 6 months–8 years in the U.S. were fully vaccinated against influenza in the two studied influenza seasons. Approximately 60% of these children required two doses of influenza vaccine to be considered fully vaccinated against influenza. Among those children who required two doses, about half received at least one dose in 2012–2013 and 2013–2014, but only about 10% were fully vaccinated with two doses. The finding that approximately half of children who required two doses of influenza vaccine received their first but not second dose suggests there are barriers to receipt of the second required dose. These findings are similar to what was found based upon a study using provider-reported vaccination information, finding that for the subset of children aged 6–23 months requiring two doses and who received one dose, only 64% went on to receive their required second dose.<sup>19</sup> A study based on IIS data reported estimates of full influenza vaccination coverage stratified by age for the 2012–2013

**Table 1.** Demographic Characteristics of the Study Population of Children 6 Months Through 8 Years

Demographic characteristic	2012–2013 influenza season		2013–2014 influenza season	
	Unweighted <i>n</i>	Weighted % (±95% CI)	Unweighted <i>n</i>	Weighted % (±95% CI)
Overall	51,620	100	65,848	100
Gender				
Male	26,593	51.0 (0.9)	33,789	51.3 (0.9)
Female	25,027	49.0 (0.9)	32,059	48.7 (0.9)
Age <sup>a</sup>				
6–23 months	10,632	17.1 (0.7)	13,414	17.4 (0.6)
2–4 years	18,082	33.6 (0.9)	22,782	33.5 (0.8)
5–8 years	22,906	49.4 (0.9)	29,652	49.1 (0.9)
Child's race/ethnicity				
Hispanic	9,757	25.3 (1.0)	12,828	24.6 (0.9)
Black, non-Hispanic	5,344	14.1 (0.7)	6,774	14.1 (0.7)
White, non-Hispanic	30,250	50.7 (1.0)	37,970	51.4 (0.9)
Other/multiple races, non-Hispanic	6,269	10.0 (0.6)	8,276	9.8 (0.5)
Mother's education level				
< 12 years	4,938	12.7 (0.7)	6,499	13.1 (0.7)
12 years	9,704	20.5 (0.8)	12,039	19.3 (0.7)
> 12 years, not college graduate	13,077	25.6 (0.9)	16,663	25.5 (0.8)
College graduate	21,940	38.0 (0.9)	28,070	38.6 (0.8)
Poverty status <sup>b</sup>				
Above poverty, > \$75,000/year	18,278	30.1 (0.9)	23,596	30.8 (0.8)
Above poverty, ≤ \$75,000/year	18,845	35.2 (0.9)	23,122	33.3 (0.8)
At or below poverty level	9,711	25.9 (1.0)	12,520	25.3 (0.9)
Unknown	4,786	8.9 (0.5)	6,610	10.5 (0.5)
No. of children < 18 in household				
1 child	17,578	25.8 (0.8)	21,005	23.5 (0.7)
2 children	20,653	41.4 (1.0)	26,301	40.9 (0.9)
≥ 3 children	13,206	32.7 (1.0)	18,276	35.4 (0.9)
Household in MSA				
MSA, principal city	18,067	34.8 (0.9)	18,331	27.5 (0.8)
MSA, not principal city	22,318	48.9 (1.0)	34,460	58.1 (0.9)
Non-MSA	11,235	16.3 (0.6)	13,057	14.4 (0.5)
Doses to be fully vaccinated				
1 dose	20,802	38.0 (0.9)	28,518	41.7 (0.9)
2 doses	30,818	62.0 (1.0)	32,632	58.3 (0.9)
6–23 months				
1 dose	2,128	16.4 (1.4)	2,974	18.8 (1.3)
2 doses	8,504	83.6 (1.4)	10,440	81.2 (1.3)
2–4 years				
1 dose	7,989	41.1 (1.6)	10,678	45.4 (1.6)
2 doses	10,093	58.9 (1.6)	12,104	54.6 (1.6)
5–8 years				
1 dose	10,685	43.3 (1.3)	14,866	47.3 (1.2)
2 doses	12,221	56.7 (1.3)	14,786	52.7 (1.2)

Source: National Immunization Survey-Flu (NIS-Flu), 2012–2013 and 2013–2014 influenza seasons.

<sup>a</sup>Age as of November 1 of the respective influenza season.

<sup>b</sup>Income/poverty level was defined based on total family income in the past calendar year, and the U.S. Census poverty thresholds for that year specified for the applicable family size and number of children aged < 18 years. Poverty thresholds are available at [www.census.gov/hhes/www/poverty/data/threshld/index.html](http://www.census.gov/hhes/www/poverty/data/threshld/index.html).

MSA, Metropolitan Statistical Area; No., number.

**Table 2.** Influenza Vaccination Coverage Among Children 6 Months Through 8 Years, by Characteristics and Dose Recommendations

Demographic characteristic	2012–2013 influenza season, estimate <sup>a</sup> (±95% CI)		2013–2014 influenza season, estimate (±95% CI)	
	≥ 1 dose <sup>b</sup>	Fully vaccinated <sup>c</sup>	≥ 1 dose	Fully vaccinated
Overall	65.9 (1.2)	41.0 (1.1)	67.2 (1.1)	45.2 (1.3) <sup>f</sup>
Gender				
A. Male	66.1 (1.6)	41.7 (1.6)	66.9 (1.4)	45.1 (1.7) <sup>f</sup>
B. Female	65.6 (1.7)	40.4 (1.6)	67.5 (1.7)	45.3 (1.8) <sup>f</sup>
Age <sup>d</sup>				
A. 6–23 months	77.0 (2.3) <sup>g,B,C</sup>	36.8 (2.3) <sup>B,C</sup>	74.4 (2.0) <sup>B,C</sup>	39.3 (2.3) <sup>B,C</sup>
B. 2–4 years	65.9 (1.9) <sup>A,C</sup>	42.8 (2.1) <sup>A</sup>	68.1 (1.8) <sup>A,C</sup>	45.6 (2.3) <sup>A</sup>
C. 5–8 years	61.7 (1.8) <sup>A,B</sup>	41.3 (1.6) <sup>A</sup>	63.9 (1.7) <sup>A,B</sup>	47.0 (1.8) <sup>f,A</sup>
Child's race/ethnicity				
A. Hispanic	69.0 (2.8) <sup>B,C</sup>	41.4 (2.8) <sup>B</sup>	74.2 (2.9) <sup>f,B,C</sup>	47.9 (3.9) <sup>f,B</sup>
B. Black, non-Hispanic	63.5 (3.6) <sup>A,D</sup>	33.9 (3.0) <sup>A,C,D</sup>	63.3 (3.0) <sup>A,D</sup>	37.8 (3.2) <sup>A,C,D</sup>
C. White, non-Hispanic	64.0 (1.4) <sup>A,D</sup>	42.5 (1.4) <sup>B</sup>	64.2 (1.2) <sup>A,D</sup>	45.9 (1.2) <sup>f,B</sup>
D. Other/multiple races, non-Hispanic	69.7 (3.7) <sup>B,C</sup>	42.5 (3.1) <sup>B</sup>	70.9 (2.7) <sup>B,C</sup>	46.3 (2.9) <sup>B</sup>
Mother's education level				
A. < 12 years	66.7 (4.1) <sup>C</sup>	35.5 (3.6) <sup>D</sup>	72.5 (4.4) <sup>B,C</sup>	45.9 (5.4) <sup>f,B,C,D</sup>
B. 12 years	63.5 (2.8) <sup>D</sup>	36.8 (2.6) <sup>D</sup>	64.0 (2.3) <sup>A,C,D</sup>	37.8 (3.2) <sup>A,D</sup>
C. > 12 years, not college graduate	61.4 (2.3) <sup>A,D</sup>	37.8 (2.3) <sup>D</sup>	60.2 (2.1) <sup>A,B,D</sup>	39.5 (2.3) <sup>A,D</sup>
D. College graduate	69.6 (1.7) <sup>B,C</sup>	47.9 (1.7) <sup>A,B,C</sup>	71.6 (1.3) <sup>B,C</sup>	53.2 (1.4) <sup>f,A,B,C</sup>
Poverty status <sup>e</sup>				
A. Above poverty, > \$75,000/year	71.2 (1.9) <sup>B,C,D</sup>	49.7 (1.9) <sup>B,C,D</sup>	71.2 (1.4) <sup>B</sup>	54.0 (1.6) <sup>f,B,C,D</sup>
B. Above poverty, ≤ \$75,000/year	61.2 (2.0) <sup>A,C</sup>	38.1 (1.9) <sup>A</sup>	62.0 (1.7) <sup>A,B,D</sup>	40.0 (1.7) <sup>A,D</sup>
C. At or below poverty level	67.0 (2.7) <sup>A,B</sup>	36.4 (2.5) <sup>A</sup>	68.6 (2.8) <sup>B</sup>	42.2 (1.9) <sup>f,A,D</sup>
D. Unknown	63.7 (3.9) <sup>A</sup>	36.8 (3.6) <sup>A</sup>	68.9 (3.7) <sup>B</sup>	43.0 (4.1) <sup>f,A,B,C</sup>
No. of children < 18 in household				
A. 1 child	67.9 (2.1) <sup>C</sup>	40.1 (2.1) <sup>B</sup>	67.6 (1.7)	41.3 (1.8) <sup>B</sup>
B. 2 children	67.8 (1.8) <sup>C</sup>	44.1 (1.9) <sup>A,C</sup>	68.5 (1.5) <sup>C</sup>	48.2 (1.7) <sup>f,A,C</sup>
C. ≥ 3 children	61.7 (2.3) <sup>A,B</sup>	37.8 (2.0) <sup>B</sup>	65.6 (2.2) <sup>f,B</sup>	42.2 (2.6) <sup>f,B</sup>
Household in MSA				
A. MSA, principal city	67.3 (2.0) <sup>C</sup>	40.4 (1.9) <sup>B,C</sup>	69.6 (2.0) <sup>C</sup>	45.2 (2.4) <sup>f,C</sup>
B. MSA, not principal city	66.7 (1.9) <sup>C</sup>	43.0 (1.8) <sup>A,C</sup>	67.8 (1.5) <sup>A,C</sup>	46.4 (1.7) <sup>f,C</sup>
C. Non-MSA	60.1 (2.4) <sup>A,B</sup>	37.0 (2.2) <sup>A,B</sup>	60.2 (2.3) <sup>A,B</sup>	40.4 (2.3) <sup>f,A,B</sup>
No. of doses to be fully vaccinated				
A. 1 dose	90.6 (1.4) <sup>B</sup>	90.6 (1.4) <sup>B</sup>	93.2 (1.2) <sup>f,B</sup>	93.2 (1.2) <sup>f,B</sup>
B. 2 dose	50.9 (1.6) <sup>A</sup>	10.7 (1.0) <sup>A</sup>	48.9 (1.3) <sup>A</sup>	10.9 (1.2) <sup>A</sup>

Source: National Immunization Survey-Flu (NIS-Flu), 2012–2013 and 2013–2014 influenza seasons.

<sup>a</sup>Influenza vaccination coverage estimates were calculated using the Kaplan-Meier survival analysis procedure. For the 2012–2013 season, estimates include vaccinations received from July 2012 through May 2013 and are based on interviews conducted October 2012 through June 2013. For the 2013–2014 season, estimates include vaccinations received from July 2013 through May 2014 and are based on interviews conducted October 2013 through June 2014.

<sup>b</sup>Any (≥ 1) dose defined as receipt of at least one dose of influenza vaccine.

<sup>c</sup>Fully vaccinated was defined as either (1) receipt of two doses of influenza vaccine for children who were previously unvaccinated or did not receive a total of two or more doses of influenza vaccine from July 1, 2010, to the end of June 2012 for the 2012–2013 influenza seasons or June 2013 for the 2013–2014 influenza season, or (2) receipt of one dose of influenza vaccine otherwise.

<sup>d</sup>Age as of November 1 of the respective influenza season.

<sup>e</sup>Income/poverty level was defined based on total family income in the past calendar year, and the U.S. Census Poverty thresholds for that year specified for the applicable family size and number of children aged < 18 years. Poverty thresholds are available at <http://www.census.gov/hhes/www/poverty/data/threshld/index.html>.

<sup>f</sup>Statistically significant difference compared to the 2012–2013 influenza season estimate.

<sup>g</sup>The presence or absence of capital letters denotes whether that estimate was statically significantly different at  $p < 0.05$  from another row, and denotes which row it differed from (A, B, C, D), based on pairwise comparison  $t$ -test. For example, the 77.0% of ≥ 1 dose vaccination coverage estimate of 6–23 months (A) was statistically significantly different from the 65.9% of coverage estimates of 2–4 years (B) and 61.7% of 5–8 years (C) in the 2012–2013 season.

MSA, Metropolitan Statistical Area; No., number.

**Table 3.** Influenza Vaccination Coverage Among Children 6 Months Through 8 Years, by State and HHS Region

State	2012–2013 influenza season, estimate <sup>a</sup> (±95% CI)		2013–2014 influenza season, estimate <sup>a</sup> (±95% CI)	
	≥ 1 dose <sup>b</sup>	Fully vaccinated <sup>c</sup>	≥ 1 dose	Fully vaccinated
National	65.9 (1.2)	41.0 (1.1)	67.2 (1.1)	45.2 (1.3) <sup>d</sup>
Region 1	79.6 (2.7)	56.8 (3.2)	79.9 (2.1)	60.4 (2.7)
Connecticut	80.5 (4.4)	59.1 (5.9)	84.0 (3.7)	62.6 (5.0)
Maine	65.3 (6.1)	40.4 (5.9)	68.7 (4.8)	45.0 (5.0)
Massachusetts	83.0 (4.7)	59.9 (5.6)	81.8 (3.7)	64.3 (4.8)
New Hampshire	71.5 (5.8)	50.7 (5.8)	71.3 (5.4)	53.4 (5.6)
Rhode Island	87.6 (7.5)	60.5 (8.1)	84.0 (4.3)	64.9 (5.3)
Vermont	69.6 (6.1)	49.7 (6.3)	66.6 (5.3)	46.7 (5.4)
Region 2	73.1 (3.1)	48.9 (3.4)	74.5 (2.5)	52.2 (2.8)
New York	69.2 (3.6)	46.2 (4.0)	71.2 (3.3)	49.3 (3.5)
New Jersey	81.3 (5.5)	54.0 (6.2)	81.4 (3.6)	58.3 (4.6)
Region 3	73.2 (3.5)	49.2 (3.9)	71.2 (2.9)	49.3 (3.1)
Delaware	72.3 (9.6)	48.5 (8.7)	77.6 (4.8)	49.9 (5.7)
Maryland	71.7 (7.3)	50.0 (7.8)	76.2 (5.9)	52.4 (6.8)
Pennsylvania	77.8 (5.8)	55.5 (6.8)	69.8 (4.9) <sup>d</sup>	51.6 (5.2)
Virginia	70.3 (6.8)	42.8 (7.3)	70.7 (6.1)	45.6 (5.8)
West Virginia	60.9 (6.7)	34.3 (5.7)	62.2 (5.0)	39.0 (4.9)
District of Columbia	82.2 (5.7)	48.8 (7.1)	75.5 (5.5)	50.5 (7.3)
Region 4	61.3 (2.9)	37.5 (2.8)	61.2 (2.1)	38.7 (2.0)
Alabama	64.3 (7.1)	47.1 (12.6)	68.5 (6.5)	45.0 (7.1)
Florida	57.2 (8.4)	29.0 (7.0)	57.2 (4.9)	31.2 (4.4)
Georgia	61.3 (6.3)	40.8 (6.9)	58.9 (5.4)	39.8 (5.1)
Kentucky	70.3 (7.8)	43.3 (6.1)	60.9 (6.3)	42.3 (6.3)
Mississippi	56.0 (6.8)	29.6 (5.7)	49.8 (5.1)	32.9 (5.0)
North Carolina	63.6 (5.0)	41.4 (5.0)	66.9 (5.1)	44.6 (5.2)
South Carolina	58.3 (6.0)	34.9 (5.6)	62.5 (6.2)	38.0 (5.0)
Tennessee	67.2 (6.1)	44.4 (6.2)	68.1 (5.2)	45.7 (5.2)
Region 5	63.1 (2.5)	40.1 (2.3)	62.9 (2.1)	41.9 (2.1)
Illinois	64.1 (5.3)	37.9 (4.8)	61.2 (3.7)	37.8 (3.7)
Indiana	61.0 (5.3)	39.8 (4.9)	63.0 (5.0)	41.1 (4.4)
Ohio	61.5 (6.5)	40.8 (5.4)	62.4 (5.2)	45.4 (5.5)
Michigan	60.4 (5.6)	37.6 (5.6)	60.3 (5.5)	36.2 (4.9)
Minnesota	68.3 (6.1)	45.3 (5.7)	70.1 (5.4)	51.0 (5.8)
Wisconsin	66.3 (5.8)	44.3 (5.9)	65.2 (5.3)	47.5 (5.5)
Region 6	65.3 (3.0)	39.3 (2.7)	70.2 (2.8) <sup>d</sup>	45.4 (4.1) <sup>d</sup>
Arkansas	63.9 (7.5)	41.6 (5.5)	71.5 (5.0)	47.0 (5.9)
Louisiana	61.8 (6.2)	36.2 (4.9)	62.7 (4.9)	40.5 (5.2)
New Mexico	70.8 (6.2)	45.9 (6.4)	73.3 (5.1)	51.2 (5.2)
Oklahoma	58.6 (6.4)	28.0 (5.1)	62.3 (5.4)	41.6 (5.4) <sup>d</sup>
Texas	66.4 (4.2)	40.7 (3.9)	72.1 (3.8) <sup>d</sup>	46.2 (5.9)
Region 7	62.5 (3.1)	39.2 (2.9)	66.2 (2.8)	45.3 (2.9) <sup>d</sup>
Iowa	65.5 (6.2)	40.5 (6.1)	66.4 (6.2)	45.2 (6.4)
Kansas	56.2 (5.5)	33.1 (4.8)	68.6 (5.1) <sup>d</sup>	48.1 (5.7) <sup>d</sup>
Missouri	61.7 (5.7)	38.9 (5.4)	62.3 (4.9)	41.7 (4.7)
Nebraska	69.7 (5.9)	47.1 (5.7)	75.0 (4.6)	52.0 (5.5)
Region 8	65.5 (3.0)	42.0 (3.1)	65.6 (2.8)	47.1 (2.8) <sup>d</sup>
Colorado	68.0 (4.7)	43.2 (5.2)	71.6 (4.4)	54.6 (4.3) <sup>d</sup>

(continued on next page)

**Table 3.** Influenza Vaccination Coverage Among Children 6 Months Through 8 Years, by State and HHS Region (continued)

State	2012–2013 influenza season, estimate <sup>a</sup> (±95% CI)		2013–2014 influenza season, estimate <sup>a</sup> (±95% CI)	
	≥ 1 dose <sup>b</sup>	Fully vaccinated <sup>c</sup>	≥ 1 dose	Fully vaccinated
Montana	59.1 (6.2)	36.9 (5.3)	63.1 (6.7)	43.5 (6.6)
North Dakota	68.9 (5.9)	45.7 (6.1)	66.2 (5.1)	46.5 (4.8)
South Dakota	81.6 (9.5)	51.7 (7.4)	70.5 (6.4)	50.0 (6.2)
Utah	60.8 (5.9)	40.0 (6.0)	58.9 (5.5)	39.8 (6.8)
Wyoming	51.0 (7.3)	30.8 (6.6)	50.2 (7.9)	33.5 (6.6)
Region 9	64.8 (4.2)	36.5 (3.9)	69.0 (4.7)	47.5 (5.6) <sup>d</sup>
Arizona	60.7 (5.9)	36.1 (5.7)	59.3 (6.1)	36.6 (6.4)
California	65.6 (5.2)	36.0 (4.8)	71.3 (5.8)	50.2 (7.0) <sup>d</sup>
Hawaii	68.2 (9.9)	43.2 (9.5)	73.9 (7.7)	49.0 (7.5)
Nevada	61.2 (5.4)	38.6 (5.9)	57.0 (5.0)	35.1 (4.7)
Region 10	63.3 (4.7)	35.9 (3.7)	63.4 (3.8)	41.8 (3.6) <sup>d</sup>
Alaska	55.0 (6.7)	29.8 (5.2)	61.7 (5.7)	35.6 (5.3)
Idaho	53.9 (6.3)	34.1 (6.0)	53.0 (6.2)	31.1 (5.2)
Oregon	52.3 (5.2)	31.4 (4.4)	61.6 (5.6) <sup>d</sup>	43.3 (5.6) <sup>d</sup>
Washington	73.7 (7.7)	39.9 (6.6)	67.0 (6.3)	44.2 (5.8)

Source: National Immunization Survey-Flu (NIS-Flu), 2012–2013 and 2013–2014 influenza seasons.

<sup>a</sup>Influenza vaccination coverage estimates were calculated using the Kaplan-Meier survival analysis procedure. For the 2012–2013 season, estimates include vaccinations received from July 2012 through May 2013 and are based on interviews conducted October 2012 through June 2013. For the 2013–2014 season, estimates include vaccinations received from July 2013 through May 2014 and are based on interviews conducted October 2013 through June 2014.

<sup>b</sup>Any (≥ 1) dose defined as receipt of at least one dose of influenza vaccine.

<sup>c</sup>Fully vaccinated was defined as either (1) receipt of two doses of influenza vaccine for children who were previously unvaccinated or did not receive a total of two or more doses of influenza vaccine from July 1, 2010, to the end of June 2012 for the 2012–2013 influenza seasons or June 2013 for the 2013–2014 influenza season, or (2) receipt of one dose of influenza vaccine otherwise.

<sup>d</sup>Statistically significant difference compared to the 2012–2013 influenza season estimate.

HHS, Health and Human Services.

and 2013–2014 seasons; these estimates were 46.8% and 47.0% for children aged 6–23 months, 38.9% and 38.8% for children aged 2–4 years, and 30.9% and 32.7% for children aged 5–8 years, respectively.<sup>34</sup> These IIS estimates are higher than the estimates from this study for children aged 6–23 months but lower for children aged 2–4 years and 5–8 years. Additionally, this IIS study found that for the subset of children aged 6–23 months requiring two doses and who received one dose, 65.6% (in 2012–2013) and 67.6% (in 2013–2014) went on to receive their required second dose.<sup>34</sup> Barriers to receipt of the second dose might include inconvenience, difficulty making a doctor appointment, insurance/financial barriers, difficulty getting time off of work, lack of provider–parent discussions on the importance of returning for the child’s second dose, parental beliefs and attitudes about vaccine effectiveness and safety, or other unknown factors.<sup>35</sup>

Children aged 6–23 months had lower full influenza vaccination coverage than older children. Preventing influenza among infants and young children is a public health priority because of their high risk for influenza-related complications.<sup>36,37</sup> The second dose is essential, as evidenced by at least one study, which found that receipt of

two doses of influenza vaccine was 69% effective against office visits for influenza-like illness and 87% effective against office visits for influenza-related pneumonia, whereas receipt of one dose did not prevent office visits at all for children aged 6–21 months.<sup>6</sup> More widespread use of strategies known to increase second dose vaccination rates is warranted.<sup>38</sup> One study found that text reminders that educated the parent on the importance of the second dose were effective at increasing the percentage of children who received their needed second dose.<sup>39</sup>

This study found racial/ethnic differences in full vaccination coverage that were in contrast to one or more dose coverage. Non-Hispanic black children had lower full vaccination coverage compared to all of the other race/ethnicity groups in both the 2012–2013 and 2013–2014 seasons; however, black and white children had similar one or more dose coverage. This suggests there may be more barriers for black children to receive their second dose. Another recent study of full vaccination coverage of children aged 6–23 months based upon provider report likewise found that black children had lower full vaccination coverage than white children for all ten studied influenza seasons.<sup>19</sup> Minority children

**Table 4.** Demographic Characteristics Associated With Full Influenza Vaccination Coverage Among Children 6 Months Through 8 Years

Demographic characteristics	Fully vaccinated, <sup>a</sup> HR (95% CI)	
	2012–2013 influenza season	2013–2014 influenza season
Gender		
Male	1.04 (0.98, 1.11)	0.99 (0.93, 1.05)
Female	ref	ref
Age <sup>b</sup>		
6–23 months	ref	ref
2–4 years	<b>1.50 (1.37, 1.64)</b>	<b>1.52 (1.40, 1.65)</b>
5–8 years	<b>1.41 (1.30, 1.54)</b>	<b>1.49 (1.38, 1.60)</b>
Child's race/ethnicity		
Hispanic	<b>1.27 (1.11, 1.44)</b>	<b>1.35 (1.20, 1.53)</b>
Black, non-Hispanic	ref	ref
White, non-Hispanic	<b>1.22 (1.09, 1.36)</b>	<b>1.21 (1.10, 1.35)</b>
Other/multiple races, non-Hispanic	<b>1.21 (1.05, 1.40)</b>	<b>1.25 (1.11, 1.42)</b>
Mother's education level		
< 12 years	ref	ref
12 years	1.11 (0.96, 1.28)	<b>0.88 (0.77, 1.00)</b>
> 12 years, not college graduate	<b>1.16 (1.00, 1.34)</b>	0.98 (0.85, 1.13)
College graduate	<b>1.44 (1.25, 1.65)</b>	<b>1.34 (1.18, 1.52)</b>
Poverty status <sup>c</sup>		
Above poverty, > \$75,000/year	<b>1.28 (1.18, 1.39)</b>	<b>1.31 (1.22, 1.41)</b>
Above poverty, ≤ \$75,000/year	ref	ref
At or below poverty level	1.02 (0.91, 1.14)	1.05 (0.94, 1.17)
Unknown	0.91 (0.80, 1.04)	0.99 (0.88, 1.11)
No. of children < 18 in household		
1 child	1.01 (0.92, 1.10)	0.99 (0.92, 1.07)
2 children	<b>1.13 (1.04, 1.22)</b>	<b>1.12 (1.04, 1.20)</b>
≥ 3 children	ref	ref
Household in MSA		
MSA, principal city	1.08 (0.98, 1.18)	1.07 (0.97, 1.17)
MSA, not principal city	<b>1.16 (1.06, 1.26)</b>	1.06 (0.98, 1.15)
Non-MSA	ref	ref

Source: National Immunization Survey-Flu (NIS-Flu), 2012–2013 and 2013–2014 influenza seasons.

Note: Boldface indicates statistical significance ( $p < 0.05$ ) compared to the referent group.

<sup>a</sup>Fully vaccinated was defined as either (1) receipt of two doses of influenza vaccine for children who were previously unvaccinated or did not receive a total of two or more doses of influenza vaccine from July 1, 2010, to the end of June 2012 for the 2012–2013 influenza seasons or June 2013 for the 2013–2014 influenza season, or (2) receipt of one dose of influenza vaccine otherwise.

<sup>b</sup>Age as of November 1 of the respective influenza season.

<sup>c</sup>Income/poverty level was defined based on total family income in the past calendar year, and the U.S. Census poverty thresholds for that year specified for the applicable family size and number of children < 18 years. Poverty thresholds are available at [www.census.gov/hhes/www/poverty/data/threshld/index.html](http://www.census.gov/hhes/www/poverty/data/threshld/index.html).

HR, hazard ratio; MSA, Metropolitan Statistical Area; No., number.

have also been found to have a longer interval between first and second doses.<sup>24</sup>

Children of mothers with a college degree and children living in households with a higher annual household income consistently had higher full vaccination coverage. Studies of other childhood vaccinations had likewise shown that lower family income was associated with lower vaccination rates, perhaps because of numerous barriers faced by lower-income families such as lack of access to medical care, transportation issues, difficulty

obtaining time off of work, and other barriers.<sup>40,41</sup> Children living in an MSA had higher full vaccination coverage than children residing in non-MSAs, suggesting there might be additional barriers to children in non-MSAs receiving their second required dose. As seen in publications on one or more dose influenza vaccination coverage among children, large variability in full influenza vaccination coverage by state was also found.<sup>42,43</sup> It is unknown why this variability exists, but factors likely include differences in programmatic and provider implementation

of influenza recommendations, medical care delivery infrastructure, population norms, state and local immunization program efforts and resources, and other factors.<sup>44,45</sup> Further study is needed to understand the variability in full influenza vaccination coverage between states.

### Limitations

This study is subject to the following limitations. First, NIS-Flu is a telephone survey and selection and non-response bias is possible and may remain after weighting adjustments. Second, the Council of American Survey Research Organizations response rate was low, especially for the cellular sample, and non-response bias may remain even after weighting adjustments. Third, influenza vaccination status was based on parental report and was not validated with medical records. Validity studies have shown that parents may overreport their child's influenza vaccination status and this may vary by race/ethnicity, income, and other sociodemographic characteristics.<sup>46</sup> An analysis of full influenza vaccination based upon provider report among children aged 6–23 months found that full influenza vaccination coverage was 42.9% in the 2012–2013 season, higher than the 36.8% found in this paper based on parental report.<sup>19</sup> Although parent report may not be equally valid as provider report, estimates based on parental report can be obtained for one influenza season before the start of the next, and have been routinely reported since 2009.<sup>18</sup> Fourth, the 2013–2014 NIS-Flu questionnaire did not allow the precise measure of full influenza vaccination because the survey asked for vaccination history since July 1, 2011, rather than 2010. This likely led to an overestimation of the number of children who needed a second dose of influenza vaccine and resulted in an underestimation of full vaccination coverage rates for the 2013–2014 influenza season. Additionally, using only one ACIP approach and treating missing responses to vaccination history as needing two doses may have also resulted in underestimation of full vaccination coverage. Fifth, when evaluating the proportional hazards assumption for the Cox model, age group did not satisfy the assumption but was kept in the final Cox regression because it was a primary variable of interest. The literature suggests that the proportional hazards model is robust to departures from this assumption.<sup>47–49</sup>

### CONCLUSIONS

This study indicates that the percentage of children aged 6 months–8 years who are fully vaccinated against influenza remains low. These results demonstrate the need for continued emphasis of the importance of younger children receiving their second influenza dose

when it is needed. Targeted interventions based on sociodemographic factors associated with low coverage, interventions recommended by the Community Guide such as expanded access in healthcare settings, intensive outreach and home visits, client reminder and recall systems, and client or community-wide education can help improve coverage.<sup>38</sup>

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YZ and TAS conceived the study; YZ wrote the first draft of the manuscript and led revisions of all subsequent versions. YZ had access to all data and takes responsibility for their integrity. YZ also performed the statistical analyses. TAS, KEK, and AS participated in data interpretation and writing of the manuscript, and advised on the data analysis. All authors have reviewed and approved the submitted version of the manuscript.

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