

Seasonal Influenza Vaccination Coverage Trends Among Adult Populations, U.S., 2010–2016



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Introduction: Influenza is a major cause of morbidity and mortality among adults. The most effective strategy for preventing influenza is annual vaccination. However, vaccination coverage has been suboptimal among adult populations. The purpose of this study is to assess trends in influenza vaccination among adult populations.

Methods: Data from the 2010–2016 National Health Interview Survey were analyzed in 2018 to estimate vaccination coverage during the 2010–2011 through 2015–2016 seasons. Trends of vaccination in recent years were assessed. Vaccination coverage by race/ethnicity within each group was examined. Multivariable logistic regression and predictive marginal models were conducted to identify factors associated with vaccination, and interactions between race/ethnicity and other demographic and access-to-care characteristics were assessed.

Results: Vaccination coverage among adults aged ≥ 18 years increased from 38.3% in the 2010–2011 season to 43.4% in the 2015–2016 season, with an average increase of 1.3 percentage points annually. From the 2010–2011 through 2015–2016 seasons, coverage was stable for adults aged ≥ 65 years and changed by -0.1 to 9.9 percentage points for all other examined subgroups. Coverage in 2015–2016 was 70.4% for adults aged ≥ 65 years, 46.4% for those aged 50–64 years, and 32.3% for those aged 18–49 years; 47.9% for people aged 18–64 years with high-risk conditions; 64.8% for healthcare personnel; and 50.3% for pregnant women. Among adults aged ≥ 18 years for the 2015–2016 season, coverage was significantly lower among non-Hispanic blacks and Hispanics compared with non-Hispanic whites.

Conclusions: Overall, influenza vaccination coverage among adults aged ≥ 18 years increased during 2010–2016, but it remained below the national target of 70%. Vaccination coverage varied by age, risk status, race/ethnicity, healthcare personnel, and pregnancy status. Targeted efforts are needed to improve coverage and reduce disparities.

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INTRODUCTION

Annual influenza epidemics typically occur during the late fall through early spring in the U.S., and influenza continues to be a major cause of morbidity and mortality among adults.^{1–4} The Centers for Disease Control and Prevention estimates that influenza has resulted in between 140,000 and 960,000 hospitalizations annually since 2010.² Influenza-associated respiratory and circulatory deaths have ranged from a low of 12,000 (during 2011–2012) to a high of 79,000

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(during 2017–2018).² Influenza illness burden among healthy adults aged 18–49 years is an important cause of outpatient medical visits and loss of workdays.^{5,6} Influenza vaccination is a cost effective tool for reducing morbidity and mortality associated with influenza among adults.^{5,7–19} Since the 2010–2011 influenza season, the Advisory Committee on Immunization Practices has recommended annual influenza vaccination for all individuals aged ≥ 6 months.¹

Influenza vaccination coverage by race/ethnicity, access-to-care, and other factors among adults was reported previously, indicating that vaccination coverage was suboptimal.^{1,20–26} However, trends of vaccination coverage in recent years and assessment of factors independently associated with vaccination using recent data are limited.^{1,20–26} The objective of this study is to examine the following questions using the 2010–2016 National Health Interview Survey (NHIS):

1. What was the influenza vaccination coverage among adult populations in the 2015–2016 season?
2. What are the coverage trends for recent years among people aged ≥ 18 , 18–49, 50–64, and ≥ 65 years, those with high-risk conditions, healthcare personnel (HCP), and pregnant women? Has vaccination coverage significantly increased or plateaued in recent years?
3. What kinds of factors are independently associated with vaccination in recent years among adults aged ≥ 18 years?

METHODS

Study Sample

Data from the 2010–2016 NHIS were analyzed in 2018. NHIS is a national cross-sectional household survey conducted by the U.S. Census Bureau for the Centers for Disease Control and Prevention's National Center for Health Statistics.²⁷ The survey samples civilian, non-institutionalized populations living in the U.S. at the time of the survey. Face-to-face interviews are conducted weekly throughout the year among a probability sample of U.S. households. Final response rates for the core survey sample of adults ranged from 54.3% in 2016 to 66.3% in 2011.^{28,29}

Measures

Seasonal influenza vaccination status was assessed by asking respondents whether they had received the influenza vaccine during the past 12 months, and in what month and year the vaccine was received. High-risk individuals were defined as individuals who self-reported one or more of the following: ever being told by a physician they had diabetes, emphysema, chronic obstructive pulmonary disease, coronary heart disease, angina, heart attack, or other heart condition; being diagnosed with cancer in the past 12 months (excluding nonmelanoma skin cancer) or ever being told by a physician they had lymphoma, leukemia, or blood cancer; during the past 12 months, being told by a

physician they had chronic bronchitis or weak or failing kidneys; or reporting an asthma episode or attack in the past 12 months.^{1,19,24} Information on chronic obstructive pulmonary disease was not collected in the NHIS during 2010–2011. People with those high-risk conditions are at increased risk for severe complications from influenza.^{1,19,24}

The sample of pregnant women for this analysis included female respondents aged 18–49 years who would have been pregnant at any time during August–March of each respective influenza season. HCP were defined as adults aged ≥ 18 years who reported they currently volunteered or worked in a hospital, medical clinic, doctor's office, dentist's office, nursing home, or some other healthcare facility, including part-time and unpaid work in a healthcare facility as well as professional nursing care provided in the home.

Statistical Analysis

Point estimates and 95% CIs were calculated using SUDAAN, version 11.0.1, a statistical tool for complex sample surveys. The sample population of this study was described. In bivariate analyses, influenza vaccination coverage among adults was stratified by demographic and access-to-care characteristics. To better assess influenza vaccination coverage for each season, analysis of season-specific coverage was restricted to individuals interviewed during August–June, and vaccinated during July–May, using the Kaplan–Meier survival analysis procedure. For example, respondents interviewed during August 2015–June 2016 were analyzed to estimate influenza vaccination received during July 2015–May 2016. For the Kaplan–Meier survival analysis, vaccination month is the time-to-event variable. The time-to-event variable was considered censored if a person was not vaccinated by the month of interview, or a person was vaccinated in the same month as interviewed. The time-to-event variable was considered not censored if a person was vaccinated in a month before the month of interview. The *t*-tests for linear trends in recent years were conducted for each group and for comparison between individuals with and without high-risk conditions. All analyses were weighted to reflect the age, sex, and race/ethnicity of the U.S. non-institutionalized civilian population. Multivariable logistic regression and predictive marginal models were used to generate adjusted vaccination coverage and prevalence ratios and identify variables independently associated with influenza vaccination. The variables selected in the model were covariates that may be associated with vaccination coverage empirically or based on previous studies.^{20–24} For multivariable logistic regression, the data were restricted to individuals interviewed during August 2015–June 2016, and the outcome variable was whether individuals received the influenza vaccine in the past 12 months. Overall, 8.1% of participants were missing from the logistic regression model. Interactions between race/ethnicity and other demographic and access-to-care characteristics were assessed. All tests were two-tailed with the significance level set at $\alpha < 0.05$.

In the 2010–2011 through 2015–2016 seasons, the NHIS analytic sample size ranged from 28,445 to 33,126 adults. Individuals who refused to answer the influenza vaccination question or did not know their vaccination status (about 1.6% annually) were excluded from the analysis. Vaccination month and year were imputed for individuals who reported they received vaccination but did not report their month and year of vaccination (about 3.8% annually).

RESULTS

Sample characteristics of the study population by age and high-risk status are given in [Table 1](#). During the 2010–2011 through 2015–2016 influenza seasons, the prevalence of high-risk conditions ranged from 13.0% to 14.0% and 30.8% to 31.9% for adults aged 18–49 years and 50–64 years, respectively. During the 2010–2011 through 2015–2016 influenza seasons, the proportion of people in the samples who were classified as HCP ranged from 8.1% to 8.7%. The proportion of pregnant women (aged 18–49 years) among the adult (aged ≥ 18 years) population was 2.0% for all assessed influenza seasons ([Table 1](#)).

Overall, influenza vaccination coverage among adults aged ≥ 18 , 18–64, and 18–49 years increased significantly from 38.3%, 31.7%, and 26.3%, respectively, in the 2010–2011 season to 43.4%, 36.8%, and 32.3%, respectively, in the 2015–2016 season, with respective annual average percentage point increases of 1.3%, 1.2%, and 1.4% (test for trend, $p < 0.05$) ([Table 2](#), [Appendix Figure 1](#), available online). Among adults aged ≥ 18 years, the annual average percentage point increases were 1.2% for non-Hispanic whites, 1.4% for non-Hispanic blacks, and 1.1% for Hispanics ([Table 2](#), [Appendix Figure 2](#), available online). Coverage for adults aged 50–64 and ≥ 65 years was stable (test for trend, $p > 0.05$).

Among adults with high-risk conditions, influenza vaccination coverage for adults aged 18–64, 18–49, and 50–64 years was stable during the 2010–2011 through 2015–2016 seasons (test for trend, $p > 0.05$) ([Table 2](#), [Appendix Figure 1](#), available online). Among adults without high-risk conditions, influenza vaccination coverage for adults aged 18–64 years and those aged 18–49 years significantly increased from 28.3% and 24.5%, respectively, in the 2010–2011 season to 34.1% and 31.6%, respectively, in the 2015–2016 season, with a respective annual average percentage point increase of 1.5% and 1.7% (test for trend, $p < 0.05$) ([Table 2](#), [Appendix Figure 1](#), available online). For all years, within each age group, vaccination coverage was significantly lower among those without high-risk conditions compared with those with high-risk conditions ([Table 2](#), [Appendix Figure 1](#), available online).

Influenza vaccination coverage for the 2015–2016 season was 64.8% for HCP and 50.3% for pregnant women ([Table 2](#)). Linear trends for both groups were not statistically significant ([Table 2](#), [Appendix Figure 1](#), available online). Among HCP, coverage increased from 55.9% in 2010–2011 to 61.6% in 2011–2012 and 66.9% in 2012–2013, and then ranged from 64.8% to 68.6% in subsequent seasons.

Influenza vaccination coverage for the 2015–2016 season by race and ethnicity, age group, and high-risk

status is shown in [Table 3](#). For the 2015–2016 season, vaccination coverage was significantly lower for non-Hispanic blacks compared with non-Hispanic whites among those aged ≥ 18 years (39.7% vs 46.1%, respectively) and ≥ 65 years (65.1% vs 72.0%, respectively) ([Table 3](#)). Coverage for the 2015–2016 season among adults aged 18–64 years with high-risk conditions was similar across racial/ethnic groups. Vaccination coverage was significantly lower for Hispanics compared with non-Hispanic whites in all age subgroups and among people who reported having no high-risk conditions ([Table 3](#)). For the 2015–2016 season, influenza vaccination coverage among HCP was significantly lower for non-Hispanic black HCP (56.7%) compared with non-Hispanic white HCP (66.7%) ([Table 3](#)). For the 2015–2016 season, influenza vaccination coverage among pregnant women was significantly lower for non-Hispanic black (31.3%) and Hispanic pregnant women (36.1%) compared with non-Hispanic white pregnant women (63.6%) ([Table 3](#)).

Three interactions, including race/ethnicity and age group, race/ethnicity and educational level, and race/ethnicity and the U.S.-born status, were significant in the multivariable logistic model. Multivariable analysis showed that when the three interactions were also adjusted in the model, characteristics independently associated with increased likelihood of vaccination among adults aged ≥ 18 years were Asian race (among those aged 18–64 years, those with less than college education, or those who were born in the U.S. or born outside of the U.S. and stayed in the U.S. ≥ 10 years), being married, not being employed, having at least one physician contact within the past year, being hospitalized in the past 12 months, having high-risk conditions, having a usual place for health care, having health insurance, and being an HCP ([Table 4](#)). Blacks and Hispanics were less likely to be vaccinated (among those aged ≥ 65 years, those with some college or college education, or those who were born in the U.S.) ([Table 4](#)).

DISCUSSION

Overall, influenza vaccination coverage among adults aged ≥ 18 years increased during the 2010–2016 seasons but was still below the national target of 70%.³⁰ Vaccination coverage varied widely by age, risk status, race/ethnicity, and HCP and pregnancy status. Vaccination coverage among all groups recommended for vaccination remains suboptimal, including HCP and pregnant women. Targeted efforts are needed to improve coverage and reduce disparities.

Table 1. Characteristics of Participants Aged ≥18 Years During the 2010–2011 Through 2015–2016 Influenza Seasons

Subgroup and age group (years)	Influenza season ^a					
	2010–2011, n (weighted %)	2011–2012, n (weighted %)	2012–2013, n (weighted %)	2013–2014, n (weighted %)	2014–2015, n (weighted %)	2015–2016, n (weighted %)
All participants, age, years						
≥18	28,445 (100.0)	30,194 (100.0)	31,077 (100.0)	33,126 (100.0)	32,790 (100.0)	29,345 (100.0)
18–64	22,574 (82.9)	23,835 (82.5)	24,233 (81.9)	25,555 (81.4)	24,839 (81.0)	21,602 (80.4)
18–49	15,635 (57.5)	16,094 (56.7)	16,268 (56.0)	17,008 (55.4)	16,385 (55.1)	14,021 (54.8)
50–64	6,939 (25.4)	7,741 (25.7)	7,965 (25.9)	8,547 (25.9)	8,454 (25.9)	7,581 (25.6)
≥65	5,871 (17.1)	6,359 (17.5)	6,844 (18.1)	7,571 (18.6)	7,951 (19.0)	7,743 (19.6)
Race/ethnicity (aged ≥18 years)						
Non-Hispanic white	16,568 (68.2)	17,954 (67.1)	18,542 (66.3)	20,321 (66.0)	20,368 (65.3)	19,406 (64.5)
Non-Hispanic black	4,351 (11.3)	4,430 (11.4)	4,510 (11.4)	4,562 (11.5)	4,310 (11.6)	3,472 (11.6)
Hispanic	5,163 (13.8)	5,327 (14.6)	5,406 (15.0)	5,490 (15.0)	5,489 (15.4)	4,044 (15.7)
Other	2,363 (6.6)	2,483 (6.9)	2,619 (7.3)	2,753 (7.4)	2,623 (7.7)	2,423 (8.2)
Person with high-risk conditions, ^b years						
18–64	4,478 (19.5)	4,704 (19.1)	4,853 (18.9)	5,175 (19.0)	5,021 (18.9)	4,389 (18.9)
18–49	2,178 (14.0)	2,184 (13.6)	2,264 (13.4)	2,352 (13.5)	2,257 (13.0)	1,927 (13.0)
50–64	2,300 (31.9)	2,520 (31.3)	2,589 (30.8)	2,823 (30.9)	2,764 (31.3)	2,462 (31.4)
Healthcare personnel (≥18 years) ^c	2,300 (8.2) ^d	2,541 (8.5) ^d	2,597 (8.7) ^d	2,651 (8.2) ^d	2,646 (8.4) ^d	2,458 (8.1) ^d
Pregnant women (18–49 years) ^e	NA	NA	697 (2.0) ^f	712 (2.0) ^f	655 (2.0) ^f	559 (2.0) ^f

^aEstimates are based on interviews conducted during August–June for each influenza season (e.g., the 2010–2011 season included persons interviewed from August 2010 through June 2011, and vaccination received during July 2010–May 2011).

^bAdults categorized as being at high risk for influenza-related complications reported one or more of the following: (1) ever being told by a physician that they had diabetes, emphysema, chronic obstructive pulmonary disease (starting from the 2012–2013 season), coronary heart disease, angina, heart attack, or another heart condition; (2) receiving a diagnosis of cancer during the preceding 12 months (excluding nonmelanoma skin cancer) or ever being told by a physician that they had lymphoma, leukemia, or blood cancer; (3) being told by a physician that they had chronic bronchitis or weak or failing kidneys during the preceding 12 months; or (4) reporting an asthma episode or attack during the preceding 12 months. In addition, the weighted percentage is prevalence of high-risk conditions by age groups.

^cAdults were classified as healthcare personnel if they reported that they currently volunteer or work in a hospital, medical clinic, doctor's office, dentist's office, nursing home, or some other healthcare facility, including part-time and unpaid work in a healthcare facility as well as professional nursing care provided in the home.

^dPercentage of adults aged ≥18 years who were healthcare personnel.

^eAdult women were classified as pregnant if they reported they were pregnant anytime during August through March for each influenza season. Data were not available for the 2010–2011 and 2011–2012 influenza seasons.

^fPercentage of pregnant women among adults aged ≥18 years.

NA, not available.

Table 2. Influenza Vaccination Coverage Among Adults Aged ≥18 Years During the 2010–2011 Through 2015–2016 Influenza Seasons

Subgroup and age group (years)	Influenza season ^a						Total change % ^b	Average annual change % ^c
	2010–2011, % (95% CI)	2011–2012, % (95% CI)	2012–2013, % (95% CI)	2013–2014, % (95% CI)	2014–2015, % (95% CI)	2015–2016, % (95% CI)		
All participants, age, years								
≥18	38.3 (37.4, 39.2)	39.4 (38.5, 40.3)	42.6^d (41.6, 43.7)	42.9 (41.8, 44.1)	44.6^d (43.6, 45.7)	43.4 (42.3, 44.6)	5.1	1.3^e
18–64	31.7 (30.7, 32.6)	32.7 (31.8, 33.7)	36.1^d (34.9, 37.2)	36.5 (35.3, 37.7)	37.7 (36.6, 38.8)	36.8 (35.5, 38.1)	5.1	1.2^e
18–49	26.3 (25.2, 27.4)	27.3 (26.2, 28.4)	30.5^d (29.2, 31.9)	31.3 (29.9, 32.8)	32.5 (31.1, 34.0)	32.3 (30.7, 33.9)	6.0	1.4^e
50–64	43.8 (42.2, 45.4)	44.8 (42.9, 46.7)	48.0^d (46.1, 50.0)	47.7 (45.7, 49.7)	48.7 (46.6, 50.8)	46.4 (44.4, 48.4)	2.6	0.7
≥65	70.4 (68.5, 72.3)	70.2 (68.3, 72.1)	71.6 (69.6, 73.7)	71.5 (69.6, 73.3)	73.5 (71.7, 75.2)	70.4^d (68.6, 72.2)	0.0	0.3
Race/ethnicity (aged ≥18 years)								
Non-Hispanic white	41.1 (40.0, 42.3)	42.5 (41.3, 43.7)	46.5^d (45.2, 47.8)	46.4 (45.0, 47.9)	48.2 (46.9, 49.5)	46.1^d (44.9, 47.4)	5.0	1.2^e
Non-Hispanic black	32.4 (29.8, 35.1)	34.1 (31.9, 36.5)	33.5 (30.8, 36.3)	36.5 (34.2, 38.9)	37.7 (35.2, 40.3)	39.7 (36.4, 43.2)	7.3	1.4^e
Hispanic	29.3 (27.5, 31.2)	28.5 (26.3, 30.9)	30.5 (28.4, 32.8)	32.9 (30.6, 35.4)	33.3 (31.2, 35.5)	33.2 (30.1, 36.6)	3.9	1.1^e
Other	37.8 (34.3, 41.5)	40.9 (38.1, 43.8)	46.7^d (43.6, 50.0)	42.6 (39.0, 46.4)	47.3 (43.6, 51.2)	46.7 (42.6, 51.0)	8.9	1.8
Person with high-risk conditions, ^g years								
18–64	45.8^f (43.3, 48.4)	45.1^f (42.8, 47.5)	49.5^{d,f} (47.2, 51.9)	47.2^f (44.9, 49.6)	46.0^f (43.5, 48.5)	47.9^f (45.2, 50.7)	2.1	0.3
18–49	36.9^f (33.5, 40.5)	36.5^f (33.1, 40.2)	39.0^f (35.8, 42.4)	37.5^f (34.2, 41.1)	35.8^f (32.6, 39.1)	36.8^f (33.2, 40.6)	−0.1	−0.1
50–64	54.6^f (51.2, 58.1)	53.6^f (50.6, 56.7)	59.3^{d,f} (55.8, 62.8)	56.7^f (53.7, 59.7)	55.0^f (51.3, 58.8)	57.4^f (53.7, 61.1)	2.8	0.5
Person without high-risk conditions, years								
18–64	28.3 (27.3, 29.3)	29.8^d (28.8, 30.9)	32.9^d (31.6, 34.2)	33.9 (32.6, 35.3)	35.8^d (34.6, 37.0)	34.1 (32.7, 35.6)	5.8	1.5^e
18–49	24.5 (23.5, 25.6)	25.8 (24.7, 27.0)	29.2^d (27.8, 30.7)	30.3 (28.8, 31.9)	32.1 (30.6, 33.6)	31.6 (29.9, 33.3)	7.1	1.7^e
50–64	38.8 (36.9, 40.7)	40.8 (38.4, 43.2)	42.8 (40.5, 45.2)	43.7 (41.3, 46.0)	45.8 (43.3, 48.4)	41.1^d (38.7, 43.5)	2.3	0.8
Healthcare personnel (≥18 years) ^h	55.9 (52.8, 59.0)	61.6^d (58.5, 64.7)	66.9^d (63.4, 70.3)	64.9 (60.5, 69.3)	68.6 (65.0, 72.2)	64.8 (61.2, 68.4)	8.9	1.9
Pregnant women (18–49 years) ⁱ	NA	NA	40.4 (34.0, 47.4)	45.4 (38.5, 52.8)	43.1 (36.0, 51.0)	50.3 (41.9, 59.3)	9.9	2.6

Note: Boldface indicates statistical significance ($p < 0.05$).

^aEstimates are based on interviews conducted during August–June for each influenza season (e.g., the 2010–2011 season included persons interviewed from August 2010 through June 2011, and vaccination received during July 2010–May 2011).

^bTotal change from the 2010–2011 season to the 2015–2016 season. Change from the 2012–2013 to 2015–2016 seasons for pregnant women (data were not available before the 2012–2013 season).

^cAverage annual change from the 2010–2011 season to the 2015–2016 season, estimated by weighted linear regression. Change from the 2012–2013 to 2015–2016 seasons for pregnant women (data were not available before the 2012–2013 season).

^d $p < 0.05$ for comparison with the previous season (t-test for comparison between two seasons, with the prior season as the reference group—for example, 2011–2012 vs 2010–2011, 2012–2013 vs 2011–2012, 2013–2014 vs 2012–2013, 2014–2015 vs 2013–2014, and 2015–2016 vs 2014–2015).

^e $p < 0.05$ for overall trend (linear trend test for trend from the 2010–2011 season through the 2015–2016 season).

^f $p < 0.05$ for comparison between high-risk and low-risk participants (t-test for comparison between persons with high-risk conditions and persons without high-risk conditions within the same age group in each season).

^gAdults categorized as being at high risk for influenza-related complications reported one or more of the following: (1) ever being told by a physician that they had diabetes, emphysema, chronic obstructive pulmonary disease (starting from the 2012–2013 season), coronary heart disease, angina, heart attack, or another heart condition; (2) receiving a diagnosis of cancer during the preceding 12 months (excluding nonmelanoma skin cancer) or ever being told by a physician that they had lymphoma, leukemia, or blood cancer; (3) being told by a physician that they had chronic bronchitis or weak or failing kidneys during the preceding 12 months; or (4) reporting an asthma episode or attack during the preceding 12 months.

^hAdults were classified as healthcare personnel if they reported that they currently volunteer or work in a hospital, medical clinic, doctor's office, dentist's office, nursing home or some other healthcare facility including part-time and unpaid work in a healthcare facility as well as professional nursing care provided in the home.

ⁱAdult women were classified as pregnant if they reported they were pregnant anytime during August through March for each influenza season. Data were not available for 2010–2011 and 2011–2012 influenza seasons.

NA, not available.

Table 3. Influenza Vaccination Coverage Among Adults ≥18 Years During the 2015–2016 Influenza Season, by Race/Ethnicity^a

Subgroup and age group (years)	Race/Ethnicity			
	Non-Hispanic white, % (95% CI)	Non-Hispanic black, % (95% CI)	Hispanics, % (95% CI)	Other, ^b % (95% CI)
All participants, age, years				
≥18	46.1 (44.9, 47.4)	39.7^c (36.4, 43.2)	33.2^c (30.1, 36.6)	46.7 (42.6, 51.0)
18–64	38.2 (36.7, 39.7)	35.3 (31.7, 39.1)	30.1^c (26.9, 33.7)	42.3 (37.9, 47.1)
18–49	33.3 (31.4, 35.2)	31.3 (27.0, 36.1)	27.5^c (23.7, 31.9)	37.0 (32.5, 41.9)
50–64	46.7 (44.6, 48.9)	44.7 (39.0, 50.7)	39.7^c (33.8, 46.2)	56.4^c (47.7, 65.4)
≥65	72.0 (69.9, 74.0)	65.1^c (59.2, 70.9)	60.0^c (52.3, 67.8)	74.2 (66.2, 81.5)
Person with high-risk condition, ^d years				
18–64	47.8 (44.7, 51.1)	48.8 (41.8, 56.4)	46.3 (39.1, 54.2)	50.6 (40.0, 62.1)
18–49	37.8 (33.6, 42.4)	39.5 (29.7, 51.1)	33.1 (23.3, 45.5)	34.9 (24.5, 48.1)
50–64	55.6 (51.2, 60.0)	57.3 (47.2, 67.8)	60.6 (50.7, 70.6)	67.4 (51.8, 82.2)
Person without high-risk condition, years				
18–64	35.8 (34.1, 37.5)	31.7 (27.9, 35.9)	27.0^c (23.3, 31.2)	40.3 (35.9, 45.1)
18–49	32.6 (30.5, 34.7)	30.1 (25.6, 35.3)	26.9^c (22.8, 31.5)	37.2 (32.4, 42.3)
50–64	42.8 (40.2, 45.4)	36.8 (30.0, 44.5)	27.3^c (21.1, 35.0)	51.0 (40.9, 62.0)
Healthcare personnel (≥18 years) ^e	66.7 (62.7, 70.6)	56.7^c (47.8, 66.0)	59.4 (47.4, 71.8)	70.9 (56.4, 84.0)
Pregnant women (18–49 years) ^f	63.6 (52.0, 75.0)	31.3^c (17.0, 53.0)	36.1^c (21.0, 57.4)	42.5 (22.2, 70.4)

Note: Boldface indicates statistical significance ($p < 0.05$).

^aEstimates are based on interviews conducted during August 2015 – June 2016 and vaccination received during July 2015–May 2016.

^bIncluded Asian, American Indian/Alaska Native, and multiple races.

^c $p < 0.05$ for race/ethnicity (t -test for comparison with non-Hispanic whites).

^dAdults categorized as being at high risk for influenza-related complications reported one or more of the following: (1) ever being told by a physician that they had diabetes, emphysema, chronic obstructive pulmonary disease (starting from the 2012–2013 season), coronary heart disease, angina, heart attack, or another heart condition; (2) receiving a diagnosis of cancer during the preceding 12 months (excluding nonmelanoma skin cancer) or ever being told by a physician that they had lymphoma, leukemia, or blood cancer; (3) being told by a physician that they had chronic bronchitis or weak or failing kidneys during the preceding 12 months; or (4) reporting an asthma episode or attack during the preceding 12 months.

^eAdults were classified as healthcare personnel if they reported they currently volunteer or work in a hospital, medical clinic, doctor's office, dentist's office, nursing home or some other healthcare facility including part-time and unpaid work in a healthcare facility as well as professional nursing care provided in the home.

^fAdult women were classified as pregnant if they reported they were pregnant anytime during August through March.

Table 4. Multivariable Logistic Regression Analyses of Persons ≥18 Years Who Received Influenza Vaccination, 2015–2016 Influenza Season

Characteristic	Adjusted coverage, % (95% CI) ^a	Prevalence ratio, (95% CI) ^b
Age and race/ethnicity		
18–49 years		
Non-Hispanic white	34.0 (32.4, 35.6)	ref
Non-Hispanic black	33.7 (30.6, 37.0)	0.99 (0.90, 1.10)
Hispanic	34.1 (31.2, 37.1)	1.00 (0.91, 1.10)
Asian	47.8 (41.5, 54.1)	1.40 (1.22, 1.62)^c
Other	32.8 (27.0, 39.3)	0.97 (0.79, 1.17)
50–64 years		
Non-Hispanic white	42.1 (40.2, 44.0)	ref
Non-Hispanic black	38.4 (34.1, 42.9)	0.91 (0.81, 1.03)
Hispanic	38.9 (34.3, 43.7)	0.92 (0.82, 1.05)
Asian	53.7 (44.4, 62.7)	1.28 (1.07, 1.53)^c
Other	52.3 (42.2, 62.2)	1.24 (1.02, 1.52)
≥65 years		
Non-Hispanic white	59.5 (57.3, 61.6)	ref
Non-Hispanic black	53.4 (48.5, 58.1)	0.90 (0.82, 0.98)^c

(continued on next page)

Table 4. Multivariable Logistic Regression Analyses of Persons ≥ 18 Years Who Received Influenza Vaccination, 2015–2016 Influenza Season (continued)

Characteristic	Adjusted coverage, % (95% CI) ^a	Prevalence ratio, (95% CI) ^b
Hispanic	49.4 (43.8, 54.9)	0.83 (0.74, 0.93)^c
Asian	64.7 (55.9, 72.7)	1.09 (0.95, 1.25)
Other	59.3 (47.6, 69.9)	1.00 (0.82, 1.21)
Sex		
Male	42.0 (40.8, 43.2)	0.99 (0.96, 1.03)
Female	42.2 (41.1, 43.4)	ref
Marital status		
Married	44.3 (43.1, 45.4)	1.14 (1.09, 1.20)^c
Widowed/divorced/separated	40.8 (39.2, 42.4)	1.05 (1.00, 1.12)
Never married	38.7 (37.1, 40.4)	ref
Education and race/ethnicity		
High school or less		
Non-Hispanic white	37.4 (35.7, 39.1)	ref
Non-Hispanic black	36.6 (33.2, 40.1)	0.98 (0.88, 1.08)
Hispanic	38.9 (35.8, 42.0)	1.04 (0.95, 1.14)
Asian	49.0 (40.5, 57.5)	1.31 (1.09, 1.57)^c
Other	37.8 (30.5, 45.7)	1.01 (0.82, 1.24)
Some college or college graduate		
Non-Hispanic white	41.4 (40.0, 42.8)	ref
Non-Hispanic black	38.0 (34.9, 41.1)	0.92 (0.84, 1.00)^c
Hispanic	37.3 (33.9, 40.8)	0.90 (0.82, 0.99)^c
Asian	54.4 (48.7, 60.1)	1.31 (1.18, 1.47)^c
Other	47.5 (40.8, 54.3)	1.15 (0.99, 1.33)
Above college graduate		
Non-Hispanic white	52.1 (49.6, 54.6)	ref
Non-Hispanic black	50.2 (42.9, 57.4)	0.96 (0.83, 1.12)
Hispanic	42.8 (34.4, 51.5)	0.82 (0.67, 1.01)^c
Asian	54.9 (47.1, 62.5)	1.05 (0.91, 1.22)
Other	42.4 (30.2, 55.5)	0.81 (0.59, 1.11)
Employment status		
Employed	40.6 (39.5, 41.7)	ref
Not employed	44.5 (43.1, 45.9)	1.10 (1.05, 1.14)^c
Poverty level		
At or above poverty	42.3 (41.3, 43.3)	1.04 (0.99, 1.10)
Below poverty	40.7 (38.6, 42.7)	ref
Region		
Northeast	42.9 (40.7, 45.2)	ref
Midwest	41.7 (40.2, 43.2)	0.97 (0.91, 1.03)
South	41.8 (40.4, 43.3)	0.97 (0.92, 1.03)
West	42.3 (40.7, 44.0)	0.99 (0.93, 1.05)
U.S.-born status and race/ethnicity		
U.S. born		
Non-Hispanic white	42.7 (41.7, 43.8)	ref
Non-Hispanic black	38.0 (35.7, 40.3)	0.89 (0.83, 0.95)^c
Hispanic	38.6 (35.8, 41.6)	0.90 (0.84, 0.98)^c
Asian	53.7 (46.9, 60.3)	1.26 (1.11, 1.43)^c
Other	41.8 (36.8, 47.0)	0.98 (0.86, 1.11)
Born outside U.S.—in U.S. <10 years		
Non-Hispanic white	31.8 (21.7, 43.9)	ref

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Table 4. Multivariable Logistic Regression Analyses of Persons ≥ 18 Years Who Received Influenza Vaccination, 2015–2016 Influenza Season (continued)

Characteristic	Adjusted coverage, % (95% CI) ^a	Prevalence ratio, (95% CI) ^b
Non-Hispanic black	53.1 (42.2, 63.7)	1.67 (1.11, 2.52)^c
Hispanic	39.1 (31.9, 46.8)	1.23 (0.82, 1.84)
Asian	41.9 (34.8, 49.4)	1.32 (0.88, 1.98)
Other	43.2 (19.2, 70.9)	1.36 (0.64, 2.87)
Born outside U.S.–in U.S. ≥ 10 years		
Non-Hispanic white	34.9 (30.4, 39.7)	ref
Non-Hispanic black	41.8 (33.2, 50.9)	1.20 (0.93, 1.54)
Hispanic	37.9 (34.6, 41.3)	1.09 (0.93, 1.27)
Asian	48.4 (43.7, 53.1)	1.39 (1.18, 1.63)^c
Other	52.3 (37.0, 67.1)	1.50 (1.09, 2.06)^c
Physician contacts within past year		
None	28.9 (26.9, 31.1)	ref
1	37.2 (35.4, 39.0)	1.28 (1.18, 1.40)^c
2–3	43.3 (41.8, 44.8)	1.50 (1.38, 1.62)^c
4–9	47.3 (45.6, 49.0)	1.63 (1.50, 1.78)^c
≥ 10	50.1 (47.9, 52.4)	1.73 (1.58, 1.89)^c
Hospitalization within past year		
Yes	46.9 (44.4, 49.3)	1.13 (1.06, 1.19)^c
No	41.6 (40.7, 42.6)	ref
Usual place for health care		
Yes	43.3 (42.3, 44.2)	1.37 (1.26, 1.48)^c
No	31.7 (29.2, 34.3)	ref
Health insurance		
Yes	43.0 (42.0, 43.9)	1.39 (1.27, 1.53)^c
No	30.9 (28.1, 33.8)	ref
Healthcare personnel		
Yes	65.1 (62.5, 67.7)	1.63 (1.56, 1.70)^c
No	39.9 (39.0, 40.8)	ref
Person with high-risk conditions ^d		
Yes	46.3 (44.7, 47.9)	1.14 (1.09, 1.18)^c
No	40.7 (39.7, 41.7)	ref

Note: Boldface indicates statistical significance ($p < 0.05$).

^aAdjusted coverage, adjusted for all variables included in the table and interactions including age groups and race/ethnicity, education and race/ethnicity, and the U.S.-born status and race/ethnicity.

^bAdjusted prevalence ratios, adjusted for all variables included in the table and interactions including age groups and race/ethnicity, education and race/ethnicity, and U.S.-born status and race/ethnicity.

^c $p < 0.05$ by *t*-test for comparison within each covariate category with the indicated reference level.

^dAdults categorized as being at high risk for influenza-related complications reported one or more of the following: (1) ever being told by a physician that they had diabetes, emphysema, chronic obstructive pulmonary disease (starting from the 2012–2013 season), coronary heart disease, angina, heart attack, or another heart condition; (2) receiving a diagnosis of cancer during the preceding 12 months (excluding nonmelanoma skin cancer) or ever being told by a physician that they had lymphoma, leukemia, or blood cancer; (3) being told by a physician that they had chronic bronchitis or weak or failing kidneys during the preceding 12 months; or (4) reporting an asthma episode or attack during the preceding 12 months.

By the 2015–2016 season (five seasons after annual influenza vaccination was recommended for all adults), vaccination coverage among adults aged ≥ 18 years was 43.4%, with vaccination coverage estimates steadily increasing from the 2010–2011 through the 2015–2016 seasons. Vaccination coverage also increased steadily during 2010–2011 through 2015–2016 among healthy adults (those without high-risk conditions) aged 18–49 years, with an annual average increase of 1.7 percentage points.

In 2010, healthy adults aged 18–49 years were included for the first time among those for whom annual vaccination is recommended by the Advisory Committee on Immunization Practices.¹ This group was added given the substantial morbidity and economic impact of influenza in working-age adults.^{5,6,12} Previous studies indicated that higher vaccination coverage could have prevented a substantial number of influenza cases and hospitalizations.^{31,32}

Influenza vaccination coverage among adults aged 18–64 years with high-risk conditions remains suboptimal. In 2015–2016, only 47.9% had received the vaccination, and vaccination coverage did not significantly increase during the 2010–2011 through 2015–2016 influenza seasons. There may be several factors associated with lower influenza vaccination coverage among adults with high-risk conditions. There might not be a pre-existing relationship between state immunization programs and providers who serve adults at high risk. People with underlying health conditions might not consider themselves as high risk, limiting the effectiveness of targeted messages. Finally, many people with high-risk conditions see subspecialists, but subspecialists are less likely to recommend influenza vaccination than general practitioners.^{20,33–35} In addition, one previous study showed that 90% of unvaccinated high-risk individuals may have missed at least one potential opportunity for receiving vaccination,³⁶ which could result in lower vaccination coverage and put those unvaccinated individuals at risk.^{25,36} Even though the influenza vaccination recommendation was expanded to include all individuals aged ≥ 6 months in the 2010–2011 season, the Advisory Committee on Immunization Practices continued to emphasize that people with high-risk conditions should be a focus of vaccination efforts.¹

This study showed that vaccination coverage for adults aged ≥ 65 years has plateaued in recent years. The lack of change in influenza vaccination coverage in this age group indicates that new approaches are needed to increase influenza vaccination. One study indicated that adults aged ≥ 65 years are more likely to receive their influenza vaccination in a clinical setting than younger adults.³⁷ An increase in vaccination in alternative settings (e.g., community immunizers, health department clinics, pharmacies, and educational settings) may help improve influenza vaccination; however, individuals must be motivated to seek out vaccination. A provider's recommendation remains one of the most important determinants of vaccination. However, one recent study indicated that only about 51% of adults aged ≥ 65 years received a vaccination recommendation from a provider.³⁸ Adults aged ≥ 65 years are likely to be at highest risk of influenza complications and more likely to have a chance to visit a doctor.¹

Findings from this study showed that for people aged ≥ 18 years, influenza vaccination among non-Hispanic whites, non-Hispanic blacks, Hispanics, and others significantly increased over these survey seasons, but in the 2015–2016 season, racial/ethnic disparities, especially vaccination differences between older Hispanics and non-Hispanic blacks compared with whites, remained. Racial/ethnic disparities in influenza vaccination have been described in previous studies.^{21,22,25,39} Multiple factors

likely contribute to racial and ethnic differences in adult vaccination, including differences in attitudes toward vaccination and preventive care, propensity to seek and accept vaccination, variations in the likelihood that providers recommend vaccination, differences in quality of care received by racial and ethnic populations, differences in access to health care, differences in concerns about vaccination including vaccine safety,^{21,22,25,39–42} and differences in perceived discrimination in the healthcare system.⁴³

Substantial improvement in annual influenza vaccination of adults is needed to maximally reduce the health impact of influenza. Primary care providers, subspecialists, and pharmacists should routinely recommend and offer vaccinations when all adult patients access the medical system.⁴⁴ Use of standing-order programs can help reduce the number of missed opportunities for vaccination of individuals who have already accessed the medical system and should be instituted in all healthcare settings, including inpatient and outpatient settings.⁴⁴ Incorporating the standards of practice for adult immunizations, which include routinely assessing vaccination needs during clinical encounters, providing a strong recommendation for vaccination to patients in need of vaccines, and then offering vaccination at the visit, can have a significant impact on coverage and reduce disparities.⁴⁴

In addition, several demographic and access-to-care characteristics such as employment, number of physician contacts in the past 12 months, hospitalization status, having high-risk conditions, having a usual place for health care, having health insurance, and being an HCP were independently associated with vaccination in this study, similar to findings from previous reports.^{36,38–41,44} Intervention programs should target groups where vaccination coverage was low.

Influenza vaccination coverage ranged from 56% to 69% among HCP over six seasons, and coverage among HCP was only 64.8% in 2015–2016, well below the *Healthy People 2020* target of 90%.³⁰ Employers and healthcare administrators should implement evidence-based interventions to increase influenza vaccination coverage among HCP, including onsite vaccination at no or low cost to HCP.^{45,46} The highest influenza vaccination coverage among HCP continues to be reported in work-sites with employer requirements for vaccination.⁴⁷ Such requirements could significantly improve influenza vaccination coverage among HCP.⁴⁶ Additional approaches include electronic tracking of coverage levels by ward, unit, and occupation; a mandatory declination policy; mask wearing for nonvaccinated HCP; highly visible acknowledgement of vaccinated HCP; weekly compliance reports to managers and other administrators; disciplinary measures for noncompliant HCP; vaccination stations at

facility entrances; and employee financial incentives for achieving high facility vaccination rates.^{45–48}

Vaccination could help protect pregnant women and also protect their baby for several months after birth.⁴⁹ However, only half of pregnant women reported receiving influenza vaccination during the 2015–2016 season. Pregnant women's low awareness of their increased risk for complications from influenza infection and misconceptions about vaccination safety and effectiveness have been reported as barriers to vaccination uptake.^{50–52} Lower coverage among non-Hispanic black or Hispanic women compared with white women might be partly because of differences in socioeconomic norms and differences in access to vaccines and healthcare services.^{50,52,53} Provider recommendations and offers of vaccination have been reported as the strongest predictor for vaccination acceptance among pregnant women.⁴⁸ Positive attitudes toward and advocacy of influenza vaccination among physicians may facilitate counseling, discussion, and recommendation of vaccination to pregnant women and help increase vaccination acceptance and uptake.⁵⁴

In the 2015–2016 season, coverage from NHIS (43.0% for adults aged ≥ 18 years, 64.8% for HCP, and 50.3% for pregnant women) differed from other estimates based on surveys including the Behavioral Risk Factor Surveillance System (41.7% for adults aged ≥ 18 years), and internet panel surveys for pregnant women (49.9%) and HCP (79.0%).²⁹ Differences in estimates across these surveys might be because of different sampling frame, survey mode, survey questions, order of survey questions, operations, response rates, and weighting.⁵⁵

Limitations

Several limitations should be considered in interpreting these results. First, information on influenza vaccination was self-reported and may be subject to recall bias. However, self-reported seasonal influenza vaccination status has been shown to have relatively high agreement with vaccination status ascertained from medical records.^{56–59} Second, high-risk conditions were self-reported and not validated by medical records. Third, the analyses in this study generated results that are associative and not causal. Fourth, the sampling redesign of the 2016 NHIS may have an impact on influenza vaccination coverage estimates. Finally, other factors associated with vaccination were not measured by NHIS (e.g., concerns of vaccine safety or effectiveness) and could not be ascertained in this analysis.

CONCLUSIONS

Influenza vaccination coverage among people aged ≥ 18 years, HCP, and pregnant women remains suboptimal.

Vaccination coverage varies by age, risk status, race/ethnicity, and HCP and pregnancy status. Substantial improvement in annual influenza vaccination is needed to maximally reduce the health impact of influenza. Expanded access through greater use of complementary settings and vaccine providers,⁴⁴ and better use of evidence-based practices at medical sites (e.g., standing orders, and reminder/recall notification), are important to improve influenza vaccination coverage further.⁴⁶

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SUPPLEMENTAL MATERIAL

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