

Influenza Vaccination Coverage Among Pregnant Women in the U.S., 2012–2015



Helen Ding, MD, MSPH,¹ Katherine E. Kahn, MPH,² Carla L. Black, PhD,³ Alissa O'Halloran, MSPH,⁴ Peng-Jun Lu, MD, PhD,³ Walter W. Williams, MD, MPH³

Introduction: Pregnant women are at increased risk for severe illness from influenza and influenza-related complications. Vaccinating pregnant women is the primary strategy to protect them and their infants from influenza. This study aims to assess influenza vaccination coverage during three influenza seasons (2012–2015) from a national probability-based sampling survey and evaluate potential factors that influence vaccination uptake among pregnant women.

Methods: Data from the 2012 through 2015 National Health Interview Surveys were analyzed in 2017. Pregnant women aged 18–49 years were included in the analysis. The Kaplan–Meier survival analysis procedure was used for vaccination coverage in each season. Bivariate and multivariable logistic regression analyses were performed to examine factors associated with vaccination. Adjusted vaccination coverage and adjusted prevalence ratios are reported with corresponding 95% CIs.

Results: In the 2012–2013, 2013–2014, and 2014–2015 influenza seasons, 40.4%, 45.4%, and 43.1% of pregnant women were vaccinated, respectively. Multivariable analysis indicated that factors independently associated with a lower likelihood of vaccination included having only a high school education, having three or less provider visits, and having no usual place of care ($p < 0.05$). Less than half of women with ten or more visits were vaccinated (48.6%).

Conclusions: Vaccination coverage among pregnant women from this nationally representative sample was suboptimal during recent influenza seasons. Vaccination coverage was lower among certain sociodemographic, access-to-care subgroups. Multifactorial vaccination barriers may exist. Interventions, such as assessing vaccination history at every visit and implementing reminder–recall systems, standing orders, and addressing vaccination hesitancy, are needed to increase vaccination uptake among pregnant women.

Am J Prev Med 2019;56(4):477–486. © 2018 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

INTRODUCTION

Pregnant women are at increased risk for influenza-related morbidity and mortality.^{1–3} Influenza vaccination among pregnant women can protect pregnant women and reduce their likelihood of influenza-related illness and hospitalization during pregnancy, and can also protect their infants, especially those aged less than 6 months who are too young to be vaccinated.^{4,5} The Centers for Disease Prevention and Control (CDC), the Advisory Committee on Immunization Practices, and the American College of Obstetricians and Gynecologists have recommended that women who

are or will be pregnant during influenza season receive an influenza vaccination, regardless of trimester.^{2,6}

From the ¹CFD Research Corporation, Huntsville, Alabama; ²Leidos Inc., Atlanta, Georgia; ³Immunization Service Division, Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia; and ⁴Influenza Division, Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

Address correspondence to: Helen Ding, MD, MSPH, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, 1600 Clifton Road, NE, Mail Stop A–19, Atlanta GA 30333. E-mail: hchding@gmail.com.

0749-3797/\$36.00

<https://doi.org/10.1016/j.amepre.2018.11.020>

Monitoring influenza vaccination coverage among pregnant women is not only important for immunization programs and policies, but also for monitoring progress toward the *Healthy People 2020* objective for vaccinating pregnant women.⁷ Despite the longstanding recommendation, reported influenza vaccination coverage among pregnant women has remained at approximately 50% since the 2010–2011 influenza season based on non-probability samples of pregnant women from Internet panel surveys.⁸ To obtain a nationally representative sample of pregnant women during the influenza season, in 2012 new questions about timing of pregnancy and timing of influenza vaccination were added to the National Health Interview Survey (NHIS). These new questions aim to capture all women pregnant during the influenza vaccination period and to ascertain whether vaccination was received before or during pregnancy. These new data allow the calculation of population-based estimates of season-specific influenza vaccination coverage among U.S. pregnant women.

This study aims to assess influenza vaccination coverage among pregnant women for the 2012–2013 through 2014–2015 influenza seasons using a probability-based national sample and to evaluate potential factors associated with vaccination uptake.

METHODS

NHIS data collected in 2012, 2013, 2014, and 2015 were analyzed in 2017. The NHIS is a large-scale annual household survey conducted by the U.S. Census Bureau for the National Center for Health Statistics, CDC, that collects health information on the U.S. civilian, non-institutionalized population through a multistage probability sampling design. Each year about 75,000–100,000 individuals were interviewed from 35,000 to 40,000 households. Details about NHIS methods have been published previously.^{9–11} The final response rates for the sample adult modules were 61.2% for 2012, 61.2% for 2013, 58.9% for 2014, and 55.2% for 2015.⁹ The NHIS data collected from August 2012 through July 2013 were combined to generate estimates for the 2012–2013 influenza season, data from August 2013 through July 2014 were combined to generate estimates for the 2013–2014 influenza season, and so on.

Study Sample

Pregnant women are a dynamic cohort. To select women pregnant during the influenza season, all female NHIS respondents aged 18–49 years were asked if they were pregnant at the time of interview; if not, they were asked if they had been pregnant any time since August (if interviewed August–March) or if they had been pregnant any time during August through March (if interviewed April–July). Women pregnant at the time of interview during April–July were also asked if they were pregnant at any time during August–March. The same questions were asked each year during 2012–2015. The pregnant women sample for this analysis included women pregnant at any time during August–March (the usual vaccination period) of each respective

influenza season (usually October through May; 2012–2013 $n=697$; 2013–2014 $n=712$; 2014–2015 $n=655$).

Measures

Influenza vaccination status was determined based on the following questions: *During the past 12 months, have you had a flu shot?*; *During what month and year did you receive your most recent seasonal flu shot?*; *During the past 12 months, have you had a seasonal flu vaccine that was sprayed in your nose?*; and *During what month and year did you receive your most recent seasonal flu vaccine that was sprayed in your nose?* Women who answered *yes* to any of the influenza vaccination questions and answered *yes* to any of the aforementioned pregnancy questions were asked if they received the vaccination before, during, or after their most recent pregnancy.

All potential factors (sociodemographic, access-to-care, and behavioral characteristics of pregnant women) that could be associated with influenza vaccination coverage were explored and included for bivariate and multivariable analysis. The factors were categorized into three domains: pregnant women themselves, healthcare providers, and health systems, as described previously.¹² In this study, factors in the pregnant women domain included age, race/ethnicity, education level, marital status, employment status, poverty level, high-risk conditions, and current cigarette use and alcohol use. NHIS did not collect data on provider recommendation and offer of influenza vaccination to pregnant women. For the provider domain factor, the number of provider visits was examined. U.S.-born status and having a usual source of care could be categorized as health system domain. The characteristic variables were categorized into subgroups to be consistent with previous literature for easy comparison.

Statistical Analysis

Kaplan–Meier survival analysis was used to determine cumulative influenza vaccination coverage before and during pregnancy among women pregnant anytime during August through March of each influenza season, by using interview data collected during the typical vaccination period (August through July). Using interviews from the typical vaccination period can generate more statistically stable estimates with less recall bias. The cumulative in-season monthly vaccination estimates are very useful for evaluation of vaccination safety and effectiveness and can help vaccine distribution and vaccination program planning, especially during an urgent public health response.¹³

In the Kaplan–Meier analysis, for women vaccinated before or during pregnancy in the month prior to the interview month, the time-to-event variable was defined as the vaccination month; for women not vaccinated before or during pregnancy at the time of interview, or vaccinated in the same month as the interview month, the time-to-event variable was defined as the interview month and the data on these women were treated as censored; for unvaccinated women whose pregnancy ended before the month of interview, the time-to-event variable was defined as the month when the pregnancy ended and the data on these women were treated as censored. Because information about pregnancy end date is not available in the NHIS, follow-up time for recently pregnant women who reported not having been vaccinated was estimated by assuming that the pregnancy ended at the midpoint between August 1 and the date of interview. Sensitivity analysis

was conducted using different ways to impute the pregnancy end date for the recently unvaccinated pregnant women; there was no significant variation of the final estimates from different imputation approaches. Women with missing vaccination status were excluded from the analysis ($\cong 1\%$). Month or year of vaccination were imputed ($<4\%$) if a woman reported being vaccinated but the date information was missing. This Kaplan–Meier method has been developed, validated, and used by CDC for season-specific estimates since the 2009–2010 influenza season.^{14–16}

Overall cumulative influenza vaccination coverage estimates and estimates by sociodemographic characteristics (age group, race/ethnicity, education, marital status, insurance coverage at interview, employment status, poverty level), influenza-related high-risk conditions, access-to-care (having a usual source of medical care, number of doctor visits in the past year), and behavioral characteristics (smoking status at interview and alcohol use during the past year) of the sampled pregnant women were calculated for each influenza season. Influenza vaccination coverage was compared between subgroups and the two estimates were significantly different if their 95% CIs did not overlap ($p < 0.05$).

To increase the sample size and power for analysis, data from the most recent two seasons (2013–2014 and 2014–2015) were combined for multivariable analysis. The logistic regression analysis was limited to women who were interviewed during October through July to account for censoring of women interviewed early in the vaccination period (August–September) who might have been vaccinated after the date of interview. Adjusted prevalence ratios (APRs) and 95% CIs were reported. The logistic regression approach may ignore the time-to-event and censoring characteristics of the influenza data. However, one study showed that the results based on a logistic regression model are similar compared with the results based on a Cox proportional hazard model, which could take into account the time-to-event and censoring issues.¹⁷ Using Cox proportional hazards model to assess factors associated with influenza vaccination is still under discussion in terms of model appropriation and results interpretation.

All analyses were weighted taking into account the complex survey design using SUDAAN, version 11.1. Analysis weights were adjusted for using partial months of the annual NHIS data and for combining multiple years of data. The use of public NHIS data does not require IRB approval.

RESULTS

In the 2014–2015 influenza season, the majority of the sampled women were aged 25–34 years (59.5%), were non-Hispanic white (53.3%), had more than a high school education (64.4%), were married (58.3%), had private or public health insurance (88.8%), were employed (52.7%), were living at or above the poverty level (72.6%), had no conditions other than pregnancy that put them at increased risk for complications from influenza (90.1%), had a usual place for health care (88.7%), had four or more visits to a doctor in the past year (64.8%), were nonsmokers (86.6%), were not alcohol users (75.3%), and were born in the U.S. (77.3%). The distributions of these characteristics were similar in

the 2012–2013, 2013–2014, and 2014–2015 influenza seasons (Table 1).

Overall vaccination coverage for the 2014–2015 influenza season was 43.1% (95% CI=36.0%, 51.0%), similar to the 2013–2014 (45.4%, 95% CI=38.5%, 52.8%) and 2012–2013 (40.4%, 95% CI=34.0%, 47.4%) seasons. Across all three seasons, vaccination coverage estimates were higher among women who had four to nine doctor visits in the past year or ten or more visits compared with women who did not visit a provider. However, in all seasons, even among women with ten or more visits, vaccination coverage only reached 47.7%–61.0% (Table 1).

In bivariate analysis of combined data from the 2013–2014 and 2014–2015 seasons, vaccination coverage estimates were higher among women aged 25–34 years (versus 18–24 years), women who were married (versus unmarried), women who were employed, women who were at or above poverty level, and women who had a usual source of care (Table 2). Vaccination coverage was lower among women who were non-Hispanic black (versus non-Hispanic white), women who had a high school education or less (versus more than a high school education), women who had public health insurance or no insurance (versus private insurance), women who had three or fewer provider visits (versus ten or more visits) and women who smoked cigarettes (versus nonsmokers). In multivariable analysis, being a high school graduate (versus more than high school: APR=0.51, 95% CI=0.35, 0.73) and having no provider visit (versus ten or more visits: APR=0.31, 95% CI=0.13, 0.71) or one to three visits (versus ten or more visits: APR=0.56, 95% CI=0.39, 0.81) in the past year were independently associated with lower vaccination coverage after adjusting for other characteristics in the model. Having a usual place of care (versus no usual source of care: APR=1.80, 95% CI=1.16, 2.80) was independently associated with higher vaccination coverage.

DISCUSSION

This is the first study to assess season-specific influenza vaccination coverage from the NHIS, a national population-based probability sampling survey, among women who were pregnant during the influenza season since the new questions on timing of vaccination and timing of pregnancy were added in 2012. An estimated 43.1% of U.S. pregnant women were vaccinated in the 2014–2015 influenza season, similar to the estimate in the 2013–2014 (45.4%) and 2012–2013 (40.4%) influenza seasons. Previously reported vaccination coverage estimates among women aged 18–44 years who were pregnant at interview during October through January were 48.7%, 46.4%, and 39.9% from the state-based Behavioral Risk Factor Surveillance System and were 50.3%, 52.2%, and 50.5%

Table 1. Characteristics of Pregnant Women and Their Cumulative Influenza Vaccination Coverage^a Before and During Pregnancy, U.S. – National Health Interview Survey, 2012–2015

Characteristics	2012–2013 influenza season		2013–2014 influenza season		2014–2015 influenza season	
	N (weighted %)	Vaccinated, weighted % (95% CI)	N (weighted %)	Vaccinated, weighted % (95% CI)	N (weighted %)	Vaccinated, weighted % (95% CI)
Overall	697 (100)	40.4 (34.0, 47.4)	712 (100)	45.4 (38.5, 52.8)	655 (100)	43.1 (36.0, 51.0)
Age, years						
18–24 ^b	211 (32.3)	35.1 (23.7, 50.0)	162 (26.3)	42.1 (26.9, 61.4)	154 (23.5)	33.9 (20.1, 53.4)
25–34	371 (52.8)	40.8 (33.0, 49.6)	416 (56.0)	47.6 (39.3, 56.7)	390 (59.5)	45.5 (38.0, 53.7)
35–49	115 (14.9)	50.8 (34.8, 69.2)	134 (17.7)	44.3 (27.4, 65.7)	111 (17.0)	62.8 (33.9, 90.6)
Race/ethnicity						
White, non-Hispanic ^b	322 (53.2)	44.6 (35.8, 54.5)	369 (56.7)	48.7 (39.4, 59.0)	349 (53.3)	47.4 (37.6, 58.4)
Black, non-Hispanic	117 (13.3)	29.4 (19.0, 43.7)	104 (13.7)	43.8 (22.5, 72.7)	106 (16.2)	36.2 (21.4, 56.6)
Hispanic	211 (27.7)	34.2 (23.0, 48.9)	167 (19.7)	40.4 (27.9, 55.9)	162 (24.7)	36.3 (25.5, 50.0)
Other, non-Hispanic	47 (5.9)	57.3 (37.2, 79.0)	72 (9.9)	41.6 (25.8, 62.1)	38 (5.8)	35.9 (15.7, 68.6)
Education						
< High school	117 (16.2)	40.1 (23.4, 62.7)	141 (17.8)	37.8 (23.5, 57.0)	98 (15.0)	35.0 (18.6, 59.4) ^c
High school	183 (24.6)	22.5 (15.2, 32.6)	154 (19.0)	23.1 (14.7, 35.4)	135 (20.6)	40.2 (16.9, 75.8) ^c
> High school ^b	396 (59.2)	47.4 (39.5, 56.1)	417 (63.2)	52.8 (44.0, 62.2)	421 (64.4)	48.2 (40.8, 56.2)
Married						
Yes	379 (59.5)	46.8 (38.9, 55.5)	409 (60.4)	49.7 (41.6, 58.5)	382 (58.3)	44.5 (37.0, 52.7)
No ^b	317 (40.5)	27.7 (20.1, 37.5)	303 (39.6)	39.2 (27.2, 54.2)	273 (41.7)	43.6 (29.4, 61.1)
Insurance coverage						
Private	302 (48.5)	51.7 (42.8, 61.3)	343 (51.4)	52.5 (43.6, 62.0)	333 (51.0)	49.4 (41.5, 58.0)
Public	282 (36.7)	33.1 (22.9, 46.3)	271 (35.7)	38.1 (26.4, 52.9)	247 (37.8)	33.3 (22.2, 48.0)
None ^b	111 (14.9)	22.6 (13.3, 36.8)	96 (13.0)	31.8 (16.0, 56.8) ^c	73 (11.2)	32.2 (17.3, 54.7)
Employment status ^d						
Yes	342 (50.2)	43.5 (34.4, 53.7)	374 (53.8)	49.5 (40.8, 58.8)	345 (52.7)	45.2 (36.9, 54.5)
No ^b	355 (49.9)	37.2 (28.5, 47.6)	338 (46.2)	40.1 (29.6, 52.5)	310 (47.3)	41.3 (30.2, 54.6)
Poverty level ^e						
At or above poverty	425 (73.1)	46.9 (39.1, 55.4)	477 (76.0)	49.5 (41.6, 58.0)	462 (72.6)	46.8 (38.6, 55.7)
Below poverty ^b	216 (26.9)	28.9 (17.4, 45.7)	215 (24.0)	36.7 (23.4, 54.4)	174 (27.4)	30.5 (21.2, 42.7)
High-risk condition ^f						
Yes	95 (11.8)	29.7 (18.0, 46.5)	85 (11.4)	47.9 (25.5, 76.5)	65 (9.9)	44.9 (26.5, 68.4)
No ^b	602 (88.2)	41.4 (34.6, 49.0)	627 (88.6)	45.5 (38.5, 53.2)	590 (90.1)	43.2 (35.9, 51.4)
Usual source of care ^g						
Yes	605 (86.1)	43.0 (35.7, 51.0)	625 (88.6)	48.2 (41.0, 56.0)	581 (88.7)	44.9 (26.5, 68.4)
No ^b	92 (13.9)	28.9 (18.5, 43.3)	87 (11.4)	19.5 (10.0, 35.9) ^c	74 (11.3)	43.2 (35.9, 51.4)

(continued on next page)

Table 1. Characteristics of Pregnant Women and Their Cumulative Influenza Vaccination Coverage^a Before and During Pregnancy, U.S. — National Health Interview Survey, 2012–2015 (continued)

Characteristics	2012–2013 influenza season		2013–2014 influenza season		2014–2015 influenza season	
	N (weighted %)	Vaccinated, weighted % (95% CI)	N (weighted %)	Vaccinated, weighted % (95% CI)	N (weighted %)	Vaccinated, weighted % (95% CI)
Number of doctor visits in past year ⁿ						
0 ^b	45 (4.9)	14.1 (6.3, 30.2) ^c	48 (5.6)	5.2 (1.9, 14.3) ^c	41.0 (6.3)	9.8 (2.9, 30.0) ^c
1–3	113 (16.2)	29.7 (13.8, 56.6) ^c	155 (22.0)	30.4 (17.3, 49.9)	189 (28.9)	31.0 (22.2, 42.2)
4–9	208 (31.5)	41.0 (29.5, 54.9)	208 (27.7)	44.3 (33.0, 57.4)	144 (22.0)	50.5 (35.3, 68.0)
≥10	330 (47.4)	47.7 (38.9, 57.4)	296 (44.6)	61.0 (49.1, 73.0)	280 (42.8)	48.6 (39.6, 58.5)
Current cigarette use						
Yes	106 (14.5)	47.0 (23.0, 78.5) ^c	101 (13.3)	27.2 (15.3, 45.3)	88 (13.4)	23.0 (12.1, 40.9) ^c
No ^b	591 (85.5)	40.8 (34.4, 47.9)	610 (86.7)	47.7 (40.4, 55.7)	567 (86.6)	45.3 (37.9, 53.4)
Alcohol use ^l						
Yes	108 (17.5)	45.6 (29.1, 66.0)	127 (21.3)	44.9 (31.0, 61.6)	124 (24.7)	38.3 (26.7, 52.8)
No ^b	520 (82.5)	36.7 (29.9, 44.4)	509 (78.7)	46.1 (37.9, 55.2)	456 (75.3)	40.6 (32.0, 50.5)
U.S. born						
Yes	529 (79.1)	41.6 (34.2, 49.9)	556 (81.0)	47.3 (39.2, 56.1)	506 (77.3)	44.1 (35.8, 53.4)
No ^b	168 (20.9)	37.4 (25.5, 52.4)	155 (19.0)	38.3 (26.6, 53.0)	149 (22.8)	39.2 (26.8, 54.8)

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

^aCumulative vaccination coverage through March from Kaplan–Meier analysis (assuming the pregnancy ended mid-point of August through the month of interview for recently pregnant women [not pregnant at interview but reported being pregnant any time since August] who were unvaccinated at time of interview). Vaccination coverage estimates were weighted.

^bReference group for comparing estimates between subgroup categories.

^cEstimate may not be reliable due to relative SE > 0.3.

^dEmployment status “yes” includes those working for pay at a job or business, having a job or business but not at work, or working but not for pay at a family-owned job or business. Employment status “no” includes those looking for work or not working at a job or business and not looking for work.

^ePoverty thresholds for each NHIS survey year were estimated using the most recently available average Census poverty thresholds, average Consumer Price Index from 2 years prior, actual Consumer Price Index values for January–July of the prior year, and Projected Consumer Price Index values for August–December of the prior year. Poverty status was defined as a total income of \$23,000, \$24,000, \$25,000, and \$24,000 for a family of four in 2012, 2013, 2014, and 2015, respectively. More information available at [ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2012/srvydesc.pdf](http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2012/srvydesc.pdf); [ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2013/srvydesc.pdf](http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2013/srvydesc.pdf); [ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2014/srvydesc.pdf](http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2014/srvydesc.pdf); and [ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf](http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf).

^fWomen were considered at high risk for influenza-related complications if they self-reported one or more of the following in addition to pregnancy: ever being told by a physician they had diabetes, emphysema, chronic obstructive pulmonary disease (COPD), coronary heart disease, angina, heart attack or other heart condition; being diagnosed with cancer in the past 12 months (excluding non-melanoma skin cancer) or ever being told by a physician they have lymphoma, leukemia, or blood cancer; during the past 12 months, being told by a physician they have chronic bronchitis or weak or failing kidneys; or reporting an asthma episode or attack in the past 12 months.

^gWomen were considered to have a usual source of care if they answered “yes” to the following question: *Is there a place that you usually go to when you are sick or need advice about your health?*

^hNumber of doctor visits in past year was based on the answer to the following question: *During the past 12 months, how many times have you seen a doctor or other health care professional about your own health at a doctor’s office, a clinic, or some other place? Do not include times you were hospitalized overnight, visits to hospital emergency rooms, home visits, dental visits, or telephone calls.*

ⁱAlcohol use was defined as consuming ≥12 drinks during any one year and ≥5 drinks in 1 day at least once during the past year.

Table 2. Unadjusted and Adjusted Vaccination Coverage Before and During Pregnancy Among Pregnant Women, U.S. – National Health Interview Survey, 2012–2015

Characteristics	Sample size	Unadjusted vaccination coverage, % (95% CI)	Crude prevalence ratio (95% CI)	Adjusted vaccination coverage, ^a % (95% CI)	Adjusted prevalence ratio ^a (95% CI)
Age, years					
18–24	273	28.3 (21.6, 36.0)	ref	33.7 (25.6, 42.8)	ref
25–34	711	41.4 (36.6, 46.4)	1.47 (1.12, 1.92)	38.9 (34.0, 44.0)	1.15 (0.87, 1.53)
35–49	207	36.9 (29.7, 44.8)	1.31 (0.93, 1.84)	29.9 (23.1, 37.8)	0.89 (0.61, 1.29)
Race/ethnicity					
White, non-Hispanic	635	41.4 (36.2, 46.7)	ref	36.4 (31.1, 42.1)	ref
Black, non-Hispanic	177	27.8 (21.2, 35.5)	0.67 (0.50, 0.89)	29.1 (21.6, 38.0)	0.80 (0.58, 1.10)
Hispanic	282	32.7 (25.7, 40.6)	0.79 (0.61, 1.03)	39.6 (31.3, 48.4)	1.09 (0.82, 1.44)
Other, non-Hispanic	97	33.8 (21.9, 48.3) ^b	0.82 (0.54, 1.23)	36.6 (23.3, 52.3) ^b	1.00 (0.65, 1.55)
Education					
< High school	201	25.1 (18.8, 32.7)	0.56 (0.41, 0.75)	32.7 (24.3, 42.5)	0.80 (0.58, 1.10)
High school	249	20.8 (15.3, 27.6)	0.46 (0.34, 0.63)	20.6 (14.6, 28.4)	0.51 (0.35, 0.73)
> High school	741	45.1 (40.3, 50.1)	ref	40.8 (35.7, 46.2)	ref
Married					
Yes	692	42.7 (37.8, 47.8)	1.51 (1.21, 1.90)	36.5 (31.4, 41.8)	1.04 (0.80, 1.35)
No	499	28.2 (23.2, 33.9)	ref	35.1 (28.4, 42.5)	ref
Insurance coverage					
Private	604	45.7 (40.5, 51.0)	ref	38.7 (32.9, 44.8)	ref
Public	439	28.4 (23.2, 34.3)	0.62 (0.50, 0.78)	31.6 (25.0, 39.0)	0.82 (0.61, 1.09)
None	144	22.5 (15.5, 31.5)	0.49 (0.34, 0.72)	36.0 (24.6, 49.2) ^b	0.93 (0.62, 1.40)
Employment status ^c					
Yes	639	41.5 (36.4, 46.8)	1.28 (1.04, 1.58)	36.9 (31.9, 42.2)	1.06 (0.85, 1.32)
No	552	32.4 (27.3, 38.1)	ref	34.9 (29.2, 41.1)	ref
Poverty level ^d					
At or above poverty	840	41.1 (36.4, 46.0)	1.58 (1.20, 2.08)	35.7 (31.1, 40.5)	0.96 (0.71, 1.29)
Below poverty	336	26.0 (20.3, 32.7)	ref	37.3 (28.6, 47.0)	ref
High-risk conditions ^e					
Yes	125	29.7 (20.7, 40.6)	0.78 (0.55, 1.12)	27.8 (18.5, 39.5) ^b	0.75 (0.51, 1.12)
No	1,066	37.9 (34.0, 42.1)	ref	36.9 (32.9, 41.1)	ref
Usual source of care ^f					
Yes	1,051	39.3 (35.3, 43.4)	1.93 (1.30, 2.86)	37.6 (33.6, 41.9)	1.80 (1.16, 2.80)
No	140	20.3 (13.5, 29.4)	ref	20.9 (13.2, 31.5)	ref
Number of doctor visits in past year ^g					
0	77	8.4 (3.5, 19.0) ^b	0.19 (0.08, 0.45)	12.9 (5.5, 27.4) ^b	0.31 (0.13, 0.71)
1–3	240	22.9 (16.9, 30.2)	0.51 (0.37, 0.70)	23.5 (16.6, 32.2)	0.56 (0.39, 0.81)

(continued on next page)

Table 2. Unadjusted and Adjusted Vaccination Coverage Before and During Pregnancy Among Pregnant Women, U.S. – National Health Interview Survey, 2012–2015 (continued)

Characteristics	Sample size	Unadjusted vaccination coverage, % (95% CI)	Crude prevalence ratio (95% CI)	Adjusted vaccination coverage, ^a % (95% CI)	Adjusted prevalence ratio ^a (95% CI)
4–9	352	40.8 (34.2, 47.7)	0.91 (0.73, 1.12)	38.8 (32.5, 45.6)	0.93 (0.75, 1.15)
≥10	517	45.1 (38.9, 51.3)	ref	41.9 (36.1, 48.1)	ref
Current cigarette use					
Yes	168	20.5 (13.8, 29.4)	0.52 (0.35, 0.76)	25.8 (16.4, 38.2) ^b	0.69 (0.45, 1.07)
No	1,023	39.6 (35.6, 43.8)	ref	37.2 (33.2, 41.4)	ref
Alcohol use ^h					
Yes	224	34.8 (26.6, 44.0)	0.97 (0.74, 1.28)	32.8 (25.4, 41.0)	0.89 (0.69, 1.15)
No	831	35.8 (31.7, 40.1)	ref	37.0 (32.8, 41.4)	ref
U.S. born					
Yes	936	37.9 (33.6, 42.4)	1.09 (0.84, 1.42)	36.4 (31.8, 41.3)	1.05 (0.73, 1.51)
No	254	34.7 (27.3, 42.9)	ref	34.6 (24.8, 45.9) ^b	ref

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

^aAdjusted prevalence is the predictive marginal from multivariable logistic regression. Adjusted prevalence ratio is the ratio of the adjusted prevalence for each particular group to the reference group. All variables listed in the table were included in the multivariable logistic regression model.

^bEstimate may not be reliable due to relative SE > 0.3 or half CI > 10.

^cEmployment status “yes” includes those working for pay at a job or business, having a job or business but not at work, or working but not for pay at a family-owned job or business. Employment status “no” includes those looking for work or not working at a job or business and not looking for work.

^dPoverty thresholds for each NHIS survey year were estimated using the most recently available average census poverty thresholds, average Consumer Price Index from 2 years prior, actual Consumer Price Index values for January–July of the prior year, and Projected Consumer Price Index values for August–December of the prior year. Poverty status was defined as a total income of \$23,000, \$24,000, \$25,000, and \$24,000 for a family of four in 2012, 2013, 2014, and 2015, respectively. More information available at ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2012/srvydesc.pdf; ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2013/srvydesc.pdf; ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2014/srvydesc.pdf; and ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf.

^eWomen were considered at high risk for influenza-related complications if they self-reported one or more of the following: ever being told by a physician they had diabetes, emphysema, chronic obstructive pulmonary disease (COPD), coronary heart disease, angina, heart attack or other heart condition; being diagnosed with cancer in the past 12 months (excluding non-melanoma skin cancer), or ever being told by a physician they have lymphoma, leukemia or blood cancer; during the past 12 months, being told by a physician they have chronic bronchitis or weak or failing kidneys; or reporting an asthma episode or attack in the past 12 months.

^fWomen were considered to have a usual source of care if they answered “yes” to the following question: *Is there a place that you usually go to when you are sick or need advice about your health?*

^gThe number of doctor visits in past year was based on the answer to the following question: *During the past 12 months, how many times have you seen a doctor or other health care professional about your own health at a doctor’s office, a clinic, or some other place? Do not include times you were hospitalized overnight, visits to hospital emergency rooms, home visits, dental visits, or telephone calls.*

^hAlcohol use was defined as those who had consumed ≥12 drinks during any 1 year and had ≥5 drinks in 1 day at least once during the past year.

among women pregnant any time during October through January from the national Internet panel surveys, for the 2014–2015, 2013–2014, and 2012–2013 influenza seasons, respectively.¹⁸ The stable vaccination trend across the three seasons from NHIS was similar to the trends from Behavioral Risk Factor Surveillance System and the Internet panel surveys, though estimates from NHIS were lower compared with estimates from the Internet panel surveys. The variation in estimates across the three data sources could be attributed to differences in survey methods (e.g., different sampling frame, survey mode, operations, definition of exposure period for vaccination, and weighting).^{16,19} As a probability-based national health survey, NHIS is the data source for evaluating the *Healthy People 2020* objective for influenza vaccination coverage among pregnant women.⁷ The vaccination coverage estimates found from this study were significantly higher than the coverage estimates prior to 2009–2010 H1N1 pandemic season (less than 15%),²⁰ although still well below the *Healthy People 2020* target of 80% among pregnant women.⁷

Differences in vaccination coverage in the bivariate analysis were found by age, race/ethnicity, education level, marital status, employment status, poverty level, health insurance coverage, number of provider visits, smoking status, and having a usual place of medical care. These results were consistent with previous studies.^{21–26} A few studies found that a prior history of influenza vaccination and gestational age were statistically associated with influenza vaccination coverage among pregnant women^{27,28}; however, because data on pregnancy start date were not collected from NHIS, the gestational age could not be derived. The vaccination status in the previous season was not collected either. Hence these two variables were not evaluated in both bivariate and multivariable analyses. Education level, number of provider visits, and having a usual place of medical care remained significantly associated with vaccination coverage in the multivariable model. As no specific causal model or hypothesis was posed for the relationship of vaccination with the examined factors, the significant findings from both bivariate and multivariate analysis should be considered in developing vaccination intervention activities.

Women with a high school education had significantly lower vaccination coverage, women with less than high school education also had lower coverage compared with women with more than a high school education, but this difference was not statistically significant. Level of maternal education has been reported to be associated with health literacy and both education and health literacy are related with attitudes and beliefs toward vaccination safety and effectiveness.²⁹ Pregnant women's education level might be linked to their knowledge of and perceptions about influenza vaccination. Pregnant

women's low awareness of their risk and susceptibility to influenza infection and misconception of the safety and effectiveness of the vaccination are reported barriers for vaccination uptake.^{21,25,26,30–34}

A healthcare provider's recommendation and offer of vaccination has been consistently reported as a strong factor associated with vaccination uptake among pregnant women.^{8,12,18,21,22,26,32,35–38} In this study, the number of visits to a provider was significantly associated with influenza vaccination coverage in both the unadjusted and adjusted analyses. Also, women who had a usual place for health care had higher vaccination coverage compared with women not having a usual place. These results are consistent with previous studies among adult populations.^{39,40} Having a usual place of care and more frequent provider visits likely provide more opportunities for counseling about vaccination and other preventive services, recommendation, and offer of influenza vaccination. However, even among those who had ten or more visits, a large proportion of women remained unvaccinated, which may be because of possible missed opportunities from providers or practices, vaccine hesitancy at the patient level, or both. Missed opportunities at the provider level might be attributed to providers' lack of knowledge or negative beliefs about the safety and benefit of maternal influenza vaccination to both pregnant women and their infants^{38,41} along with health system barriers, such as concern about lack of reimbursement for vaccine administration and the cost of vaccine storage, and site logistics and time constraints of staff for assessment, consultation, and administration of vaccination.⁴² Patients' vaccine hesitancy concerns might be attributed to misconceptions of the safety and efficacy of the influenza vaccination, perceived low susceptibility or low severity of the influenza infection, and negative reporting from the media about influenza vaccination.^{8,43,44}

Racial disparities in influenza vaccination coverage between black and white women have been reported previously among pregnant women²² and the general population of adults.^{38,45} In this study, a vaccination difference between black and white pregnant women was observed in the bivariate analysis. The longstanding lower coverage among non-Hispanic black women compared with white women might be partly because of differences in sociocultural norms, misperception of effectiveness and safety of vaccination, and vaccine resistance and hesitancy.^{22,46}

Limitations

There are several limitations of this study. First, influenza vaccination status was self-reported and was not verified by medical record, therefore status might be subject to recall bias. However, previous studies have found that self-report

is a reliable indicator of influenza vaccination status in adults.^{47–49} Second, the response rates of the 2012–2015 NHIS adult core ranged from 55.2% to 61.2% and nonresponse bias might still exist even after weighting adjustment. Third, the NHIS is a general population survey and the weighting was made to represent the general population, not specifically for pregnant women. Therefore, the estimates among pregnant women in this study might not be generalizable to the entire population of pregnant women. Finally, the sample size of pregnant women in the NHIS was relatively small, limiting the ability to detect statistically significant differences in vaccination coverage estimates between certain demographic characteristics for individual seasons. Despite this limitation, the results did indicate some important trends across the demographic subgroups.

CONCLUSIONS

Trends in vaccination coverage among pregnant women from a nationally representative sample for the three influenza seasons was similar to the trend of reported estimates for the three seasons from other data sources^{18,21} and still below the *Healthy People 2020* target of 80%.⁷ Pregnant women who received influenza vaccination had significantly lower rates of hospitalization than those who did not.⁵⁰ Influenza vaccination remains the primary preventive intervention for pregnant women against influenza. Vaccination coverage was lower among certain sociodemographic, access-to-care, and behavior subgroups. The reasons for suboptimal maternal vaccination are likely multifactorial and involve barriers at the patient, provider, and health system levels.⁵¹ To increase influenza vaccination uptake toward the *Healthy People 2020* target of 80% among pregnant women, continued efforts are needed among healthcare providers to (1) routinely assess patients' immunization status; (2) provide up-to-date information for needed vaccines; (3) strongly recommend needed vaccines and offer them to patients during their visit; (4) provide a referral to locations where patients can easily be vaccinated, if the provider does not stock the needed vaccines; (5) document vaccination status in an immunization information system and patients' medical records; and (6) discuss the effects and benefits of vaccination as well as address potential concerns of influenza vaccination with their pregnant patients.^{6,51,52}

ACKNOWLEDGMENTS

We thank James A. Singleton and Stacie M. Greby for their thoughtful review of the manuscript.

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

No financial disclosures were reported by the authors of this paper.

REFERENCES

- Rasmussen SA, Jamieson DJ, Uyeki TM. Effects of influenza on pregnant women and infants. *Am J Obstet Gynecol*. 2012;207(3 suppl):S3–S8. <https://doi.org/10.1016/j.ajog.2012.06.068>.
- Fiore AE, Uyeki TM, Broder K, et al. Prevention and control of influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010. *MMWR Recomm Rep*. 2010;59(RR-8):1–62.
- Neuzil KM, Reed GW, Mitchel EF, Simonsen L, Griffin MR. Impact of influenza on acute cardiopulmonary hospitalizations in pregnant women. *Am J Epidemiol*. 1998;148(11):1094–1102. <https://doi.org/10.1093/oxfordjournals.aje.a009587>.
- Galvao TF, Silva MT, Zimmermann IR, Lopes LA, Bernardo EF, Pereira MG. Influenza vaccination in pregnant women: a systematic review. *ISRN Prev Med*. 2013;2013:879493. <https://doi.org/10.5402/2013/879493>.
- Madhi SA, Cutland CL, Kuwanda L, et al. Influenza vaccination of pregnant women and protection of their infants. *N Engl J Med*. 2014;371(10):918–931. <https://doi.org/10.1056/NEJMoa1401480>.
- ACOG Committee Opinion No. 732: Influenza vaccination during pregnancy. *Obstet Gynecol*. 2018;131(4):e109–e114. <https://doi.org/10.1097/AOG.0000000000002588>.
- Office of Disease Prevention and Health Promotion. Healthy people 2020 target for pregnant women. www.healthypeople.gov/2020/data-search/Search-the-Data#objid=6362. Accessed November 21, 2018.
- Ding H, Black CL, Ball S, et al. Influenza vaccination coverage among pregnant women—United States, 2015–16. www.cdc.gov/flu/fluview/pregnant-coverage_1516estimates.htm. CDC. Published 2016. Accessed November 21, 2018.
- CDC. National Health Interview Survey public use data release: NHIS survey description. ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf. Published 2015. Accessed November 21, 2018.
- CDC. National Health Interview Survey public use data release: NHIS survey description. ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2014/srvydesc.pdf. Published 2014. Accessed November 21, 2018.
- CDC. National Health Interview Survey public use data release: NHIS survey description. http://ftp.cdc.gov/pub/health_statistics/nchs/Dataset_Documentation/NHIS/2013/srvydesc.pdf. Published 2013. Accessed November 21, 2018.
- Myers KL. Predictors of maternal vaccination in the United States: an integrative review of the literature. *Vaccine*. 2016;34(34):3942–3949. <https://doi.org/10.1016/j.vaccine.2016.06.042>.
- Lu PJ, Santibanez TA, Williams WW, et al. Surveillance of influenza vaccination coverage—United States, 2007–08 through 2011–12 influenza seasons. *MMWR Surveill Summ*. 2013;62(4):1–28.
- CDC. Interim results: state-specific seasonal influenza vaccination coverage—United States, August 2009–January 2010. *MMWR Morb Mortal Wkly Rep*. 2010;59(16):477–484.
- CDC. Interim results: influenza A (H1N1) 2009 monovalent vaccination coverage—United States, October–December 2009. *MMWR Morb Mortal Wkly Rep*. 2010;59(2):44–48.
- Furrow-Parmley C, Singleton JA, Bardenheier B, Bryan L. Combining estimates from two surveys: an example from monitoring 2009 influenza A (H1N1) pandemic vaccination. *Stat Med*. 2012;31(27):3285–3294. <https://doi.org/10.1002/sim.5333>.
- Zhai Y, Kahn KE, O'Halloran A, Santibanez TA. Comparing results from Cox proportional hazards models using SUDAAN® and SAS® survey procedures to a logistic regression model for analysis of influenza vaccination coverage. SESUG Proceedings 2015. www.lexjansen.com/sesug/2015/42_Final_PDF.pdf. Accessed November 21, 2018.
- Ding H, Black CL, Ball S, et al. Pregnant women and flu vaccination, Internet Panel Survey. www.cdc.gov/flu/fluview/pregnant-women-nov2016.htm. CDC. Published 2016. Updated November 21, 2018.

19. Kennedy ED, Ahluwalia IB, Ding H, Lu PJ, Singleton JA, Bridges CB. Monitoring seasonal influenza vaccination coverage among pregnant women in the United States. *Am J Obstet Gynecol*. 2012;207(3 suppl):S9–S16. <https://doi.org/10.1016/j.ajog.2012.06.069>.
20. Lu P, Bridges CB, Euler GL, Singleton JA. Influenza vaccination of recommended adult populations, U.S., 1989–2005. *Vaccine*. 2008;26(14):1786–1793. <https://doi.org/10.1016/j.vaccine.2008.01.040>.
21. Ding H, Black CL, Ball S, et al. Influenza vaccination coverage among pregnant women—United States, 2014–15 influenza season. *MMWR Morb Mortal Wkly Rep*. 2015;64(36):1000–1005. <https://doi.org/10.15585/mmwr.mm6436a2>.
22. Ahluwalia IB, Ding H, Harrison L, et al. Disparities in influenza vaccination coverage among women with live-born infants: PRAMS surveillance during the 2009–2010 influenza season. *Public Health Rep*. 2014;129(5):408–416. <https://doi.org/10.1177/003335491412900504>.
23. Lu PJ, O'Halloran A, Bryan L, et al. Trends in racial/ethnic disparities in influenza vaccination coverage among adults during the 2007–08 through 2011–12 seasons. *Am J Infect Control*. 2014;42(7):763–769. <https://doi.org/10.1016/j.ajic.2014.03.021>.
24. Phadke VK, Omer SB. Maternal vaccination for the prevention of influenza: current status and hopes for the future. *Expert Rev Vaccines*. 2016;15(10):1255–1280. <https://doi.org/10.1080/14760584.2016.1175304>.
25. Bodeker B, Walter D, Reiter S, Wichmann O. Cross-sectional study on factors associated with influenza vaccine uptake and pertussis vaccination status among pregnant women in Germany. *Vaccine*. 2014;32(33):4131–4139. <https://doi.org/10.1016/j.vaccine.2014.06.007>.
26. Yuen CY, Tarrant M. Determinants of uptake of influenza vaccination among pregnant women - a systematic review. *Vaccine*. 2014;32(36):4602–4613. <https://doi.org/10.1016/j.vaccine.2014.06.067>.
27. Vilca LM, Verma A, Buckeridge D, Campins M. A population-based analysis of predictors of influenza vaccination uptake in pregnant women: the effect of gestational and calendar time. *Prev Med*. 2017;99:111–117. <https://doi.org/10.1016/j.ypmed.2017.02.010>.
28. Groom HC, Henninger ML, Smith N, et al. Influenza vaccination during pregnancy: influenza seasons 2002–2012, Vaccine Safety Datalink. *Am J Prev Med*. 2016;50(4):480–488. <https://doi.org/10.1016/j.amepre.2015.08.017>.
29. Castro-Sanchez E, Chang PWS, Vila-Candel R, Escobedo AA, Holmes AH. Health literacy and infectious diseases: why does it matter? *Int J Infect Dis*. 2016;43:103–110. <https://doi.org/10.1016/j.ijid.2015.12.019>.
30. Henninger ML, Irving SA, Thompson M, et al. Factors associated with seasonal influenza vaccination in pregnant women. *J Womens Health (Larchmt)*. 2015;24(5):394–402. <https://doi.org/10.1089/jwh.2014.5105>.
31. Beigi RH, Switzer GE, Meyn LA. Acceptance of a pandemic avian influenza vaccine in pregnancy. *J Reprod Med*. 2009;54(6):341–346.
32. Yudin MH, Salaripour M, Sgro MD. Pregnant women's knowledge of influenza and the use and safety of the influenza vaccine during pregnancy. *J Obstet Gynaecol Can*. 2009;31(2):120–125. [https://doi.org/10.1016/S1701-2163\(16\)34095-6](https://doi.org/10.1016/S1701-2163(16)34095-6).
33. Mayet AY, Al-Shaikh GK, Al-Mandeeq HM, Alsaleh NA, Hamad AF. Knowledge, attitudes, beliefs, and barriers associated with the uptake of influenza vaccine among pregnant women. *Saudi Pharm J*. 2017;25(1):76–82. <https://doi.org/10.1016/j.jsps.2015.12.001>.
34. Yudin MH, Salripour M, Sgro MD. Impact of patient education on knowledge of influenza and vaccine recommendations among pregnant women. *J Obstet Gynaecol Can*. 2010;32(3):232–237. [https://doi.org/10.1016/S1701-2163\(16\)34449-8](https://doi.org/10.1016/S1701-2163(16)34449-8).
35. Wiley KE, Massey PD, Cooper SC, et al. Uptake of influenza vaccine by pregnant women: a cross-sectional survey. *Med J Aust*. 2013;198(7):373–375. <https://doi.org/10.5694/mja12.11849>.
36. Ding H, Santibanez TA, Jamieson DJ, et al. Influenza vaccination coverage among pregnant women—National 2009 H1N1 Flu Survey (NHFS). *Am J Obstet Gynecol*. 2011;204(6 suppl 1):S96–S106. <https://doi.org/10.1016/j.ajog.2011.03.003>.
37. Ding H, Black CL, Ball S, et al. Influenza vaccination coverage among pregnant women—United States, 2013–14 influenza season. *MMWR Morb Mortal Wkly Rep*. 2014;63(37):816–821.
38. Blanchard-Rohner G, Meier S, Ryser J, et al. Acceptability of maternal immunization against influenza: the critical role of obstetricians. *J Matern Fetal Neonatal Med*. 2012;25(9):1800–1809. <https://doi.org/10.3109/14767058.2012.663835>.
39. Lu PJ, O'Halloran A, Williams WW, Lindley MC, Farrall S, Bridges CB. Racial and ethnic disparities in vaccination coverage among adult populations in the U.S. *Am J Prev Med*. 2015;49(6 suppl 4):S412–S425. <https://doi.org/10.1016/j.amepre.2015.03.005>.
40. Lu PJ, O'Halloran A, Williams WW. Impact of health insurance status on vaccination coverage among adult populations. *Am J Prev Med*. 2015;48(6):647–661. <https://doi.org/10.1016/j.amepre.2014.12.008>.
41. National Vaccine Advisory Committee. The National Vaccine Advisory Committee: reducing patient and provider barriers to maternal immunizations. Approved by the National Vaccine Advisory Committee on June 11, 2014. *Public Health Rep*. 2015;130(1):10–42. <https://doi.org/10.1177/003335491513000104>.
42. Bridges CB, Hurley LP, Williams WW, Ramakrishnan A, Dean AK, Groom AV. Meeting the challenges of immunizing adults. *Vaccine*. 2015;33(suppl 4):D114–D120. <https://doi.org/10.1016/j.vaccine.2015.09.054>.
43. Schmid P, Rauber D, Betsch C, Lidolt G, Denker ML. Barriers of influenza vaccination intention and behavior: a systematic review of influenza vaccine hesitancy, 2005–2016. *PLoS One*. 2017;12(1):e0170550. <https://doi.org/10.1371/journal.pone.0170550>.
44. Kumar D, Chandra R, Mathur M, Samdaria S, Kapoor N. Vaccine hesitancy: understanding better to address better. *Isr J Health Policy Res*. 2016;5:2. <https://doi.org/10.1186/s13584-016-0062-y>.
45. Schneider EC, Cleary PD, Zaslavsky AM, Epstein AM. Racial disparity in influenza vaccination: does managed care narrow the gap between African Americans and whites? *JAMA*. 2001;286(12):1455–1460. <https://doi.org/10.1001/jama.286.12.1455>.
46. Lindley MC, Wortley PM, Winston CA, Bardenheier BH. The role of attitudes in understanding disparities in adult influenza vaccination. *Am J Prev Med*. 2006;31(4):281–285. <https://doi.org/10.1016/j.amepre.2006.06.025>.
47. Brown C, Clayton-Boswell H, Chaves SS, et al. Validity of parental report of influenza vaccination in young children seeking medical care. *Vaccine*. 2011;29(51):9488–9492. <https://doi.org/10.1016/j.vaccine.2011.10.023>.
48. Mangtani P, Shah A, Roberts JA. Validation of influenza and pneumococcal vaccine status in adults based on self-report. *Epidemiol Infect*. 2007;135(1):139–143. <https://doi.org/10.1017/S0950268806006479>.
49. Rolnick SJ, Parker ED, Nordin JD, et al. Self-report compared to electronic medical record across eight adult vaccines: do results vary by demographic factors? *Vaccine*. 2013;31(37):3928–3935. <https://doi.org/10.1016/j.vaccine.2013.06.041>.
50. Regan AK, Klerk N, Moore HC, Omer SB, Shellam G, Effler PV. Effectiveness of seasonal trivalent influenza vaccination against hospital-attended acute respiratory infections in pregnant women: a retrospective cohort study. *Vaccine*. 2016;34:3649–3656. <https://doi.org/10.1016/j.vaccine.2016.05.032>.
51. National Vaccine Advisory Committee. Recommendations from the National Vaccine Advisory committee: standards for adult immunization practice. *Public Health Rep*. 2014;129(2):115–123. <https://doi.org/10.1177/003335491412900203>.
52. Guide to Community Preventive Services. Vaccination. www.thecommunityguide.org/topic/vaccination?field_recommendation_tid=All&items_per_page=5&page=2. Accessed November 21, 2018.