# Influenza and Tetanus, Diphtheria, and Acellular Pertussis Vaccination During Pregnancy, Pregnancy Risk Assessment Monitoring System, 2019

**Titilope Oduyebo**
CDC
**Katie Kortsmit**
CDC
**Regina Simeone**
CDC
**Katherine Kahn**
CDC
**Hilda Razzaghi**
**Romeo Galang**
CDC
**Sascha Ellington** ( FRK5@CDC.GOV )
CDC
**Nan Ruffo**
CDC
**Wanda Barfield**
CDC
**Lee Warner**
CDC
**Shanna Cox**
CDC

**Research Article**

**Keywords:** influenza, offer, pregnancy, healthcare provider, recommendation, Tdap, vaccination

**Posted Date:** January 3rd, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1217686/v1

## Abstract

# Background

Influenza and tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccines is recommended for pregnant women to protect themselves and their infants from adverse health outcomes.

# Objectives

To estimate the prevalence of maternal influenza and Tdap vaccination and determine factors associated with receipt of these vaccines.

# Methods

We analyzed 2019 data from the Pregnancy Risk Assessment Monitoring System, from 43 jurisdictions. We estimated the overall prevalence of women reporting receipt of a healthcare provider offer or recommendation for influenza vaccine (n=44,528), and influenza vaccine during the 12 months before delivery (n=44,213). We also estimated Tdap vaccine receipt during pregnancy from the 21 jurisdictions (n=22,972). Maternal influenza and Tdap vaccination were examined by selected maternal characteristics and by jurisdiction.

# Results

Overall, 86.4% of women reported being offered or recommended an influenza vaccination, and 60.8% of women reported receiving an influenza vaccination in the 12 months prior to their delivery, ranging from 36.0% in Puerto Rico to 82.1% in Rhode Island. Tdap receipt during pregnancy was 73.7%, ranging from 52.2% in Mississippi to 85.1% in Vermont. Prevalence of influenza vaccination was lower among women aged 18–24 years (52.2%), who are non-Hispanic black (44.5%), with a high school diploma or less education (51.3%), with no prenatal insurance (43.2%), having no (42.0%) prenatal care, with ≥3 previous live births (49.3%) and not offered or recommended the influenza vaccine by a healthcare provider (20.0%). Tdap vaccination also varied by all characteristics examined and was lower among similar groups of women observed to have lower influenza vaccination uptake.

# Conclusion

In 2019, influenza and Tdap vaccination were suboptimal among women with a recent live birth. It is important that U.S. jurisdictions provide equitable access to these vaccines during pregnancy. These results may also inform efforts for vaccination for other infectious diseases among pregnant women.


## Synopsis

A. Study question? *To estimate prevalence of influenza and Tetanus, Diphtheria, and Acellular Pertussis (Tdap) vaccination and determine factors associated with receipt of these vaccines among women who delivered a live birth in 2019.*

B. What is already known? *Influenza and Tdap vaccines protect pregnant women and their infants from adverse health outcomes. However, available national data show that receipt of these vaccines is suboptimal.*

C. What does this study add to what is already known? *Many women did not receive influenza and Tdap vaccines and it varied widely by state of residence. Population-based prevalence estimates of maternal vaccination at the state level are*

*crucial for tailoring vaccination campaigns and programs to maximize impact and to provide equitable access to influenza and Tdap vaccines during pregnancy.*

## Background

Influenza during pregnancy is associated with severe maternal illness[1, 2] and increased risk of poor infant outcomes including preterm birth.[2] The Advisory Committee on Immunization Practices (ACIP) and the American College of Obstetricians and Gynecologists (ACOG) recommend that pregnant women receive influenza vaccine to protect themselves and their infants.[3, 4] ACIP specifically recommends that all women who are pregnant or who might be pregnant or postpartum during the influenza season receive influenza vaccine. Influenza vaccine can be safely administered before and at any time during pregnancy, and has been shown to reduce the risk of infection by 50%,[5] the risk of hospitalization by an average of 40%,[6] and to protect infants from influenza during the first 6-months of life when infants are not eligible for influenza vaccination.[7] Similarly, both ACIP and ACOG recommend the tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine during every pregnancy, preferably in the early part of 27–36 weeks gestation.[8, 9] Tdap vaccination during pregnancy protects infants, during the first 2-months of life, who are at the greatest risk of contracting pertussis and having severe complications from the infection including pneumonia and death.[10, 11]

Despite recommendations, available data show that prevalence of maternal vaccination is suboptimal, with variation by certain characteristics and receipt of healthcare providers recommendation or offer of a vaccine.[12] The Centers for Disease Control and Prevention (CDC) conducted an Internet panel survey that found only 40.3% of women pregnant during the 2019–20 influenza season received both influenza and Tdap vaccines. Seasonal influenza vaccination prevalence among pregnant women was 61.2%, while 56.6% of pregnant women reported receipt of Tdap during pregnancy.[12] However, these estimates are based on a non-probability sample of 1,841 respondents who were pregnant anytime during October 2019–January 2020 in the United States. Population-based estimates of maternal vaccination at the state and local level as well as determining factors associated with vaccination are crucial for tailoring vaccination campaigns and programs to maximize impact. Thus, we analyzed data from the Pregnancy Risk Assessment Monitoring System (PRAMS), a population-based and jurisdiction-specific surveillance system, to provide past-year jurisdictional-level influenza and Tdap vaccination prevalence estimates and to determine factors associated with receipt of these vaccines among women who delivered a liveborn infant in 2019.

## Methods

## Data Source and Population

PRAMS is an ongoing surveillance system conducted by CDC in collaboration with participating jurisdictions' health departments. Details about the PRAMS methodology have been published previously.[13] It uses a standardized mixed-mode mail and telephone questionnaire to obtain information from a population-based sample of women with recent live births; responses are linked to selected data extracted from the birth certificate. The PRAMS questionnaire captures information about maternal behaviors and experiences before, during, and shortly after pregnancy. Each jurisdiction's questionnaire contains "core" questions. Jurisdictions also have the option to include "standard" questions which address additional topics of interest. Data are weighted for sample design, nonresponse, and noncoverage to produce estimates representative of participating jurisdictions' live birth populations.

This analysis includes 43 jurisdictions (40 states, the District of Columbia, New York City, and Puerto Rico) that achieved a weighted response rate of ≥50%. The overall mean weighted response rate for these sites was 59%, ranging from 50–81%. The PRAMS protocol was reviewed and approved by CDC's IRB and each participating PRAMS jurisdiction's IRB.

## Exposures

Maternal characteristics of interest included sociodemographic characteristics (i.e., maternal age, race/Hispanic-ethnicity, education, prenatal Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation, and jurisdiction), indicators of healthcare access and utilization (i.e., type of prenatal care insurance, number of prenatal care visits), and previous live birth. Factors of interest were selected a priori based on previous literature.[12] Most characteristics were obtained from data available in the PRAMS dataset from the birth certificate; however, prenatal insurance status, and healthcare provider offer of or recommendation for influenza vaccination were obtained from the PRAMS survey.

# Outcomes

To determine past-year influenza vaccination prevalence for women who gave birth in 2019 and whether influenza vaccine was offered or recommended by a healthcare provider, we analyzed 2019 PRAMS data from the 43 jurisdictions. To measure healthcare provider offer of or recommendation for an influenza vaccination, all women were asked the core question, “During the 12 months before the delivery of your new baby, did a doctor, nurse, or other healthcare worker offer you a flu shot or tell you to get one?” The response options included “no” and “yes.” To measure influenza vaccination prevalence before or during pregnancy, all women were asked the core question, “During the 12 months before the delivery of your new baby, did you get a flu shot?” The response options included “no,” “yes, before my pregnancy,” and “yes, during my pregnancy.” In four jurisdictions (Montana, Rhode Island, Washington, and New York City), women who did not get an influenza vaccination were also asked the standard question, ”What were your reasons for not getting a flu shot during the 12 months before the birth of your new baby”. They were asked to select “no” or “yes” for each statement which included “my doctor didn’t mention anything about a flu shot,” “I was worried about side effects of the flu shot for me,” “I was worried that the flu shot might harm my baby,” “I was not worried about getting sick with the flu,” “I do not think the flu shot works,” “I don’t normally get a flu shot,” and “Other” with the option to write in a response.

To measure Tdap vaccination prevalence during pregnancy, all women from 21 jurisdictions (20 states and New York City) were asked the following standard question included on their PRAMS survey, “During your most recent pregnancy, did you get a Tdap shot or vaccination? A Tdap vaccination is a tetanus booster shot that also protects against pertussis (whooping cough).” The response options included “no,” “yes,” and “I don’t know.” The PRAMS survey did not assess healthcare provider offer or recommendation for Tdap.

# Statistical Analysis

We calculated the weighted prevalence, with 95% confidence intervals (CIs), of a healthcare provider offer or recommendation for influenza vaccination, overall influenza vaccination prevalence and overall Tdap vaccination prevalence, by jurisdiction, and by selected maternal characteristics. In addition, we evaluated variation in the prevalence of influenza vaccination by reported receipt of a healthcare provider offer of or recommendation for an influenza vaccine, overall and by maternal characteristics in a stratified analysis.

We used Chi-squared testing (statistical significance level set at p-value <0.05) and 95% CIs (i.e., nonoverlap of CIs) to identify differences across groups within each selected characteristic. Among 45,226 PRAMS participants from 43 jurisdictions, 44,528 women completed the question on whether a healthcare provider offered or recommended the influenza vaccination, and 44,213 women completed the question on influenza vaccination; 43,881 women completed both questions. Among the subset of women (n=23,198) who were asked the question on Tdap vaccination from 21 jurisdictions, 22,972 women completed the question. All analyses were performed using SAS-callable SUDAAN 11.0.04 (RTI International, Research Triangle Park, NC) to account for the complex survey design of PRAMS.

## Results

Among 45,226 women, from 43 jurisdictions, the majority were aged 25–34 years (58.2%), non-Hispanic White (56.1%), had some college or higher (63.3%), were not prenatal WIC participants (65.3%), reported having private insurance for prenatal care (59.8%), had ≥11 prenatal care visits (63.3%), and were multiparous (60.5%) (Table 1).

# Provider Offer of or Recommendation for Influenza Vaccination

Among 44,528 women who answered the question on whether a healthcare provider offered or recommended an influenza vaccination, 86.4% of women reported receiving a provider offer or recommendation, ranging from 67.7% in Puerto Rico to 95.0% in New Hampshire (Figure 1). Receipt of provider offer or recommendation was lower among women aged ≤17 (72.7%) and 18–24 years (81.9%) compared with women aged 25–34 (87.9%) and ≥35 years (87.8%); non-Hispanic Black (82.7%) and Hispanic (81.9%) women compared with non-Hispanic White (89.0%), non-Hispanic American Indian or Alaska Native (89.3%), and non-Hispanic Asian or Pacific Islander (87.3%) women; women with no prenatal insurance (62.8%) and those with Medicaid (82.8%) compared with women with private prenatal insurance (90.7%); women with no prenatal care visits (73.1%), 1–5 visits (78.4%) compared with women with or 6–10 visits (84.5%) compared or ≥11 visits (88.5%), and women with no (84.9%) or ≥3 previous live births (83.7%) compared with women with one (88.6%) or two previous live births (88.1%); (Table 1). Healthcare provider offer or recommendation for an influenza vaccine was lowest among women with a high school diploma or less education (81.5%) and prenatal WIC participants (82.9%).

# Influenza Vaccination

Among 44,213 women who answered the question on influenza vaccination, 60.8% reported being vaccinated (Table 2) in the year before their most recent live birth; 11.3% reported being vaccinated before pregnancy and 49.5% during pregnancy. Past-year influenza vaccination prevalence ranged from 36.0% in Puerto Rico to 82.1% in Rhode Island (Figure 1). Variation in influenza vaccination by maternal characteristics followed similar patterns as prevalence of provider offer of or recommendation for influenza vaccination (Table 2). Prevalence of influenza vaccination was lower among women aged 18–24 years (52.2%) compared with women aged 25–34 (62.4%) and ≥35 years (65.7%); women with a high school diploma or less education (51.3%), some college (53.5%), or associate's degree (59.4%) compared with a bachelor's degree or higher (74.3%); women with no prenatal insurance (43.2%) and those with Medicaid (49.4%) compared with women with private prenatal insurance (69.5%); and those with zero (42.0%) or 1–5 prenatal care visits (47.6%) compared with 6–10 (56.7%) or ≥11 prenatal care visits (64.6%). Prevalence of influenza vaccination was lowest among non-Hispanic Black women (44.5%), prenatal WIC participants (52.8%), and women who had ≥3 previous live births (49.3%).

Among 43,881 women who answered both questions on receipt of a healthcare provider offer of or recommendation for an influenza vaccine and receipt of influenza vaccine in the 12 months prior to delivery, the prevalence of influenza vaccination was lower among those who were not offered or recommended an influenza vaccine (20.0%) compared with those who were (67.5%) (Table 2). When examining prevalence of influenza vaccination by receipt of a provider offer or recommendation, vaccination was consistently lower among those who were not offered or recommended an influenza vaccination compared with those who were, regardless of maternal characteristics. When restricting analyses to women who reported receipt of a provider offer or recommendation, the variation of influenza vaccination by characteristics examined was similar to that observed for the entire sample, with a lower prevalence of vaccination observed among the same groups of women (Table 2). However, when restricting to women who did not report receipt of a provider offer or recommendation, vaccination prevalence was not significantly different by receipt of prenatal WIC and number of previous live births.

Among women in Montana, Rhode Island, Washington, and New York City, that reported reasons for not receiving influenza vaccine, the most commonly cited reason was that they don't normally get a flu shot (74.4%). Women also indicated that they were worried about side effects of the vaccine for themselves (56.9%), they do not think the flu shot works (45.3%), they were worried the vaccine might harm their baby (41.5%), they were not worried about getting sick with the flu (39.7%), and their doctor didn't mention anything about a flu shot (15.9%) (data not shown).

# Tdap Vaccination

Among 22,972 women from 21 jurisdictions, 73.7% reported receiving a Tdap vaccination during pregnancy (Table 3), ranging from 52.2% in Mississippi to 85.1% in Vermont (Figure 2). Tdap vaccination during pregnancy was lower among

women aged ≤17 (62.2%) and 18–24 years (69.6%) compared with women aged 25–34 years (75.5%), those who were non-Hispanic Black (63.2%) compared with non-Hispanic White (76.6%), Hispanic (73.0%), non-Hispanic Asian or Pacific Islander (72.6%) and non-Hispanic other (72.3%); women with no prenatal insurance (40.2%) and those with Medicaid (66.1%) compared with women with private prenatal insurance (80.7%); and those with zero (54.9%) or 1–5 prenatal care visits (55.5%) compared with 6–10 (70.4%) or ≥11 prenatal care visits (77.1%). Overall prevalence of Tdap vaccination was lowest among women who had ≤high school diploma (64.7%), prenatal WIC participants (67.7%), and had ≥3 previous live births (57.5%) (Table 3).

## Comment

# Principal Findings and Interpretation

Slightly more than three-fifths of women with a live birth in 2019 reported influenza vaccination in the year before delivery, with a majority receiving it during pregnancy. In addition, approximately 73.7% of women received a Tdap vaccination during pregnancy. Prevalence estimates of influenza vaccination from PRAMS and the Internet panel survey conducted by the CDC for pregnant women for the 2019-2020 influenza season (61.2%)[14] were similar, although not directly comparable due to different methodologies and time period assessed. The prevalence of Tdap vaccination from this Internet panel survey was 56.6%; the difference with our findings might be explained by the limited number of jurisdictions that included the PRAMS question on Tdap vaccination during pregnancy in 2019, the time period assessed, and inability of PRAMS survey to calculate the prevalence of Tdap vaccination by provider recommendation. The prevalence of influenza and Tdap vaccination varied across jurisdictions which might be explained by differences in provider and healthcare delivery practices, preferences and attitudes toward vaccination of women, and strategies implemented by jurisdictions to address barriers to maternal vaccination.

Examples of strategies several jurisdictions have implemented to address barriers to maternal vaccination include providing incentives to health plans, increasing access to vaccinations through alternative sites like pharmacies, and using data to identify populations and regions with substandard influenza vaccination rates.[15] For example, compared with other jurisdictions, we found Massachusetts and Rhode Island were among the sites with the highest reported prevalence of influenza vaccination being offered or recommended by a healthcare provider and past-year influenza vaccination prevalence among women with a recent live birth. The Massachusetts Department of Health has a history of supporting vaccine education and access to vaccinations statewide through collaboration with community-based organizations to share tailored, accurate, and culturally appropriate messages about the importance of influenza vaccination as well as establishing additional venues, including obstetrics sites, to administer the vaccine.[16] Massachusetts also has programs to reimburse public providers for administration of the vaccine to incentivize providers to incorporate vaccine programs in their practices. During the H1N1 pandemic, the Rhode Island Department of Health ensured that the influenza vaccine was accessible to pregnant women statewide by recruiting obstetric providers; this led to dramatic increases in influenza vaccination among pregnant women.[17] Rhode Island's Immunize for Life initiative offers pregnant women home visitation that includes vaccine education and referral.[18]

Similar to other studies,[12, 19] our findings indicate that influenza and Tdap vaccination prevalence was lower for women who were younger, non-Hispanic black, with a lower level of education, uninsured, had Medicaid insurance coverage for prenatal care, had less frequent prenatal care visits, participated in WIC during the prenatal period, and had higher number of previous live births. Also consistent with prior literature, [20,21] reasons cited for not getting an influenza vaccination among pregnant women included that they don't normally get vaccinated, concerns about vaccine safety and effectiveness, not being worried about getting sick with influenza, and lack of provider offer or recommendation. To improve maternal immunization, the development or continued support of organized, multidisciplinary efforts are needed to address vaccine hesitancy and ensure equitable access for all pregnant women regardless of sociodemographic characteristics and

healthcare coverage. Vaccine hesitancy in African American communities is thought to stem from the mistrust that has developed due to a history of racial discrimination and exploitation in the United States which continue to the present day.[22] Efforts to prevent continued discrimination and exploitation as well as strategic messaging are needed to overcome this distrust in order to improve the confidence in getting any vaccine, including influenza and Tdap vaccines.

Influenza vaccination prevalence was lower among women not offered or recommended influenza vaccine by a healthcare provider. As observed previously with data from an Internet panel survey, receipt of a provider offer of vaccination is strongly associated with higher vaccination prevalence among pregnant women, for both influenza and Tdap vaccines.[12] We observed differences in whether the influenza vaccine was offered or recommended by a healthcare provider for all characteristics examined. This underscores the importance of equitable provision of care by healthcare providers discussing, offering, and/or recommending influenza vaccination to all women who are pregnant or will be pregnant during influenza season. However, among women who reported that a healthcare provider offered or recommended influenza vaccine, vaccination prevalence still varied by sociodemographic characteristics, health insurance coverage, and receipt of prenatal care, highlighting the importance of addressing other factors influencing influenza vaccination beyond healthcare provider counseling.

## Strengths of the study and limitations of the data

Strengths of this analysis include the use of a population-based sample of women with a recent live birth and the ability to estimate jurisdiction-level influenza and Tdap vaccination prevalence. However, our findings should be interpreted in the context of several limitations. PRAMS is a cross-sectional survey with self-reported data and subject to social desirability and recall bias. Women who receive a vaccine might be more likely to recall a conversation in which their provider offered or suggested that they get the vaccine. Additionally, the results for influenza and Tdap vaccination may only be generalizable to women whose pregnancies ended in a live birth residing in the participating jurisdictions included in the analysis. Given that the survey does not report timing of healthcare provider offer of or recommendation for influenza vaccine, we were unable to determine whether it happened prior to vaccination. Furthermore, the survey did not distinguish between an offer of or recommendation for influenza vaccine, and women were not asked whether a healthcare provider offered or recommended Tdap vaccine. Also, we are unable to determine the prevalence of influenza and Tdap vaccination by provider practice type. Last, we were unable to determine influenza vaccination prevalence by specific influenza season because the survey asks about influenza vaccination during the 12 months before delivery and does not capture the date the vaccine was received. However, all women delivering in 2019 would have been pregnant in either the 2018-2019 or 2019-2020 influenza seasons.

## Conclusion

Influenza and Tdap vaccination was suboptimal among women with a recent live birth in 2019. Vaccination prevalence varied by jurisdiction as well as by several factors, including receipt of a healthcare provider offer or recommendation for influenza vaccination, sociodemographic characteristics, health insurance coverage, and receipt of prenatal care. Due to the recent decline in routine vaccination rates during the current COVID-19 pandemic,[23, 24] it is more important than ever for jurisdictions to implement innovative approaches to improve vaccination rates, and to provide accurate and clear messages to address vaccine hesitancy. It is imperative that U.S. jurisdictions support strategies to provide equitable access to influenza and Tdap vaccines during pregnancy including vaccination efforts against other infectious diseases that disproportionately impact pregnant women.

## Declarations


## Funding:

Not applicable

# Acknowledgements:

Pregnancy Risk Assessment Monitoring System (PRAMS) Working Group members: Kathy Perham-Hester, Alaska; Ashley Juhl, Colorado; Jennifer Morin, Connecticut; George Yocher, Delaware; Fay Stephens, Georgia; Julie Doetsch, Illinois; Lisa Williams, Kansas; Tracey D. Jewell, Kentucky; Rosaria Trichilo, Louisiana; Virginia Daniels, Maine; Hafsatou Diop, Massachusetts; Peterson Haak, Michigan; Mira Grice Sheff, Minnesota; Brenda Hughes, Mississippi; Venkata Garikapaty, Missouri; Jessica Seberger, Nebraska; Sharon Smith Cooley, New Jersey; Sarah Schrock, New Mexico; Lauren Birnie, New York City; Grace Njau, North Dakota; Sara E. Thuma, Pennsylvania; Wanda Hernández, Puerto Rico; Karine Tolentino Monteiro, Rhode Island; Maggie Minett, South Dakota; Nicole Stone, Utah; Peggy Brozicevic, Vermont; Kenesha Smith, Virginia; Linda Lohdefinck, Washington; Melissa Baker, West Virginia; Fiona Weeks, Wisconsin; Lorie W. Chesnut, Wyoming; PRAMS Team, Women's Health and Fertility Branch, Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, CDC.

## References

1. Mertz D, Geraci J, Winkup J, Gessner BD, Ortiz JR, Loeb M. Pregnancy as a risk factor for severe outcomes from influenza virus infection: A systematic review and meta-analysis of observational studies. *Vaccine*. Jan 23 2017;35(4):521–528. doi:10.1016/j.vaccine.2016.12.012
2. Mosby LG, Rasmussen SA, Jamieson DJ. 2009 pandemic influenza A (H1N1) in pregnancy: a systematic review of the literature. *American journal of obstetrics and gynecology*. Jul 2011;205(1):10–8. doi:10.1016/j.ajog.2010.12.033
3. ACOG Committee Opinion No. 741: Maternal Immunization. *Obstetrics and gynecology*. Jun 2018;131(6):e214-e217. doi:10.1097/AOG.0000000000002662
4. Grohskopf LA, Alyanak E, Broder KR, et al. Prevention and Control of Seasonal Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices - United States, 2020-21 Influenza Season. *MMWR Recomm Rep*. Aug 21 2020;69(8):1–24. doi:10.15585/mmwr.rr6908a1
5. Thompson MG, Li DK, Shifflett P, et al. Effectiveness of seasonal trivalent influenza vaccine for preventing influenza virus illness among pregnant women: a population-based case-control study during the 2010-2011 and 2011-2012 influenza seasons. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. Feb 2014;58(4):449–57. doi:10.1093/cid/cit750
6. Thompson MG, Kwong JC, Regan AK, et al. Influenza Vaccine Effectiveness in Preventing Influenza-associated Hospitalizations During Pregnancy: A Multi-country Retrospective Test Negative Design Study, 2010-2016. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. Apr 24 2019;68(9):1444–1453. doi:10.1093/cid/ciy737
7. Nunes MC, Madhi SA. Influenza vaccination during pregnancy for prevention of influenza confirmed illness in the infants: A systematic review and meta-analysis. *Hum Vaccin Immunother*. Mar 4 2018;14(3):758–766. doi:10.1080/21645515.2017.1345385
8. Havers FP, Moro PL, Hunter P, Hariri S, Bernstein H. Use of Tetanus Toxoid, Reduced Diphtheria Toxoid, and Acellular Pertussis Vaccines: Updated Recommendations of the Advisory Committee on Immunization Practices - United States, 2019. *MMWR Morbidity and mortality weekly report*. Jan 24 2020;69(3):77-83. doi:10.15585/mmwr.mm6903a5
9. Liang JL, Tiwari T, Moro P, et al. Prevention of Pertussis, Tetanus, and Diphtheria with Vaccines in the United States: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep*. Apr 27 2018;67(2):1–44. doi:10.15585/mmwr.rr6702a1
10. Skoff TH, Blain AE, Watt J, et al. Impact of the US Maternal Tetanus, Diphtheria, and Acellular Pertussis Vaccination Program on Preventing Pertussis in Infants <2 Months of Age: A Case-Control Evaluation. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. Nov 29 2017;65(12):1977–1983. doi:10.1093/cid/cix724

11. Mbayei SA, Faulkner A, Miner C, et al. Severe Pertussis Infections in the United States, 2011-2015. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. Jul 2 2019;69(2):218-226. doi:10.1093/cid/ciy889
12. Razzaghi H, Kahn KE, Black CL, et al. Influenza and Tdap Vaccination Coverage Among Pregnant Women - United States, April 2020. *MMWR Morbidity and mortality weekly report*. Oct 2 2020;69(39):1391–1397. doi:10.15585/mmwr.mm6939a2
13. Shulman HB, Gilbert BC, Msphbrenda CG, Lansky A. The Pregnancy Risk Assessment Monitoring System (PRAMS): current methods and evaluation of 2001 response rates. *Public Health Rep*. Jan-Feb 2006;121(1):74–83.
14. Lindley MC, Kahn KE, Bardenheier BH, et al. Vital Signs: Burden and Prevention of Influenza and Pertussis Among Pregnant Women and Infants - United States. *MMWR Morbidity and mortality weekly report*. Oct 11 2019;68(40):885–892. doi:10.15585/mmwr.mm6840e1
15. Officials; AoSaTH. Emphasizing Seasonal Flu Vaccination Amid the COVID-19 Pandemic. Accessed 2/1/2021, 2021. https://www.astho.org/StatePublicHealth/Emphasizing-Seasonal-Flu-Vaccination-Amid-the-COVID-19-Pandemic/12-07-20/
16. Centers for Disease C, Prevention. Influenza vaccination among pregnant women--Massachusetts, 2009-2010. *MMWR Morbidity and mortality weekly report*. Nov 1 2013;62(43):854–7.
17. Kim H, Raymond P, Cain R. Seasonal influenza vaccination among pregnant women in Rhode Island, 2002-2011. *Med Health R I*. Sep 2012;95(9):296–9.
18. Officials; AoSaTH. *Rhode Island's Immunize for Life Program*. 2013. https://www.astho.org/Programs/Infectious-Disease/Rhode-Island-Immunize-for-Life-Program/
19. Ahluwalia IB, Ding H, D'Angelo D, et al. Tetanus, diphtheria, pertussis vaccination coverage before, during, and after pregnancy - 16 States and New York City, 2011. *MMWR Morbidity and mortality weekly report*. May 22 2015;64(19):522–6.
20. Yuen CY, Tarrant M. Determinants of uptake of influenza vaccination among pregnant women - a systematic review. *Vaccine*. Aug 6 2014;32(36):4602-13. doi:10.1016/j.vaccine.2014.06.067
21. Bodeker B, Betsch C, Wichmann O. Skewed risk perceptions in pregnant women: the case of influenza vaccination. *BMC Public Health*. Dec 29 2015;16:1308. doi:10.1186/s12889-015-2621-5
22. Corbie-Smith G, Thomas SB, St George DM. Distrust, race, and research. *Arch Intern Med*. Nov 25 2002;162(21):2458–63. doi:10.1001/archinte.162.21.2458
23. Bramer CA, Kimmins LM, Swanson R, et al. Decline in Child Vaccination Coverage During the COVID-19 Pandemic - Michigan Care Improvement Registry, May 2016-May 2020. *MMWR Morbidity and mortality weekly report*. May 22 2020;69(20):630–631. doi:10.15585/mmwr.mm6920e1
24. Santoli JM, Lindley MC, DeSilva MB, et al. Effects of the COVID-19 Pandemic on Routine Pediatric Vaccine Ordering and Administration - United States, 2020. *MMWR Morbidity and mortality weekly report*. May 15 2020;69(19):591–593. doi:10.15585/mmwr.mm6919e2

## Tables

**Table 1.** Overall sample distribution and prevalence of healthcare provider offer or recommendation for influenza vaccination during the 12 months before infant delivery by selected characteristics — Pregnancy Risk Assessment Monitoring System, 40 States, the District of Columbia, New York City, and Puerto Rico, 2019

| Select Characteristics | Overall Distribution | | Healthcare provider offered or recommended the influenza vaccine n=44,528[a] | | |
|---|---|---|---|---|---|
| | Total | | | | |
| | n[a] | %[b] | n[a] | % (95% CI)[c,d] | *P* value[d] |
| Total | 45,226 | — | 39,080 | 86.4 (85.9,87.0) | — |
| Age group, years[e] | | | | | <0.001 |
| ≤17 | 497 | 1.1 | 366 | 72.7 (65.0,79.4) | |
| 18–24 | 9,280 | 21.4 | 7,584 | 81.9 (80.5,83.3) | |
| 25–34 | 26,469 | 58.2 | 23,279 | 87.9 (87.2,88.6) | |
| ≥35 | 8,976 | 19.2 | 7,847 | 87.8 (86.5,88.9) | |
| Race/Ethnicity [e] | | | | | <0.001 |
| Non-Hispanic Black | 7,947 | 16.9 | 6,559 | 82.7 (81.2,84.0) | |
| Non-Hispanic White | 21,152 | 56.1 | 18,879 | 89.0 (88.3,89.7) | |
| Hispanic | 8,683 | 18.5 | 7,125 | 81.9 (80.3,83.4) | |
| Non-Hispanic American Indian or Alaska Native | 1,693 | 0.6 | 1,500 | 89.3 (84.1,93.0) | |
| Non-Hispanic Asian or Pacific Islander | 3,172 | 4.9 | 2,776 | 87.3 (85.1,89.2) | |
| Non-Hispanic other[f] | 2,414 | 3.0 | 2,112 | 85.1 (81.2,88.4) | |
| Education[e] | | | | | <0.001 |
| ≤High school diploma or GED | 15,710 | 36.7 | 12,763 | 81.5 (80.4,82.5) | |
| Completed some college | 8,906 | 18.0 | 7,724 | 85.5 (84.1,86.8) | |
| Associate's degree | 4,050 | 8.9 | 3,531 | 87.1 (85.1,88.8) | |
| ≥Bachelor's degree | 16,201 | 36.4 | 14,771 | 91.8 (91.0,92.5) | |
| Prenatal WIC participation[e] | | | | | <0.001 |
| Yes | 16,415 | 34.7 | 13,603 | 82.9 (81.9,83.9) | |
| No | 28,228 | 65.3 | 24,979 | 88.3 (87.6,88.9) | |
| Prenatal insurance status[g, h] | | | | | <0.001 |
| Private | 24,661 | 59.8 | 22,354 | 90.7 (90.0,91.3) | |
| Medicaid | 16,110 | 36.2 | 13,374 | 82.8 (81.7,83.8) | |
| Uninsured | 1,044 | 2.8 | 725 | 62.8 (57.2,68.0) | |
| Other | 380 | 1.1 | 297 | 81.1 (75.0,86.0) | |

| | | | | | |
|---|---|---|---|---|---|
| Number of prenatal care visits[e] | | | | | <0.001 |
| None | 654 | 1.4 | 453 | 73.1 (66.9,78.5) | |
| 1–5 | 2,876 | 5.3 | 2,274 | 78.4 (75.4,81.1) | |
| 6–10 | 13,940 | 29.9 | 11,866 | 84.5 (83.4,85.6) | |
| ≥11 | 26,375 | 63.3 | 23,334 | 88.5 (87.8,89.2) | |
| Previous live births[e] | | | | | <0.001 |
| 0 | 17,648 | 39.5 | 15,010 | 84.9 (83.9,85.8) | |
| 1 | 14,261 | 32.4 | 12,591 | 88.6 (87.6,89.5) | |
| 2 | 7,460 | 16.3 | 6,514 | 88.1 (86.8,89.2) | |
| ≥3 | 5,771 | 11.8 | 4,892 | 83.7 (81.9,85.4) | |

GED, General Education Diploma; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

[a] Unweighted sample size; sample size for select characteristics may vary because of missing responses on the PRAMS survey or missing data on the Birth Certificate; [b] Weighted percentage; percentages for the individual categories might not add to 100 because of rounding; [c] Weighted percentage (95% Confidence Interval); [d] Chi-squared tests and 95% Confidence Intervals (i.e., nonoverlap of CIs) were used to determine differences in the prevalence of whether a healthcare provider offered or recommended the influenza vaccine across groups within each maternal characteristic; [e] Birth certificate variable; [f] Non-Hispanic other includes women who self-reported multiple races or other non-White on the birth certificate; [g] PRAMS survey variable;

[h] Insurance is coded as Medicaid (Medicaid or state-named Medicaid program); Private (Private only, any other insurance in combination with private, TRICARE or other military insurance); No insurance (no insurance or Indian Health Service (IHS) only; in Alaska this also includes Alaska Tribal Health System that are part of the IHS response option); other includes state-specific government plans or programs such as SCHIP/CHIP.

**Table 2.** Prevalence of influenza vaccination in the 12 months before infant delivery overall and by whether influenza vaccination was offered or recommended by a healthcare provider, by selected characteristics — Pregnancy Risk Assessment Monitoring System, 40 States, the District of Columbia, New York City, and Puerto Rico, 2019

| Select Characteristics | Vaccination Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Overall Vaccination Rate n=44,213[a] | | | Influenza vaccination was offered or recommended by a healthcare provider n=43,881[a] | | | | | |
| | | | | Yes | | | No | | |
| | n[a] | % (95% CI)[b,c] | *P* value | n[a] | % (95% CI)[b,c] | *P* value | n[a] | % (95% CI)[b,c] | *P* value |
| Total | 28,558 | 60.8 (60.1,61.6) | — | 27,150 | 67.5 (66.7,68.2) | — | 1,264 | 20.0 (18.3,21.8) | — |
| Age group, years[d] | | | <0.001 | | | <0.001 | | | 0.002 |
| ≤17 | 273 | 60.3 (52.0,68.1) | | 245 | 76.6 (68.2,83.3) | | 26 | 15.9 (8.2,28.6) | |
| 18–24 | 5,141 | 52.2 (50.4,54.0) | | 4,820 | 60.5 (58.5,62.4) | | 286 | 15.0 (12.4,18.2) | |
| 25–34 | 17,124 | 62.4 (61.4,63.4) | | 16,349 | 68.2 (67.1,69.2) | | 703 | 22.6 (20.1,25.3) | |
| ≥35 | 6,017 | 65.7 (64.0,67.4) | | 5,733 | 72.2 (70.4,73.9) | | 249 | 20.9 (17.3,25.1) | |
| Race/Ethnicity[d] | | | <0.001 | | | <0.001 | | | 0.001 |
| Non-Hispanic Black | 3,798 | 44.5 (42.6,46.3) | | 3,553 | 50.9 (48.8,53.0) | | 213 | 15.3 (12.4,18.8) | |
| Non-Hispanic White | 14,223 | 64.3 (63.3,65.3) | | 13,709 | 70.1 (69.0,71.1) | | 472 | 18.8 (16.4,21.5) | |
| Hispanic | 5,426 | 61.5 (59.6,63.4) | | 5,033 | 70.1 (68.1,72.1) | | 353 | 23.5 (19.9,27.5) | |
| Non-Hispanic American Indian or Alaska Native | 1,080 | 65.9 (60.4,71.1) | | 1,025 | 70.7 (65.6,75.3) | | 48 | 26.0 (14.4,42.3) | |
| Non-Hispanic Asian or Pacific Islander | 2,409 | 74.7 (71.9,77.3) | | 2,292 | 81.0 (78.2,83.5) | | 102 | 32.4 (24.2,41.9) | |
| Non-Hispanic other[e] | 1,530 | 61.0 (56.7,65.2) | | 1,451 | 66.9 (62.5,71.0) | | 71 | 27.1 (16.0,42.0) | |
| Education[d] | | | <0.001 | | | <0.001 | | | <0.001 |
| ≤High school diploma or GED | 8,530 | 51.3 (49.9,52.7) | | 7,943 | 59.3 (57.8,60.8) | | 524 | 17.3 (15.1,19.9) | |
| Completed | 5,094 | 53.5 | | 4,861 | 60.1 | | 207 | 15.2 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| some college | | (51.7,55.3) | | | (58.2,62.0) | | | (12.0,19.1) | |
| Associate's degree | 2,480 | 59.4 (56.8,62.0) | | 2,347 | 64.5 (61.7,67.2) | | 121 | 26.7 (20.5,33.9) | |
| ≥Bachelor's degree | 12,227 | 74.3 (73.1,75.4) | | 11,790 | 78.5 (77.4,79.7) | | 395 | 27.8 (23.8,32.1) | |
| Prenatal WIC participation[d] | | | <0.001 | | | <0.001 | | | 0.939 |
| Yes | 9,118 | 52.8 (51.5,54.2) | | 8,511 | 59.7 (58.2,61.2) | | 541 | 20.0 (17.6,22.8) | |
| No | 19,075 | 65.0 (64.1,66.0) | | 18,297 | 71.3 (70.3,72.2) | | 703 | 19.9 (17.6,22.4) | |
| Prenatal insurance status[f,g] | | | <0.001 | | | <0.001 | | | <0.001 |
| Private | 17,664 | 69.5 (68.5,70.5) | | 17,026 | 74.2 (73.2,75.2) | | 586 | 25.0 (22.0,28.3) | |
| Medicaid | 8,482 | 49.4 (48.0,50.7) | | 7,945 | 56.5 (55.0,57.9) | | 471 | 16.5 (14.3,19.1) | |
| Uninsured | 514 | 43.2 (38.0,48.7) | | 456 | 59.7 (52.9,66.1) | | 56 | 17.6 (11.7,25.8) | |
| Publicly/State Funded | 209 | 55.4 (48.1,62.5) | | 190 | 64.3 (56.0,71.8) | | 16 | 15.6 (7.4,29.9) | |
| Number of prenatal care visits[d] | | | <0.001 | | | <0.001 | | | <0.001 |
| None | 277 | 42.0 (35.4,49.0) | | 250 | 54.8 (46.6,62.8) | | 27 | 8.6 (5.0,14.6) | |
| 1–5 | 1,430 | 47.6 (44.2,51.0) | | 1,329 | 57.7 (53.8,61.4) | | 95 | 11.5 (8.1,16.0) | |
| 6–10 | 8,326 | 56.7 (55.2,58.2) | | 7,875 | 63.9 (62.4,65.5) | | 406 | 19.4 (16.7,22.5) | |
| ≥11 | 17,672 | 64.6 (63.7,65.6) | | 16,900 | 70.2 (69.2,71.2) | | 683 | 22.3 (19.8,25.1) | |
| Previous live births[d] | | | <0.001 | | | <0.001 | | | 0.265 |
| 0 | 11,553 | 63.9 (62.7,65.1) | | 10,945 | 71.8 (70.5,73.0) | | 543 | 20.7 (18.1,23.5) | |
| 1 | 9,280 | 63.3 (61.9,64.6) | | 8,903 | 69.1 (67.7,70.4) | | 341 | 19.7 (16.5,23.4) | |
| 2 | 4,530 | 57.0 (55.0,58.9) | | 4,285 | 61.9 (59.8,64.0) | | 214 | 22.2 (18.1,27.1) | |
| ≥3 | 3,139 | 49.3 (47.1,51.5) | | 2,965 | 56.2 (53.7,58.6) | | 162 | 16.6 (13.1,20.9) | |

GED, General Education Diploma WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

[a] Unweighted sample size; sample size for select characteristics may vary because of missing responses on the PRAMS survey or missing data on the Birth Certificate; [b] Weighted percentage (95% Confidence Interval); [c] Chi-squared tests and 95% Confidence Intervals (i.e., nonoverlap of CIs) were used to determine differences in the prevalence of maternal influenza vaccination in the 12 months before delivery across groups within each maternal characteristic; [d] Birth certificate variable; [e] Non-Hispanic other includes women who self-reported multiple races or other non-White on the birth certificate; [f] PRAMS survey variable; [g] Insurance is coded as Medicaid (Medicaid or state-named Medicaid program); Private (Private only, any other insurance in combination with private, TRICARE or other military insurance); No insurance (no insurance or Indian Health Service (IHS) only; in Alaska this also includes Alaska Tribal Health System that are part of the IHS response option); other includes state-specific government plans or programs such as SCHIP/CHIP; [h]Relative standard error (RSE) for the estimate is between 30–50%; estimates should be interpreted with caution.

**Table 3.** Tetanus toxoid, reduced diphtheria, and acellular pertussis vaccine (Tdap) vaccination during pregnancy by selected characteristics — Pregnancy Risk Assessment Monitoring System, 20 States and New York City, 2019

| | Received Tdap vaccination n=22,972[a] | | |
|---|---|---|---|
| **Select Characteristics** | n[a] | % (95% CI)[b, c] | *P value* |
| Total | 16,628 | 73.7 (72.8,74.6) | |
| Age group, years[d] | | | <0.001 |
| ≤17 | 140 | 62.2 (47.3,75.0) | |
| 18–24 | 3,047 | 69.6 (67.4,71.8) | |
| 25–34 | 10,151 | 75.5 (74.4,76.6) | |
| ≥35 | 3,287 | 73.0 (70.9,75.0) | |
| Race/Ethnicity[d] | | | <0.001 |
| Non-Hispanic Black | 2,746 | 63.2 (60.7,65.6) | |
| Non-Hispanic White | 8,901 | 76.6 (75.5,77.8) | |
| Hispanic | 2,332 | 73.0 (70.4,75.4) | |
| Non-Hispanic American Indian or Alaska Native | 341 | 69.3 (62.9,75.1) | |
| Non-Hispanic Asian or Pacific Islander | 1,318 | 72.6 (69.2,75.8) | |
| Non-Hispanic other[e] | 920 | 72.3 (66.5,77.4) | |
| Education[d] | | | <0.001 |
| ≤High school diploma or GED | 4,913 | 64.7 (62.8,66.5) | |
| Completed some college | 3,198 | 71.3 (69.2,73.3) | |
| Associate's degree | 1,519 | 73.5 (70.6,76.3) | |
| ≥Bachelor's degree | 6,869 | 83.4 (82.1,84.5) | |
| Prenatal WIC participation[d] | | | <0.001 |
| Yes | 5,231 | 67.7 (65.9,69.4) | |
| No | 11,113 | 76.7 (75.6,77.7) | |
| Prenatal insurance status[f,g] | | | <0.001 |
| Private | 10,364 | 80.7 (79.7,81.8) | |
| Medicaid | 5,098 | 66.1 (64.4,67.8) | |
| Uninsured | 211 | 40.2 (32.6,48.3) | |
| Publicly/State Funded | 94 | 65.6 (54.5,75.3) | |
| Number of prenatal care visits[d] | | | <0.001 |
| None | 138 | 54.9 (45.1,64.4) | |

| | | | |
|---|---|---|---|
| 1–5 | 715 | 55.5 (50.8,60.2) | |
| 6–10 | 4,856 | 70.4 (68.6,72.2) | |
| ≥11 | 10,496 | 77.1 (76.0,78.1) | |
| Previous live births[d] | | | <0.001 |
| 0 | 6,917 | 79.3 (77.9,80.6) | |
| 1 | 5,328 | 75.6 (74.1,77.1) | |
| 2 | 2,582 | 68.4 (65.9,70.8) | |
| ≥3 | 1,769 | 57.5 (54.5,60.5) | |

GED, General Education Diploma; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

[a] Unweighted sample size; sample size varies because of missing responses; [b] Weighted percentage (95% Confidence Interval), denominator includes those who responded 'yes', 'no' and 'I don't know'; [c] Chi-squared tests and 95% Confidence Intervals (i.e., nonoverlap of CIs) were used to determine differences in the prevalence of maternal influenza vaccination in the 12 months before delivery across groups within each maternal characteristic across groups within each maternal characteristic; [d] Birth certificate variable; [e] Non-Hispanic other includes women who self-reported multiple races or other non-White on the birth certificate; [f] PRAMS survey variable; [g] Insurance is coded as Medicaid (Medicaid or state-named Medicaid program); Private (Private only, any other insurance in combination with private, TRICARE or other military insurance); No insurance (no insurance or Indian Health Service (IHS) only; in Alaska this also includes Alaska Tribal Health System that are part of the IHS response option); other includes state-specific government plans or programs such as SCHIP/CHIP

# Figures

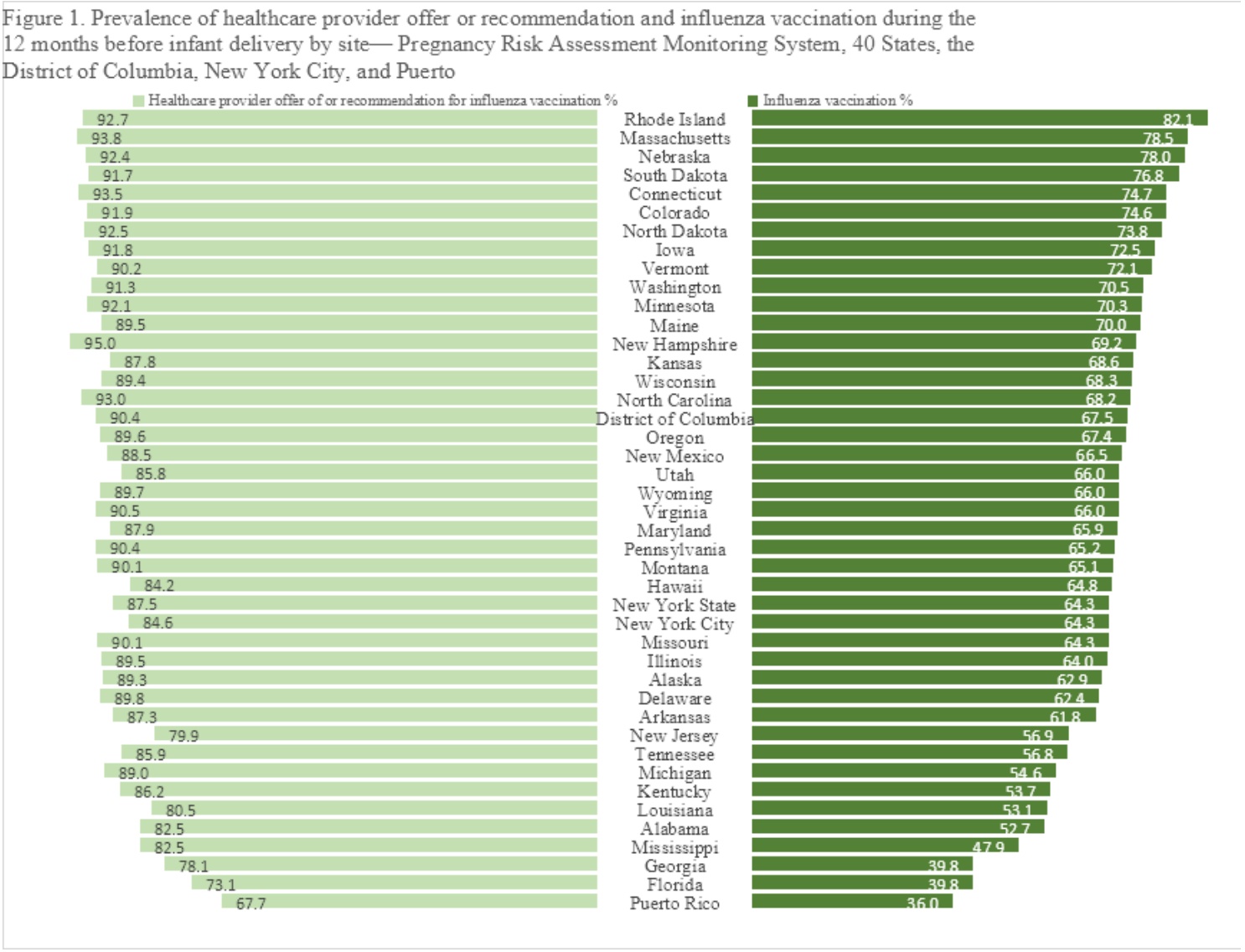
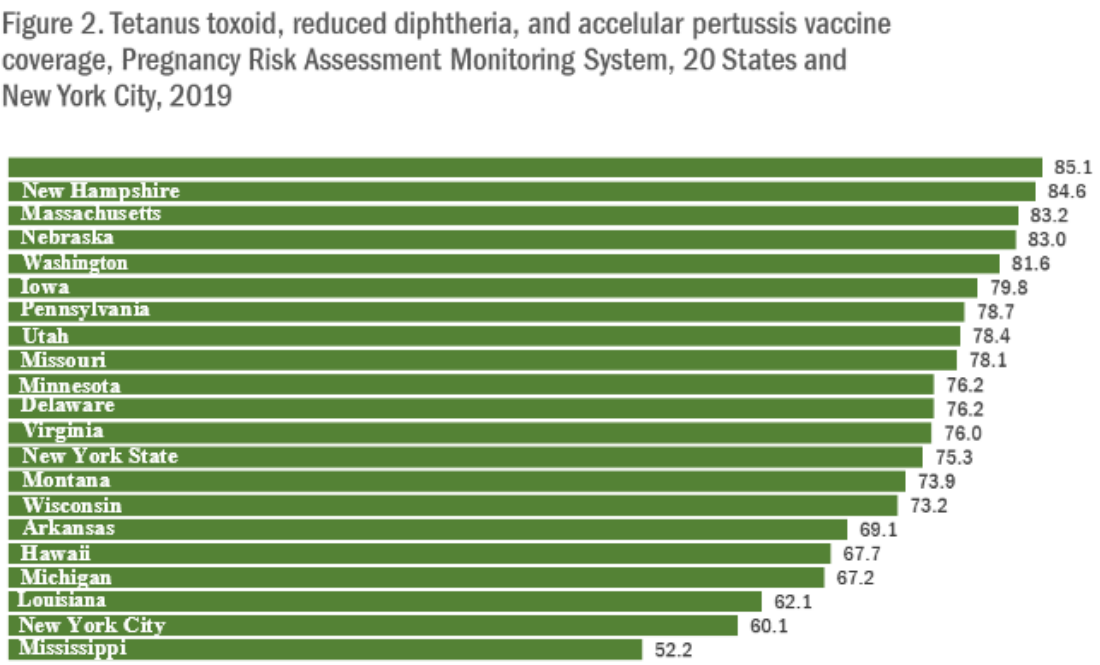



**Figure 1**

Prevalence of healthcare provider offer or recommendation and influenza vaccination during the 12 months before infant delivery by site— Pregnancy Risk Assessment Monitoring System, 40 States, the District of Columbia, New York City, and Puerto




## Figure 2

Tetanus toxoid, reduced diphtheria, and accelular pertussis vaccine coverage, Pregnancy Risk Assessment Monitorming System, 20 States and New York City, 2019