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## Association between influenza vaccination during pregnancy and infant influenza vaccination in a privately insured population

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### Abstract

**Background:** Influenza vaccination during pregnancy is safe and effective in preventing severe influenza illness for pregnant people and their infants in the first few months of life. Little is known about whether influenza vaccination status during pregnancy predicts future infant influenza vaccination.

**Objective:** Examine the association between influenza vaccination during pregnancy and infant influenza vaccination.

**Methods:** Retrospective analysis of beneficiaries aged 15–49 years who were continually privately insured from August 2017 to May 2019 and delivered singleton, live births from September 2017 through February 2018 and their infants. Influenza vaccination coverage was assessed for pregnant people during the 2017–18 influenza season and their infants during the 2018–19 season using the 2017–2019 MarketScan data. Multivariate log-binomial regressions were conducted to examine the association between influenza vaccination during pregnancy and infant influenza vaccination.

**Results:** Of the 34,919 pregnant people in this analysis, 14,168 (40.6%) received influenza vaccination during pregnancy. Of the infants born to people vaccinated during pregnancy, 90.0% received 1 dose and 75.5% received 2 doses of influenza vaccine during the 2018–19 season. Of the infants born to those not vaccinated during pregnancy, 66.3% received 1 dose and 51.8% received 2 doses of influenza vaccine. There was a 35.7% higher in 1 dose coverage (adjusted risk ratio [ARR] 1.34 [95% CI: 1.33–1.36]) and a 45.8% higher in 2 dose coverage (ARR 1.43 [95% CI: 1.41–1.46]) for infants born to people who received influenza vaccination during pregnancy compared with infants born to people who did not.

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**Conclusion:** Our results show a positive and statistically significant relationship between influenza vaccination during pregnancy and infant influenza vaccination status in their first season eligible for vaccination. Interventions to increase influenza vaccination coverage among pregnant people may also increase infant influenza vaccination coverage, offering greater protection against serious complications of influenza in both vulnerable populations.

### Keywords

influenza vaccination during pregnancy; infant influenza vaccination

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### Introduction

Influenza vaccination is safe and effective in protecting pregnant persons and their infants against influenza. Pregnant people are at increased risk of hospitalization when infected with influenza.<sup>1</sup> During the 2009 H1N1 influenza pandemic, pregnant people with influenza had notably increased risk for adverse perinatal and neonatal outcomes.<sup>2–4</sup> Infants under 6 months, are also at high risk for influenza-associated hospitalization and influenza-associated mortality – with 4 times the incidence of all children under 18 years.<sup>5</sup> Influenza vaccination during pregnancy provides protection to infants too young to receive their own influenza vaccinations through transplacental transfer of antibodies in utero and, to the infant after delivery through breastfeeding.<sup>6</sup> To prevent influenza and its serious complications, the Advisory Committee on Immunization Practices (ACIP) as well as the American College of Obstetricians and Gynecologists (ACOG) and the American Academy of Pediatrics<sup>7–9</sup> recommend that people who are or will be pregnant during the flu season receive an inactivated influenza vaccine; influenza vaccination can be received during any trimester of pregnancy. In addition, all persons aged 6 months and older are recommended to receive annual influenza vaccination each year, with children under 9 years old recommended to receive two doses of influenza vaccine in their first season of vaccination.<sup>7</sup>

In an internet panel survey assessing vaccination just prior to the COVID-19 pandemic, 61.2% of surveyed women reported influenza vaccination before or during pregnancy.<sup>10</sup> During the 2019–2020 influenza season, influenza vaccination coverage for infants 6–23 months was notably higher, at 80.6% (<https://www.cdc.gov/flu/fluview/coverage-1920estimates.htm>). Pregnancy is widely understood to be a period when people are motivated to change their health behaviors;<sup>11</sup> people who receive information about vaccination during pregnancy may use this information to make vaccination decisions both for themselves and for their newborns. Studies indicate that decision-making about infant vaccination often happens during pregnancy, so receipt of recommended vaccinations during pregnancy may be an indicator for intent to vaccinate infants after delivery.<sup>12–14</sup> Prior studies of parent-child vaccination status concordance have found significant positive associations between parental vaccine uptake and uptake of routine childhood immunization in individual U.S. states<sup>15–17</sup> and in several countries outside the United States.<sup>13, 18–20</sup> We hypothesized that more recent data from a large national sample would corroborate the trends observed elsewhere and demonstrate an association between influenza vaccination

received during pregnancy and infant influenza vaccination among privately-insured people in the United States.

## Methods

We analyzed the 2017–2019 MarketScan Commercial Claims and Encounters (CCAE) databases to conduct this study. These data cover the two influenza seasons that immediately preceded the COVID-19 pandemic. MarketScan data come from a selection of large employers, health plans, and government and public organizations and represent one of the largest collections of paid health insurance claims data for the private sector in the United States. These databases link detailed patient information across healthcare professional sites and over time using enrollee and family identification numbers. All states and Washington, D.C. were represented in the database during the time covered by this study.

All enrollees aged 15–49 years who were continually privately-insured from August 2017 to May 2019 and delivered singleton, live births from September 2017 through February 2018 and their infants were included. We limited the analysis to singleton births in order to reduce coding and linkage errors in analysis. Birthing parents and the infants were linked through family ID and birth year from the same insurance plan. The 2017–2018 influenza season was defined as August 1, 2017 through May 31, 2018, and the 2018–2019 season as August 1, 2018 through May 31, 2019. For most of these infants, the first season of eligibility for influenza vaccination would be the 2018–2019 season. Influenza vaccination coverage during pregnancy was defined as the percentage of people who received influenza vaccination from August 1, 2017 to the delivery date (i.e. were vaccinated within the 2017–2018 season) (Figure 1). Current Procedural Terminology (CPT) codes (90630, 90653, 90654, 90655, 90656, 90657, 90658, 90659, 90660, 90661, 90662, 90663, 90664, 90666, 90668, 90672, 90673, 90674, 90682, 90685, 90686, 90687, 90688, 90689, 90694, 90724, and 90756) and the Healthcare Common Procedure Coding System (HCPCS) codes (Q2033, Q2034, Q2035, Q2036, Q2037, Q2038, Q2039, G0008, and G8482) from inpatient and outpatient service claims files were used to identify influenza vaccination. Enrollees from 12 states with universal childhood vaccination programs that included influenza vaccine (Alaska, Connecticut, Idaho, Maine, Massachusetts, New Hampshire, New Mexico, Rhode Island, South Dakota, Vermont, Washington, and Wyoming) were excluded from the analyses because infant vaccinations in these states were not likely to have been billed to third-party payers and thus would probably not be recorded in these databases.

All enrollees and infants were enrolled in one of the following types of health insurance plans: fee-for-service (FFS) plans (basic/major medical and comprehensive plans), managed care plans (exclusive provider organization (EPO), health maintenance organization (HMO), non-capitated point-of-service (POS), preferred provider organization (PPO), and capitated or partially-capitated POS plans), consumer driven health plan (CDHP), or high deductible health plan (HDHP).

Values for 1 dose and 2 doses influenza vaccination coverage for infants were estimated stratified by maternal vaccination status, age group (15–34 years and 35–49 years), residence in a metropolitan statistical area (MSA vs. non-MSA), U.S. Census region of

infant residence (Northeast, Midwest, South, and West), and health plan type (FFS, managed care, CDHP, or HDHP). The difference in vaccination coverage for infants born to people who received influenza vaccination during pregnancy and infants born to people who did not were also assessed for each above variable. We conducted multivariate log-binomial regression analyses to examine the associations between infant influenza vaccination in the first season of eligibility and parental characteristics, with receipt of influenza vaccination during pregnancy as the primary explanatory variable. Unadjusted and adjusted risk ratio (RR) with 95% confidence intervals (95% CI) were calculated for these variables.

Analyses were performed with SAS 9.4 (SAS Institute Inc., Cary, NC). As a secondary analysis of de-identified data, this study did not require Institutional Review Board approval.

## Results

Our sample included 34,919 eligible parent-infant pairs. Among these, 14,168 (40.6%) received influenza vaccination during pregnancy. Of the infants born to vaccinated people, 90.0% received 1 dose and 75.5% received 2 doses of influenza vaccine during the 2018–19 season. (Table 1) Of the infants born to unvaccinated people, 66.3% received 1 dose and 51.8% received 2 doses of influenza vaccine. Comparing infants born to people who received influenza vaccination during pregnancy with infants born to those who did not, there was a 35.7% higher (unadjusted) in 1 dose coverage (adjusted risk ratio [ARR] 1.34 [95% CI: 1.33–1.36]) (Table 2) and 45.8% higher in 2 dose coverage (ARR 1.43 [95% CI: 1.41–1.46]). (Table 2)

In Table 1, infant influenza vaccination coverage varied by maternal characteristics. The 1 dose influenza vaccination coverage for infants born to parents 35–49 years is higher than coverage for those born to parents 15–34 years. A higher proportion of infants residing in an MSA were vaccinated than those living outside an MSA. A higher proportion of infants living in the Northeast were vaccinated than infants living in other regions of the United States. When examining influenza vaccination coverage by insurance type, coverage was highest among infants enrolled in HDHPs. In general, we found that variations in 2 dose influenza vaccination coverage followed a similar pattern to variations in 1 coverage.

## Discussion

This study demonstrates an association between maternal influenza vaccination and infant influenza vaccination among the U.S. privately-insured population. Infants born to people who received influenza vaccine during pregnancy were more likely to receive any dose of influenza vaccine during their first season of eligibility for vaccination and more likely to be fully vaccinated (2 doses) than infants born to people who were not vaccinated during pregnancy. Increasing uptake of influenza vaccination during pregnancy would provide greater protection against influenza-associated morbidity and mortality for infants too young to be vaccinated and may contribute to increased influenza vaccination of infants aged six months and older who remain vulnerable to hospitalization and death from influenza infection relative to older children.

Research in the United States and Australia has found that decisions to vaccinate or not vaccinate children are frequently made during pregnancy. First-time mothers in particular may still be gathering information to make decisions on whether to vaccinate their infants after birth.<sup>21, 22</sup> One study found similar attitudes toward childhood vaccination among women who received vaccine information during their pregnancy and at the first infant immunization visit, but 34% of participants indicated a preference for receiving the information at a prenatal visit.<sup>23</sup> A 2014 study found the majority of pregnant participants reported receiving no information on childhood vaccination from their pregnancy care professionals;<sup>24</sup> another study found the majority of women felt their obstetric professional was an acceptable source of information for childhood vaccinations.<sup>25</sup> Pregnancy care professionals who are counseling their patients regarding vaccination during pregnancy can use this ‘teachable moment’ to provide education about the importance of childhood vaccination for infants post-delivery as well. Continuing education from physician professional societies may be useful to support practitioners in these conversations, as a substantial proportion of obstetrician-gynecologists may not feel comfortable discussing infant vaccination with their patients.<sup>26</sup>

The uptake of prenatal influenza vaccination remains low in this study population, despite the fact that influenza vaccination during pregnancy has been recommended for decades. If a pregnant person declines prenatal influenza vaccination during a visit to an obstetric professional, this may suggest underlying vaccine hesitancy that could be addressed through healthcare professional counseling. One study found that parents who ultimately delayed or refused vaccination were more likely than vaccine-accepting parents to report thinking about infant vaccination during pregnancy and repeatedly re-evaluating this decision, suggesting that vaccination counseling by prenatal care professionals may be particularly important in reducing vaccine hesitancy.<sup>12</sup> Strong physician recommendation remains one of the most important predictors of prenatal vaccination.<sup>15, 27, 28</sup> According to the Standards for Adult Immunization Practice, all obstetric professionals should assess vaccination status at every prenatal visit, strongly recommend vaccines when patients are eligible, administer or refer patients for needed vaccines, and document vaccination in the immunization information system.<sup>29</sup> A recent survey of pregnant women indicated that one-quarter did not receive a healthcare professional recommendation for flu vaccine<sup>30</sup> and recent data indicate belief that the flu vaccine is not effective and safety concerns for the infant are the most common reasons for nonvaccination.<sup>31</sup> Early identification of unvaccinated mothers or vaccine hesitant parents can enable ongoing communication and education interventions at the individual, healthcare system and community levels to improve vaccination uptake.

These findings are subject to limitations. Our study data represented a convenience sample of paid insurance claims reported for reimbursement purposes and might not be representative of the U.S. privately-insured population. Influenza vaccination coverage for birthing parents and infants might be underestimated if a claim for vaccination was not submitted, not successfully submitted using a vaccination-specific code, not reimbursed by the insurance plan, or a parent or an infant was vaccinated outside of their insurance plan. Infant influenza vaccination might also be underestimated if the infant was vaccinated under a different insurance plan than the one that covered the birthing parent as these plans would

not share the family ID used to link infants to parents in our analysis. Finally, our findings may not be generalizable to people who are publicly insured or uninsured during pregnancy.

## Conclusion

The COVID-19 pandemic resulted in substantial reductions in utilization of preventive care,<sup>32</sup> including routine vaccination among adults.<sup>33, 34</sup> Early data for the current (2022–23) influenza season suggest lower vaccination coverage among pregnant persons than the previous season,<sup>35</sup> potentially putting greater numbers of pregnant persons and their infants at risk for preventable illness, hospitalization, and death associated with influenza infection. Our results show a positive and statistically significant relationship between receipt of influenza vaccination during pregnancy and infant influenza vaccination status in their first season of eligibility for vaccination. Interventions to increase uptake of influenza vaccination during pregnancy may also increase infant influenza vaccination coverage, offering greater protection against serious complications of influenza for both pregnant persons and their young infants. Obstetrician-gynecologists, midwives, and other healthcare professionals who may encounter pregnant patients (including pediatricians, general practitioners, and pharmacists) should strongly recommend influenza vaccination in any trimester of pregnancy throughout the influenza season. In addition, healthcare professionals, public health officials, and community groups should continue efforts to reduce misinformation about influenza vaccination and increase vaccine confidence among pregnant people to increase vaccination coverage and maximize protection from influenza infection for pregnant people and infants under 6 months.

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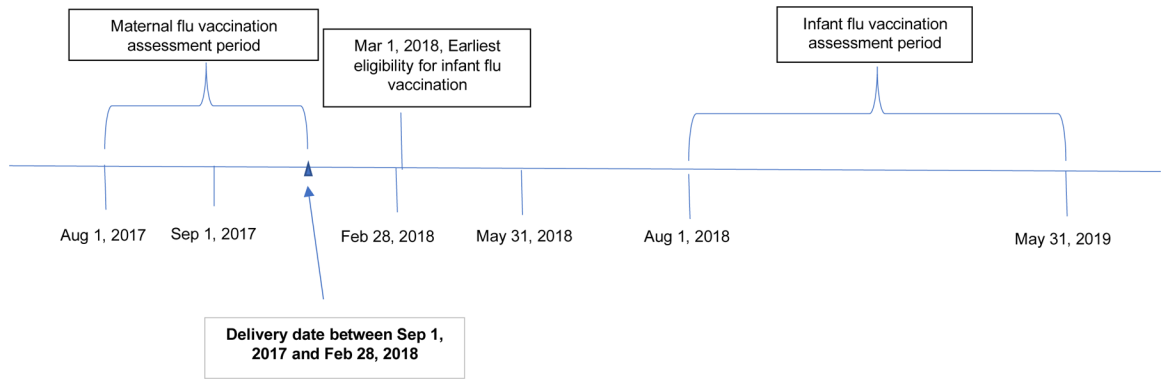
Influenza vaccination receipt during pregnancy is associated with infant influenza vaccination in their first season eligible for vaccination.

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**Figure 1.** Timing of influenza vaccination eligibility and assessments for pregnant people and infants, 2017–2018 and 2018–2019 influenza seasons.

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**Table 1.**

Association between maternal influenza vaccination and influenza vaccination of their infants among privately insured population

Variable	Maternal Influenza Vaccination Status						Difference by Maternal Vaccination Status	
	Vaccinated			Unvaccinated			Infants with 1 dose Coverage (%)	Infants with 2-dose Coverage (%)
	N	Infants with 1 dose Coverage (%)	Infants with 2-dose Coverage (%)	N	Infants with 1 dose Coverage (%)	Infants with 2-dose Coverage (%)		
Overall	14,168 (40.6%)	90.0	75.5	20,751 (59.4%)	66.3	51.8	23.7	23.7
Maternal Age (years)								
15–34	9,931 (39.3%)	89.1	74.2	15,319 (60.7%)	65.8	51.4	23.2	23.0
35–49	4,237 (43.8%)	92.2	78.8	5,432 (56.2%)	67.5	52.9	24.9	26.7
Residence in MSA								
Yes	12,961 (41.3%)	90.8	76.7	18,395 (58.7%)	67.3	53.0	23.5	24.1
No	1,207 (33.9%)	81.9	63.6	2,356 (66.1%)	58.1	42.5	23.3	20.6
Region of policyholder residence								
Northeast	2,271 (45.2%)	91.9	79.8	2,754 (54.8%)	71.4	57.4	21.0	23.0
Midwest	3,938 (44.2%)	91.2	77.3	4,978 (55.8%)	67.0	54.2	24.5	23.3
South	5,748 (36.1%)	88.1	73.5	10,161 (63.9%)	64.3	49.0	23.6	24.7
West	2,211 (43.6%)	91.0	73.4	2,858 (56.4%)	67.0	52.1	23.7	22.1
Type of benefit plan								
FFS	320 (35.0%)	88.8	74.7	594 (65.0%)	55.1	41.4	32.7	37.1
Managed	9,342 (39.2%)	90.0	75.3	14,516 (60.8%)	67.2	52.9	21.8	23.7
CDHP	2,073 (40.9%)	89.3	74.6	2,995 (59.1%)	63.4	47.5	25.0	28.2
HDHP	2,433 (47.9%)	90.8	77.5	2,646 (52.1%)	66.8	53.0	25.0	26.7

MSA = metropolitan statistical area, FFS = Fee-for-Service, Managed = Managed Care, CDHP = Consumer Driven Health Plan, HDHP=High Deductible Health Plan

**Table 2.**

Multivariate log-binomial regression analyses of factors associated with 1 dose infant influenza vaccination

Variable	Unadjusted Risk Ratio for coverage (95% CI)	Adjusted Risk Ratio for coverage (95% CI)*
Maternal influenza vaccination status		
Vaccinated	1.36 (1.34–1.37)	1.34 (1.33–1.36)
Unvaccinated	Referent	Referent
Maternal age (years)		
15–34	Referent	Referent
35–49	1.04 (1.03–1.06)	1.02 (1.01–1.03)
Residence in MSA		
Yes	1.16 (1.14–1.19)	1.12 (1.10–1.15)
No	Referent	Referent
Region of policyholder residence		
Northeast	1.04 (1.02–1.06)	1.02 (1.00–1.03)
Midwest	1.00 (0.98–1.02)	1.01 (1.00–1.03)
South	0.94 (0.92–0.96)	0.97 (0.96–0.99)
West	Referent	Referent
Type of benefit plan		
FFS	Referent	Referent
Managed	1.14 (1.09–1.19)	1.09 (1.05–1.14)
CDHP	1.11 (1.05–1.16)	1.07 (1.03–1.12)
HDHP	1.17 (1.12–1.23)	1.09 (1.04–1.14)

MSA = metropolitan statistical area, FFS = Fee-for-Service, Managed = Managed Care, CDHP = Consumer Driven Health Plan, HDHP=High Deductible Health Plan

\* The final adjusted model comprises all of the covariates included in this table.