Infant Hospitalizations and Mortality After Maternal Vaccination

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BACKGROUND: The Advisory Committee on Immunization Practices currently recommends pregnant women receive influenza and tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccines. There are limited studies of the long-term safety in infants for vaccines administered during pregnancy. We evaluate whether maternal receipt of influenza and Tdap vaccines increases the risk of infant hospitalization or death in the first 6 months of life.

METHODS: We included singleton, live birth pregnancies in the Vaccine Safety Datalink between 2004 and 2014. Outcomes were infant hospitalizations and mortality in the first 6 months of life. We performed a case-control study matching case patients and controls 1:1 and used conditional logistic regression to estimate odds ratios for maternal exposure to influenza and/or Tdap vaccines in pregnancy.

RESULTS: There were 413,034 live births in our population. Of these, 25,222 infants had hospitalizations and 157 infants died in the first 6 months of life. We found no association between infant hospitalization and maternal influenza (adjusted odds ratio: 1.00; 95% confidence interval [CI]: 0.96–1.04) or Tdap (adjusted odds ratio: 0.94; 95% CI: 0.88–1.01) vaccinations. We found no association between infant mortality and maternal influenza (adjusted odds ratio: 0.96; 95% CI: 0.54–1.69) or Tdap (adjusted odds ratio: 0.44; 95% CI: 0.17–1.13) vaccinations.

CONCLUSIONS: We found no association between vaccination during pregnancy and risk of infant hospitalization or death in the first 6 months of life. These findings support the safety of current recommendations for influenza and Tdap vaccination during pregnancy.
The Advisory Committee on Immunization Practices currently recommends 2 vaccines to be given during each pregnancy; influenza vaccine has been recommended at any time during pregnancy since 2004 to prevent maternal influenza disease and complications and tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine has been recommended during each pregnancy since 2012, with a preference for administration between 27 and 36 weeks' gestation, to protect infants from pertussis disease. Given the relative proximity of an immunization administered during pregnancy to a potential infant hospitalization or death, an observed temporal association with maternal influenza or Tdap vaccine during pregnancy and infant death or hospitalization may raise concerns about a possible causal relationship.

Both pertussis and influenza infections are associated with hospitalizations and fatalities in infants, and severity is highest before infants are eligible for the respective vaccines. Approximately half of infants <4 months of age with pertussis require hospitalization, and the majority of deaths from pertussis occur in these infants. In 2014, the US pertussis case rate in infants <6 months of age was 169 per 100 000 infants. Furthermore, there were 8 deaths in infants <3 months of age and 1 death in infants 3 to 11 months of age out of 13 total deaths from pertussis in all age groups in 2014. Similarly, infants are at high risk of hospitalization and death from influenza. The US influenza hospitalization rate ranges from 1.8 to 7.2 per 1000 in infants <6 months of age. For the 2013–2014 influenza season, there were 96 laboratory-confirmed, influenza-associated pediatric deaths, 18 of which occurred in children aged <6 months. Maternal immunization with influenza and Tdap vaccines allows for passive antibody transfer and protection to infants for the respective diseases when they are most vulnerable. In 2015, the infant (≤12 months) mortality rate in the United States was 589.5 per 100 000 live births, and the leading causes of infant deaths were (1) congenital malformations, deformations, and chromosomal abnormalities; (2) disorders related to low birth weight and short gestation; and (3) sudden infant death syndrome. In 2010, the leading causes of hospitalizations in infants ≤12 months were (1) acute bronchitis (238 per 10 000 population), (2) jaundice (104 per 10 000 population), and (3) pneumonia (56 per 10 000 population). Although there have been reassuring safety data for influenza and Tdap vaccines in which maternal acute events, pregnancy complications, and birth outcomes were evaluated, there have been limited safety studies beyond the immediate neonatal period. Vaccine safety continues to be a primary reason why providers and patients choose not to vaccinate during pregnancy. Although the biologic plausibility is unclear for the association of maternal vaccination and infant hospitalization or death, there may be concerns of long-term effects on infants after any pregnancy exposure. In this study, we evaluate whether maternal receipt of influenza and Tdap vaccines increases the risk of hospitalization or death in US infants in the first 6 months of life.

**METHODS**

**Study Population**

The Vaccine Safety Datalink (VSD) is a collaboration between the Centers for Disease Control and Prevention and 8 integrated health care systems (sites) and includes vaccination and health care data on ~10 million persons per year. In addition, the VSD includes data on ~125 000 pregnant women annually. We used data on pregnant women from 5 VSD sites with available data that comprise over 90% of the VSD population: Kaiser Permanente Northern California (Oakland, CA), Kaiser Permanente Southern California (Pasadena, CA), Kaiser Permanente Colorado (Denver, CO), Marshfield Clinic Research Foundation (Marshfield, WI), and Kaiser Permanente Northwest (Portland, OR).

We used the validated VSD Pregnancy Episode Algorithm to identify pregnant women. The Pregnancy Episode Algorithm uses comprehensive electronic medical record and administrative databases (including diagnosis and procedure codes, laboratory tests, pharmacy records, and imaging procedures) to identify pregnancies, pregnancy outcomes, and pregnancy start and end dates, and it is able to link pregnant women to their infants. We included women from the VSD with pregnancies ending in a live birth between January 1, 2004, and June 30, 2014. We required pregnant women to be enrolled at a VSD site for the duration of the pregnancy episode and to have at least 1 prenatal care visit. To increase completeness of data, infants of these pregnant women were required to have a birth record and to have VSD site enrollment until 6 months of life or until the time of death. We excluded pregnancies in which a live vaccine was administered because live vaccines are contraindicated in pregnancy. We also excluded infants of multiple gestation pregnancies, infants born before 34 weeks’ gestation, and infants with major birth defects because these infants are at a higher risk of hospitalization and death. Furthermore, we excluded all infants who died during their delivery hospitalization because cause of death in these infants is often a perinatal complication (such as placental abruption) that would likely be unrelated to maternal
controls for the infant mortality
hospitalizations from January 1,
2004, to December 31, 2013, and
deaths occurring from January 1,
state death records. Because of lag
time of death to the availability of
approximately a 1-year lag from the
electronic medical records, and
identified from state death records,
and later died. In the VSD, deaths are
patient if the infant was hospitalized
hospitalization). Furthermore, an
hospitalization was selected for
first 6 months of life. For infants
hospitalization in the
first 6 months of life. For infants
hospitalization was selected for
each category (ie, first all-cause
hospitalization, first respiratory
hospitalization). Furthermore, an
could be included as a death
case patient and hospitalization case
patient if the infant was hospitalized
and later died. In the VSD, deaths are
identified from state death records,
electronic medical records, and
administrative sources, and there is
approximately a 1-year lag from the
time of death to the availability of
state death records. Because of lag
time in the death data, we evaluated
deaths occurring from January 1,
2004, to December 31, 2013, and
hospitalizations from January 1,
controls for the infant mortality
analysis were selected among
infants in the study who survived
the first 6 months of life. Matched
controls for the infant hospitalization
and respiratory hospitalization
analyses were selected from infants
without death or hospitalization in the
first 6 months of life. All infant
controls were required to have at
least 1 diphtheria-tetanus-acellular
pertussis (DTaP) vaccine recorded
between 6 weeks and 6 months of
age to ensure infants were accessing
the health care system. We matched
case patients and controls 1:1 using
optimal matching.30 Case patients
and controls were matched on
the basis of VSD site, birth month
and year (within 1 month), and
gestational age groups of late
preterm (34–36 weeks), term (37–41
weeks), and postterm (42–44 weeks).
With our optimal matching, we
successfully found controls for 100%
of our case patients by using these
parameters.

Case-Control Matching

Among infants meeting inclusion
criteria, those infants with
hospitalizations or deaths within
the first 6 months of life were
included in this analysis. Respiratory
hospitalization case patients were
a subset of hospitalization case
patients defined by any respiratory
ICD-9 code (033, 460–488,
491–496, 510–519) associated
with a hospitalization in the
first 6 months of life. For infants
with >1 hospitalization, the first
hospitalization was selected for
each category (ie, first all-cause
hospitalization, first respiratory
hospitalization). Furthermore, an
infant could be included as a death
case patient and hospitalization case
patient if the infant was hospitalized
and later died. In the VSD, deaths are
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With our optimal matching, we
successfully found controls for 100%
of our case patients by using these
parameters.

Vaccinations

The exposure of interest was
maternal vaccination with any
influenza and/or Tdap vaccines
during pregnancy. A vaccine during
pregnancy was defined as one given
from 7 days after the pregnancy start
date to 7 days before the pregnancy
end date. These time windows were
chosen to avoid including exposures
to vaccinations given before or
immediately after pregnancy. We
stratified vaccine exposures as any
influenza vaccine (with or without
Tdap), any Tdap vaccine (with or
without influenza), and both
influenza and Tdap vaccines in the
same pregnancy. In our evaluation
of maternal influenza vaccine, we
also repeated our analysis limiting
outcomes to events occurring during
the influenza season (October
through May), to ascertain any
protective findings that may be more
evident when influenza virus is
circulating. We also did a sensitivity
analysis stratifying our exposure
by influenza vaccine only and Tdap
vaccine only to see if our results
would differ by limiting our exposure
groups.

Statistical Analysis

We measured rates of influenza and
Tdap maternal vaccination in our
study cohort from 2004 to 2013. We
also measured trends of infant deaths
and hospitalizations during this same
time period to look for any ecological
associations between maternal
vaccination and our infant outcomes.
For our main analysis, we performed
a conditional logistic regression
analysis to estimate the odds of
maternal vaccination in matched
case patients and controls. In our
analysis, we determined a priori
to include the following potential
confounders from electronic VSD
data sources28: Kotelchuck Adequacy
of Prenatal Care Index,31 race and
ethnicity (non-Hispanic African
American or American Indian versus
other races and ethnicities), maternal
age, pregnancy complications and
maternal comorbidities (hemorrhage,
hypertensive disorders, renal
disease, diabetes, thyroid disease,
cardiovascular disease, epilepsy),
smoking during pregnancy (yes, no,
or unknown), infant DTaP exposure
before outcome (or index date in
matched controls), duration of
birth hospitalization in days, and
gestational age at delivery in weeks.
We also reviewed medical records
of infants with respiratory related
deaths (ICD-10 codes: A37, J00–J99).
We reviewed clinical information
relating to a potential influenza- or
pertussis-related cause of death
and laboratory data in the 2-week
period preceding death. For influenza
laboratory data, we looked for
positive influenza A or B rapid
antigen, polymerase chain reaction
(PCR), viral culture, and direct
fluorescent antibody test results in
all respiratory death case patients.
For pertussis, we looked for positive
Bordetella pertussis PCR and culture
test results for any death case patient with the ICD-10 code A37 (whooping cough).

We determined a priori that with an expected average exposure rate of 15% for both vaccines throughout the study period, we would need at least 840 case patients to have 80% power to detect an odds ratio of 1.5. The protocol for this study was approved by the Centers for Disease Control and Prevention Institutional Review Board and institutional review boards at each of the participating VSD sites. All analyses were conducted by using SAS version 9.3 (SAS Institute, Inc, Cary, NC).

RESULTS

During our study period, we identified 500,447 pregnancies ending in a live birth that met enrollment criteria. We excluded 87,413 (17.5%) because of maternal or infant factors (Fig 1). Of the remaining 413,034 infants, 25,222 infants had 1 or more hospitalizations and 157 infants died. Of the hospitalized infants, 4,644 (18.4%) had a respiratory cause for their hospitalization; 105 (2.2%) of these infants had an influenza ICD-9 code (487, 488), and 137 (3%) had a pertussis ICD-9 code (033.0, 033.9). Of the deaths, 14 (9%) had a respiratory cause of death; however, none of these deaths were considered to have been caused by influenza or pertussis infections on the basis of our laboratory and medical record review. Of the 157 infants that died, the age at death ranged from 1 to 180 days with a mean of 61 days and a median of 51 days. The most common causes of death were unknown causes (32%), sudden infant death syndrome (21%), and certain conditions originating in the perinatal period (17%).

We analyzed overall trends of influenza and/or pertussis vaccination in pregnancy and trends of infant hospitalization and mortality in our study population from 2004 to 2013 (Fig 2). From 2004, there was an increase in maternal influenza vaccination, which became more dramatic in 2009 after the H1N1 influenza pandemic. Maternal Tdap vaccination increased starting in 2010 when California recommended pregnant women to receive Tdap in pregnancy in response to the 2010 statewide pertussis epidemic.

There was another increase in Tdap vaccination in 2012 after the most recent Advisory Committee on Immunization Practices recommendation to administer Tdap vaccination in every pregnancy. We observed no increase in the infant hospitalization rate or infant mortality rate during the same time period.

We matched case patients with eligible controls and compared characteristics between these groups (Table 1, Supplemental Table 3). Infants who were hospitalized were more likely to have mothers with pregnancy complications, less likely to be delivered by cesarean delivery, and less likely to be of African American non-Hispanic or American Indian race. Mean maternal age, gestational age at delivery, and length of birth hospitalization were statistically significantly different between the groups but not clinically different. Infants who died were similar to matched controls.

In our adjusted analysis, we found no significant association between infant hospitalization or death in the first 6 months of life and receipt of maternal influenza and/or Tdap vaccines and no significant association between infant hospitalization from respiratory causes and maternal influenza vaccine (Table 2). However, the odds of maternal Tdap vaccination was significantly lower among infants with hospitalizations because of respiratory causes (adjusted odds ratio: 0.79; 95% confidence interval [CI]: 0.67–0.94; P = .007) compared with controls without hospitalization. Furthermore, when evaluating infant hospitalizations and death occurring during periods of influenza virus circulation (October through May) and peak influenza virus circulation (November through February), we found no association with maternal influenza vaccine exposure (data not shown). When limiting our exposure groups to women receiving influenza vaccine without Tdap vaccine and Tdap vaccine without influenza vaccine, our results were similar to our main analysis (Supplemental Table 4).

DISCUSSION

In our study of maternal influenza and Tdap vaccines, we found no increased risk of infant all-cause hospitalizations, hospitalizations from respiratory causes, or all-cause mortality in the first 6 months of life. Our study helps strengthen the growing evidence of long-term safety of vaccination in pregnancy for infants.

Our findings are similar to other studies that have evaluated infant mortality and morbidity after maternal vaccination in pregnancy, most of which have evaluated the safety of adjuvanted H1N1 influenza-containing vaccines. Studies of short-term infant mortality in the first 7 days of life, growth and development and health care visits for infections in the first year of life, early neonatal or childhood death, and childhood hospitalization rates have not found an increased risk of these outcomes in children of women who received adjuvanted H1N1 influenza-containing vaccines in pregnancy. Unlike these previous studies, however, our study included women who received any type of influenza vaccine, none of which contain adjuvants in the United States, and we found similar results.
Our findings are also consistent with studies in which researchers have evaluated infant mortality and morbidity after Tdap vaccination in pregnancy. These researchers have evaluated neonatal mortality, NICU admissions, length of hospitalization, ventilation requirement, intraventricular hemorrhage, transient tachypnea of the newborn, neonatal sepsis, pneumonia, respiratory distress syndrome, and convulsions. There were no differences in outcomes between infants of Tdap-vaccinated and unvaccinated mothers in these studies. Our study included a longer follow-up period than these previous studies and still showed no increased risk of infant mortality or hospitalization after maternal Tdap vaccination.

Other long-term outcomes that have previously been studied after maternal Tdap vaccination include childhood development scores at 13 months of life, infant growth up to 5 to 7 months of age, and complex chronic conditions at 12 months.
The researchers for these studies did not find an increased risk of these infant outcomes after maternal Tdap vaccination during pregnancy. Our study managed a larger number of infants and had similar findings to these studies, further demonstrating long-term safety in infants of Tdap vaccine exposure in pregnancy.

We did find a protective association between maternal Tdap during pregnancy and infant respiratory hospitalizations, which is consistent with results of other published studies that have looked at infant pertussis as an outcome. However, only 3% of infants hospitalized for respiratory causes had a pertussis ICD-9 code. This could indicate that infants with pertussis are not being appropriately diagnosed and tested. It is also possible that other factors (eg, the healthy adherer effect and other differences in people who choose vaccination and those who do not) are contributing to this finding.

This study does have some limitations. The VSD captures data on an insured population, which could translate to better health outcomes than the general population. Additionally, VSD has a high rate of women with adequate prenatal care on the basis of the Kotelchuck index, which can translate to better infant outcomes. A recent study has revealed that despite being a fully insured population, the VSD is comparable to the total US population on many important demographic factors. Moreover, the VSD population size is large, and even groups that typically comprise a smaller proportion of insured populations (ie, lower income populations) still have a substantial (>2 million individuals) presence in the VSD. There may have been bias related to requiring controls to have a DTaP vaccine record to be included in the study. We did this to ensure we had access to health care utilization data to avoid misclassifying case patients as controls. To look for bias, we repeated our analysis of hospitalizations requiring case patients to be included in the study. We did this to ensure we had access to health care utilization data to avoid misclassifying case patients as controls. To look for bias, we repeated our analysis of hospitalizations requiring case patients to be included in the study. We did this to ensure we had access to health care utilization data to avoid misclassifying case patients as controls.

### TABLE 1 Characteristics of Matched Case Patients and Controls for Infant Hospitalizations and Mortality in the First 6 Months of Life in the VSD, 2004–2014

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hospitalization Case Patients (n = 25,222)</th>
<th>Matched Controls (n = 25,222)</th>
<th>P</th>
<th>Death Case Patients (n = 157)</th>
<th>Matched Controls (n = 157)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at event in d (range)</td>
<td>36 (1–183)</td>
<td>—</td>
<td>—</td>
<td>61 (1–180)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Mean gestational age at delivery in wk (range)</td>
<td>39 (34–43)</td>
<td>39 (34–43)</td>
<td>&lt;.0001</td>
<td>39 (34–41)</td>
<td>39 (34–41)</td>
<td>.88</td>
</tr>
<tr>
<td>Mean maternal age in y (range)</td>
<td>31 (13–54)</td>
<td>31 (13–55)</td>
<td>.0005</td>
<td>30 (15–41)</td>
<td>30 (16–41)</td>
<td>.23</td>
</tr>
<tr>
<td>Mean length of delivery hospitalization in d (range)</td>
<td>2.2 (0–103)</td>
<td>2.2 (0–110)</td>
<td>&lt;.0001</td>
<td>3.5 (0–41)</td>
<td>2.2 (0–18)</td>
<td>.43</td>
</tr>
<tr>
<td>Smoking during pregnancy, %</td>
<td>8.9</td>
<td>9.2</td>
<td>.38</td>
<td>15</td>
<td>10</td>
<td>.35</td>
</tr>
<tr>
<td>Pregnancy complications, %</td>
<td>31.0</td>
<td>28.7</td>
<td>&lt;.0001</td>
<td>34</td>
<td>27</td>
<td>.14</td>
</tr>
<tr>
<td>Cesarean delivery, %</td>
<td>23.6</td>
<td>27.9</td>
<td>&lt;.0001</td>
<td>36</td>
<td>31</td>
<td>.52</td>
</tr>
<tr>
<td>Adequate prenatal care by Kotelchuck index, %</td>
<td>94.2</td>
<td>83.9</td>
<td>.30</td>
<td>92</td>
<td>92</td>
<td>.92</td>
</tr>
<tr>
<td>African American non-Hispanic or American Indian race, %</td>
<td>5.9</td>
<td>7.2</td>
<td>&lt;.0001</td>
<td>10</td>
<td>6</td>
<td>.14</td>
</tr>
</tbody>
</table>

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*P* values calculated by *χ²* tests for categorical variables and Wilcoxon median 2-sample tests for continuous variables.

*P* values calculated by *χ²* tests for categorical variables and Wilcoxon median 2-sample tests for continuous variables.

*P* values calculated by *χ²* tests for categorical variables and Wilcoxon median 2-sample tests for continuous variables.

*P* values calculated by *χ²* tests for categorical variables and Wilcoxon median 2-sample tests for continuous variables.
patients to have a DTaP vaccine (98.0% of case patients) and found similar results to our main findings. We looked at broad safety outcomes (hospitalizations, respiratory hospitalizations, and deaths) and may not capture true increases in a specific outcome, if such an association was present. We relied on vaccination data from our VSD electronic data files and may not have captured vaccines in pregnancy occurring outside the health care system. However, previous internal work looking at influenza vaccination in pregnancy revealed that the VSD vaccine files are over 98% complete in capturing these data (J. Donahue, DVM, PhD, unpublished observations). We did not evaluate the risks of infant hospitalizations and mortality in multiple gestation infants, very preterm infants, and those with major birth defects because these infants are at a much higher risk of the outcomes we studied; therefore, our results are not generalizable to these populations. Finally, we were sufficiently powered for our outcomes of hospitalizations and hospitalizations from respiratory causes but underpowered for the outcome of death.

This is the first study in which infant hospitalizations and mortality in the first 6 months of life after maternal influenza vaccine and Tdap vaccines are evaluated. In this large case-control study, we found no increased risk of infant hospitalization and death after vaccination in pregnancy.

Our findings support the safety of influenza and pertussis vaccinations during pregnancy for infants of vaccinated mothers.

\textbf{TABLE 2} Matched Case-Control Analysis of Infant Hospitalizations and Death in the First 6 Months of Life in the VSD After Maternal Vaccination, 2004–2014

<table>
<thead>
<tr>
<th>Vaccine in pregnancy</th>
<th>Influenza$^a$</th>
<th>Tdap$^b$</th>
<th>Both$^c$</th>
<th>Influenza</th>
<th>Tdap</th>
<th>Both</th>
<th>Influenza</th>
<th>Tdap</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case patients exposed, %</td>
<td>38.7</td>
<td>12.8</td>
<td>8.6</td>
<td>38.4</td>
<td>9.9</td>
<td>7.1</td>
<td>32</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Controls exposed, %</td>
<td>39.3</td>
<td>13.4</td>
<td>9.0</td>
<td>38.1</td>
<td>11.4</td>
<td>7.4</td>
<td>37</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Crude OR (95% CI)</td>
<td>0.97 (0.93–1.01)</td>
<td>0.91 (0.85–1.01)</td>
<td>0.94 (0.87–1.01)</td>
<td>1.02 (0.93–1.12)</td>
<td>0.79 (0.67–0.93)</td>
<td>0.79 (0.67–0.93)</td>
<td>0.93 (0.78–1.13)</td>
<td>0.81 (0.69–1.00)</td>
<td>0.99 (0.81–1.04)</td>
</tr>
<tr>
<td>aOR$^d$ (95% CI)</td>
<td>1.00 (0.96–1.04)</td>
<td>0.94 (0.89–1.05)</td>
<td>0.97 (0.90–1.05)</td>
<td>1.08 (0.97–1.19)</td>
<td>0.79 (0.67–1.19)</td>
<td>0.79 (0.67–1.19)</td>
<td>0.97 (0.80–1.17)</td>
<td>0.96 (0.84–1.13)</td>
<td>0.44 (0.17–1.12)</td>
</tr>
<tr>
<td>\textit{P}$^e$</td>
<td>.93</td>
<td>.09</td>
<td>.44</td>
<td>.15</td>
<td>.07</td>
<td>.73</td>
<td>.87</td>
<td>.09</td>
<td>.10</td>
</tr>
</tbody>
</table>

$aR$, adjusted odds ratio; OR, odds ratio.

$^a$ Influenza vaccine in pregnancy given with or without Tdap vaccine.

$^b$ Tdap vaccine in pregnancy given with or without influenza vaccine.

$^c$ Both influenza and Tdap vaccines given in the same pregnancy.

$^d$ Adjusting for pregnancy complications, adequacy of prenatal care, smoking during pregnancy, race, maternal age, infant DTaP receipt before event, length of birth hospitalization in days, and gestational age at delivery in weeks.

$^e$ \textit{P} values correspond to the aOR.

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

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\textbf{ABBREVIATIONS:}

CI: confidence interval

DTaP: diphtheria-tetanus-acellular pertussis

ICD-9: International Classification of Diseases, Ninth Revision

ICD-10: International Classification of Diseases, Tenth Revision

PCR: polymerase chain reaction

Tdap: tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis

VSD: Vaccine Safety Datalink

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