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Provider group type and Tdap coverage in pregnancy

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ABSTRACT

Introduction: The Advisory Committee on Immunization Practices (ACIP) has focused on maternal Tdap immunization as an important means to protect neonates from pertussis infections. There is little published data on provider and/or clinic characteristics as predictors of maternal Tdap uptake. This study examined differences in maternal Tdap coverage in women delivering at a single academic institution, but cared for prenatally in different clinical settings, in 2013, 2014, and 2015. Additionally, the accuracy and utilization of Vermont's immunization information system (IIS) was assessed.
Methods: This was a retrospective, multiple time-point cross-sectional analysis of annual maternal Tdap coverage in women delivering at a single academic institution in the 3 years following a fundamental change in national maternal Tdap vaccination guidelines. Tdap administration was examined across different obstetric groups using chart review and data from the state's IIS.
Results: All obstetric care groups except the resident-staffed clinic significantly increased maternal Tdap coverage in 2014, compared to 2013 coverage, with no further increase in 2015. In contrast, there was no increase in maternal Tdap coverage in 2014 in the resident-staffed clinics, but then a statistically significant increase in 2015. Overall Tdap coverage in 2014 was 80.4%, with variation in Tdap coverage between clinics types. In the subset of women who were cared for by the University-based groups, there was significant variation in Tdap coverage between clinics, despite racial homogeneity, which persisted after adjustment for maternal age and insurance type. The state's IIS was found to be highly accurate, using individual chart review as the "gold standard."
Discussion: While we demonstrated high maternal Tdap coverage in women delivering at our institution, differences in clinic type and provider training appeared to impact immunization rates, as well as how quickly evolving national recommendations were adopted. Additionally, the fidelity of the state's IIS data was verified.

1. Introduction

Pertussis infections result in a considerable public health challenge worldwide. Pertussis has been called "the most poorly controlled vaccine-preventable disease in the developed world" [1]. The ongoing national resurgence of pertussis infections, which began in the 1980s, and appears to have peaked in 2012, has disproportionally affected young infants. Approximately 50% of infected infants under 1 year of age require hospitalization, of whom 1% will die of pertussis-related complications while hospitalized [2]. Because the vast majority of reported pertussis-related deaths in the U.S. occur in young infants who are not yet old enough to receive pertussis vaccination, the Advisory Committee on Immunization Practices (ACIP) of the Centers for Disease Control and Prevention (CDC) has focused on this vulnerable population through maternal immunization.

Tetanus and diphtheria toxoids with acellular pertussis vaccine (Tdap) administration during pregnancy not only reduces the risk of maternal pertussis infection, thereby reducing the risk of postnatal pertussis transmission from a woman to her infant, but also protects the infant more fundamentally, through transplacental passage of antipertussis antibodies. The ACIP's recommendations for prenatal Tdap administration have evolved significantly over the past decade, which reflect ongoing infant illness and death from pertussis, low maternal immunization rates, and increasing recognition of the importance of transplacental passage of maternal antibodies. In February of 2013, the ACIP made a significant change to prior recommendations for Tdap in pregnancy by stating

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that all pregnant women should receive a Tdap dose between 27 and 36 weeks of gestation in every pregnancy, regardless of prior immunization status [3]. Findings from a nationwide cohort study, published in 2018, support the ACIP's recommendations by showing that in infants of mothers who received prenatal Tdap at ≥27 weeks of gestation, the rate of pertussis was 58% lower (hazard ratio = 0.42, 95% CI = 0.23, 0.78) than in infants whose mothers did not receive Tdap in pregnancy or postpartum [4]. Furthermore, since this recommendation was made, the safety of maternal Tdap administration has been well- demonstrated in several large observational studies [5–10]. Currently, the 2013 ACIP guidelines remain in place, though with an adjustment (made in February 2017) that the vaccine be given during the early part of gestational weeks 27–36 [11].

Despite the ACIP's current recommendations, a multitude of U. S. studies have shown low Tdap vaccination rates in pregnancy [12,13]. While previous studies have assessed individual patient characteristics, such as age, race, socioeconomic status, insurance type, and geographic location as predictors of Tdap administration, there is little published on provider and/or clinic characteristics as predictors of Tdap uptake [14–16]. Even within the same geographic area, obstetric care providers may care for pregnant women in different clinical settings (i.e. a clinic staffed by certified nurse midwives versus one staffed by maternal fetal medicine specialists) with different clinical training (family medicine versus obstetrics), and varied years of experience (resident physicians versus attending physicians). Whether these provider and associated clinic differences impact adoption of new recommendations, and ultimate Tdap immunization uptake in pregnant women, is unknown. This is of substantial importance, as provider recommendations for the administration of vaccines are strong predictors of patient vaccine acceptance [17–20].

The primary objective of this study was to assess differences in Tdap administration in women delivering at a single academic institution and in the context of different prenatal outpatient clinical settings, in the 3 years after the 2013 ACIP maternal Tdap recommendation change. The secondary objective was to assess the local utilization and the accuracy of Vermont's Immunization Information System (IIS).

2 Methods

This was a retrospective, multiple time-point cross-sectional study, performed to assess local variation in maternal Tdap vaccine coverage in women cared for in different obstetric clinic contexts in the years following the 2013 change in the ACIP's recommendation. While the ACIP made the recommendation that all pregnant women receive Tdap vaccination between 27 and 36 weeks of gestation in late 2012, the publication appeared in early 2013 [3]. We therefore assessed Tdap vaccination coverage in women who delivered in 2013, 2014, and 2015 to assess annual vaccine coverage variation. Women who delivered at the University of Vermont Medical Center, a tertiary care academic institution, between January 1, 2013 and December 31, 2015 were included in the study. Inpatient maternal transports from outside hospitals were excluded from analyses, as were women for whom outpatient vaccination records were unavailable. Women with births <36 weeks of gestation were also excluded, as a proportion of these patients would have likely received the vaccination in the recommended time-frame had they not delivered early. This study was approved by University of Vermont's Institutional Review Board, as well as by the Vermont Department of Health (VDH). A Data Use Agreement was signed by the appropriate institutional and health department leadership.

While all women delivered at a single institution over the 3-year study period, they were cared for prenatally in varied clinical settings. Provider groups included the following university-based academic clinical groups: general obstetrics and gynecology (Ob/GYN) clinics, maternal fetal medicine (MFM) clinics, resident-staffed clinics (with both general Ob/GYN and MFM supervision), certified nurse midwifery (CNM) clinics, and family medicine service (FMS) clinics. Additionally, there were three private general Ob/GYN clinics, and one federally qualified community health center (staffed by family medicine physicians) caring for patients who ultimately delivered at our institution (Table 1 includes all of the provider groups). Delivery data, including maternal age at delivery, was obtained through ObNet, a perinatal database used regionally during this time-frame, which also allowed identification of the provider group for each patient. Deliveries and patient identifiers were sent to the VDH securely, such that names/dates of birth could be matched to Vermont Immunization Registry (our state's IIS) data. Whether or not prenatal Tdap was received, and the date of immunization were provided by the VDH. In addition to clinic/provider type, maternal age and insurance status (provided by our hospital's billing division), were assessed in relation to maternal Tdap coverage for women cared for in the university-based practices over the 3-year period (2013 through 2015).

All five university-based clinics were enrolled in Vermont's IIS, while two of the four non-university-based clinics providing obstetric care did not utilize the registry. To capture Tdap coverage in the obstetric practices not enrolled in the registry, a retrospective chart review was performed by a single author (CC) to assess the immunization status of women who received their prenatal care from a group not enrolled in the Vermont's IIS, and who delivered in 2014 (as this was the year with the greatest overall increase in Tdap vaccine coverage in the IIS dataset). Additionally, to assess the accuracy of the Vermont Immunization Registry, chart review, considered the "gold standard" for evaluation of maternal Tdap immunization status in this study, was performed for all patients cared for in practices (university-based and private practice) enrolled in the IIS who delivered at our institution at ≥36 weeks over the same one- year period. The chart review therefore included women from the five university-based practices (General Ob/GYN, MFM, CNM, Ob/GYN Resident Clinic, and FMS) and two outside practices, all of which reported to the Vermont's immunization registry, as well as the two outside clinics not reporting to the IIS (Table 1).

2.1. Statistical Methods

Maternal Tdap vaccine coverage was computed by year (2013, 2014, and 2015) for each group enrolled in the Vermont's IIS. Generalized estimating equations (GEE) were used to fit a logistic regression model to evaluate differences in Tdap administration rates between clinics, study year, along with their interaction. Statistical significance was based on Wald chi square tests. Study year was considered a categorical variable for all analyses. Comparisons of Tdap administration between years within each clinic were performed using chi square tests.

For 2014, in which chart review data was available, Tdap Immunization rates and associated exact binomial confidence intervals were computed based on both chart review and IIS data. McNemar's test for correlated proportions was used to test for differences in rates computed based on the two data sources. The overall concordance, representing the percent of cases in agreement, was computed along with exact binomial confidence intervals for each clinic. Chi square tests were used to compare immunization rates across clinics, university and non-university based groups, and those enrolled and not enrolled in the Vermont's IIS registry based on the 2014 chart review data.

Table 1
2014 Tdap administration rates and data source concordance by clinic type.

Outpatient obstetric clinic type	Number of deliveries >36 weeks	IIS immunization rate (%) (Exact 95% CI)	Chart review immunization rate (%) (Exact 95% CI)	Cases concordant (%) (Exact 95% CI)
Private Practice 1	280	70.7 (65.0, 76.0)	76.8* (71.4, 81.6)	92.5 (88.8, 95.3)
Ob/GYN Resident Clinic	133	67.7 (59.0, 75.6)	67.7 (59.0, 75.5)	94.0 (88.5, 97.4)
General Ob/GYN	143	88.1 (81.6, 92.9)	89.5 (83.3, 94.0)	96.5 (92.0, 98.9)
Certified Nurse Midwifery	278	84.9 (80.1, 88.9)	85.6 (80.9, 89.5)	96.4 (93.5, 98.3)
Maternal Fetal Medicine	166	73.5 (66.1, 80.0)	75.3 (68.0, 81.7)	95.2 (90.7, 97.9)
Family Medicine Service	72	91.7 (82.7, 96.8)	81.9* (71.1, 90.0)	87.5 (77.6, 94.1)
Community Health Center	77	79.2 (68.5, 87.6)	80.5 (69.9, 88.7)	96.1 (89.0, 99.2)
Private Practice 2	217	Not enrolled	92.6 (88.3, 95.7)	N/A
Private Practice 3	614	Not enrolled	77.2 (73.7, 80.5)	N/A

IIS = Immunization Information System.
* IIS and Chart Review immunization rates are significantly different ($p < 0.05$) based on McNemar's test for correlated proportions.

Additionally, chi square tests were used to compare university-based clinics on the distribution of maternal age (<25, 25–29, 30–34, and ≥35) and insurance status (public versus private) for each study year. Logistic regression, fit using GEE models (SAS, PROC GENMOD), were used to evaluate the association between insurance status and maternal age with Tdap vaccine coverage within university-based clinics. Unadjusted and adjusted odd ratios were computed based on univariate models (single predictor one-at-a-time) and on a multivariate model which included maternal age, insurance status, clinic group, study year, and group by year interactions. Our population demographic is 94% non-Hispanic white, thus race/ethnicity was not included as a component of our investigation. Based on the results of the multivariate logistic regression model, adjusted Tdap rates were computed for each clinic for each year using the inverse logit function. These estimates represent expected Tdap coverage if all clinics across all years had identical distributions of patients with respect to insurance status and maternal age. All statistical analyses were performed using SAS statistical software Version 9.4 (SAS Institute, Cary, NC). Statistical significance was determined based on $\alpha = 0.05$.

3. Results

3.1. State immunization registry data: Maternal Tdap coverage

There were 1119, 1153, and 1316 women who delivered at our institution in 2013, 2014, and 2015, respectively, and whose provider group was enrolled in Vermont's IIS. Fig. 1 shows Tdap vaccination coverage by year for the seven groups enrolled in Vermont's immunization registry for the entire three- year study period. Logistic regression results based on GEE modeling indicated that changes in administration rates over time were different among provider groups (group by year interaction Wald $X^2_{12} = 27.9$, $p < 0.001$). While all provider groups significantly increased their Tdap administration from 2013 to then end of 2015, this increase was due to increases in Tdap coverage from 2013 to 2014, followed by no significant changes between 2014 and 2015 for all groups except the Ob/GYN resident-staffed clinic. The resident-staffed clinic showed no significant improvement in maternal Tdap vaccine coverage from 2013 to 2014 ($X^2_1 = 0.09$, $p = 0.77$), followed by a significant increase from 2014 to 2015 ($X^2_1 = 4.16$, $p = 0.04$).

3.2. Accuracy of the State-wide IIS

There were 1989 women who delivered at our institution in 2014 (the year corresponding to the greatest overall increase in maternal Tdap administration) at ≥36 weeks. Outpatient vaccine records were unavailable for nine patients who delivered in 2014. Our medical record review therefore included 1980, or 99.5% of the 1989 women who delivered at ≥36 weeks at our institution in 2014 (after exclusion of inpatient transports). Estimated maternal Tdap vaccine coverage for each group, with associated 95% confidence intervals based on IIS registry data (if available) and chart review are displayed in Table 1. Additionally, for the seven practice groups for which data was available from both sources, the concordance is presented. For practice groups with both data sources available in 2014 (n = 1149 women), vaccine coverage was 77.7% (95% CI: 75.2, 81.1%) and 79.8% (95% CI:77.5, 82.1%) based on the IIS state registry and chart review, respectively (McNemar's test, $p < 0.001$) with 94.4% (95% CI: 93.1, 95.7%) of cases concordant. When the additional chart review data was incorporated from the practices for which IIS data was not available, the overall prenatal vaccine coverage for 2014 was 80.4% (95% CI:78.6, 82.1) based on 1980 women. Timing of Tdap administration in the same 1980 women revealed that 86.7% (95% CI: 84.7%, 88.6%) of Tdap immunizations occurred between 27 and 36 weeks of gestation (data not shown). Despite significant variation between clinics ($X^2_7 = 55.7$, $p < 0.001$), there was no significant difference in Tdap vaccine coverage between the university-based and the non-university groups (80.8% versus 80.1%, respectively, $X^2_1 = 0.14$, $p = .71$), or groups enrolled in Vermont's IIS and those not enrolled (79.8% versus 81.2%, $X^2_1 = 0.64$, $p = 0.43$).

3.3. Maternal age, insurance status and clinic type in relation to Tdap administration

Lastly, we conducted analyses to investigate the influence of maternal age and insurance type (private versus public), as well as prenatal clinic type, on maternal Tdap coverage. This data was only available for the university-based clinics, and was examined for each year of the 3 year study period (2013–2015). There were a total of 2453 women who delivered ≥36 weeks and were cared for by a university-based group over the 3 years. Maternal age

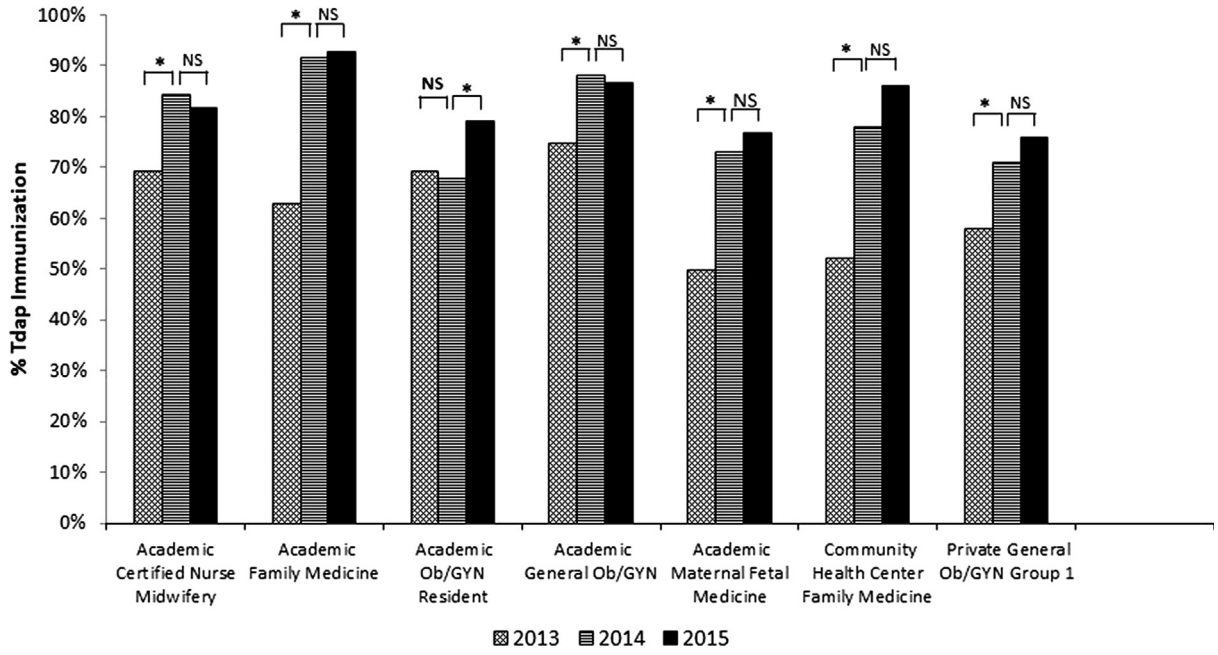

Fig. 1. Tdap immunization rates in pregnancy according to type of outpatient clinic, 2013–2015.

was considered using the following 5-year groupings: <25, 25–29, 30–34, and ≥35. As shown in Table 2, for each of the study years, the distribution of maternal age was statistically different across the clinical groups (X^2_{12} = 49.1 to 67.2, p = <0.001). Patients cared for in the Ob/GYN resident and Family Medicine clinics were younger, while women in the Maternal Fetal Medicine and General Ob/GYN clinics were more likely to be ≥35. Furthermore, there was substantial variation in the percent of women who were publicly insured across clinics for each study year, ranging from approximately 20% to 90% (X^2_4 = 99.9 to 150.3, p = <0.001). Analysis of Tdap administration as a function of maternal age and insurance type is demonstrated in Table 3. As shown, younger women were less likely to receive prenatal Tdap vaccine, with women <25 years of age being 27% less likely to receive prenatal Tdap compared to women ≥35 years of age (adjusted OR 0.73, X^2_1 = 3.98, p = 0.049). In contrast, insurance carrier (public versus private) was not significantly associated with maternal Tdap vaccination (Table 3).

Table 4 shows the association of prenatal clinic type with maternal Tdap vaccination across each of the three study years. There were significant differences in prenatal Tdap administration as a function of clinic type and study year, which persisted after adjusting for maternal age and insurance status (X^2_8 = 23.6, p = 0.003 for group by year interaction).

4. Discussion

Our study showed high Tdap vaccine coverage in pregnancy at our institution, which was higher than most previous reports, and which increased significantly after the 2013 ACIP publication recommending Tdap vaccine administration in every pregnancy [12,19,21–23]. While the overall University and non-University-based clinics showed the most substantial increase in 2014, the Ob/GYN resident-staffed clinic showed no increase in Tdap administration between 2013 and 2014. This finding suggests that resident trainees may uptake modifications to national immunization recommendations differently. However, this was the only group to significantly increase maternal Tdap vaccination in 2015. Notably, there was a resident-led quality improvement project focused on improving prenatal Tdap coverage, which was initiated in late 2014, and continued through 2015. While it is possible that this project had a more profound effect on our Ob/GYN residents as a result of it being a resident-directed quality

Table 2
Maternal age and public insurance coverage for each University-based clinic, by year for each clinic type, 2013–2015.

	2013						2014						2015					
		% in Age category (years)				% Public Insurance		% in Age category (years)				% Public Insurance		% in Age category (years)				% Public Insurance
Group*	N	<25	25–29	30–34	≥35		N	<25	25–29	30–34	≥35		N	<25	25–29	30–34	≥35	
Family Medicine Service	53	17.0	30.2	37.7	15.1	30.2	72	25.0	33.3	23.6	18.1	37.5	69	27.6	31.9	27.5	13.0	40.6
Maternal Fetal Medicine	141	21.3	19.9	25.5	33.3	31.2	166	17.5	22.3	27.1	33.1	25.3	193	25.3	24.9	25.4	24.4	50.3
Ob/GYN Resident Clinic	137	32.9	35.0	22.6	9.5	70.8	133	30.1	39.8	21.8	8.3	75.9	123	30.5	35.6	30.7	3.2	89.4
General Ob/GYN	162	13.0	25.3	33.9	27.8	21.0	143	11.9	19.6	33.6	34.9	22.4	165	15.8	27.9	30.9	25.4	30.3
Certified Nurse Midwifery	204	16.7	27.4	31.9	24.0	26.0	278	14.0	26.6	36.6	23.7	29.9	414	13.9	25.0	41.8	19.3	30.4

* Age and insurance distributions are significantly different across groups in each year (p < 0.001).

Table 3
Unadjusted and adjusted odds ratios for Tdap administration associated with maternal age and insurance type.

	Unadjusted Odds Ratio					Adjusted Odds Ratio				
	% Tdap	OR	95% CI		p-value	% Tdap	OR	95% CI		p-value
Maternal Age					0.033					0.15
<25	72.0	0.72	0.54	0.96	0.025	74.6	0.73	0.54	1.00	0.049
25–29	77.4	0.96	0.73	1.26	0.78	78.8	0.93	0.70	1.23	0.62
30–34	79.0	1.05	0.81	1.38	0.70	80.0	0.99	0.75	1.31	0.97
≥35 (reference group)	78.1	1.00				80.0	1.00			
Insurance Type					0.12					0.64
Private	78.1	1.16	0.96	1.41	0.12	78.1	1.05	0.84	1.31	0.64
Public (reference group)	75.4	1.00				75.4				

Table 4
Annual association between Tdap administration and clinic type, University-based clinics only, 2013–2015.

	2013			2014			2015		
University-based Outpatient Obstetric Clinic Type	N	Tdap Coverage (%)[a]	Adjusted Tdap Coverage (%)[b]	N	Tdap Coverage (%)[a]	Adjusted Tdap Coverage (%)[b]	N	Tdap Rate (%)[a]	Adjusted Tdap Coverage (%)[b]
Family Medicine Service	53	64.1	63.5 a	72	91.7	91.7 a	69	92.8	92.9 a
Maternal Fetal Medicine	141	47.5	46.9 b	166	73.5	72.8 b	193	76.7	76.8 b
Ob/GYN Resident Clinic	137	69.3	70.3 a	133	67.7	68.6 b	123	78.9	79.7 bc
General Ob/GYN	162	75.3	74.4 a	143	88.1	87.5 a	165	86.7	86.3 ac
Certified Nurse Midwifery	204	69.0	68.4 a	278	84.9	84.4 a	414	82.1	81.5 bc

Within each year, adjusted rates not sharing a common letter are significantly different ($p < 0.05$).
[a] Tdap rates based on State IIS database.
[b] Adjusted Tdap rates are based on logistic regression using generalized estimating equations that adjust for population differences in maternal age (<25, 25–29, 30–34, ≥35) and insurance status (Public vs Private) across clinics and years.

initiative, it is also possible that this group's improvement in maternal vaccine coverage in 2015 is simply a reflection of their lower vaccination coverage in 2014.

The variation in Tdap immunization between types of prenatal clinics was striking, and was irrespective of insurance type. While younger maternal age was a predictor of lower Tdap coverage, significant clinic differences persisted after adjusting for differences on this variable. The apparent importance of prenatal clinic type to maternal Tdap vaccine coverage demonstrated in this study may be an indication that individual providers (in the specific clinical context in which they function) are crucial to successful maternal vaccination programs. For example, as shown in Fig. 1, the University-based Family Medicine Service had the highest Tdap vaccine coverage during the study period, and also had the most robust response to the 2013 ACIP recommendation. Because family medicine physicians often provide additional immunizations to their varied patient populations than what is required in Ob/GYN, the high maternal Tdap coverage by this group may reflect increased focus on immunization status by the provider. While there is a significant literature on vaccine hesitancy and patient characteristics which may predict lower vaccine uptake, there has been less focus on provider and clinic setting characteristics [20,24–26]. Our study highlights the importance of understanding the local context in which vaccines are being administered. Differences in clinic type and provider training appear to not only impact prenatal Tdap vaccine administration, but also appear to impact how quickly evolving national recommendations are adopted.

Lastly, we were able to demonstrate the accuracy of Vermont's IIS. Most prior studies have relied on claims data, patient surveys, and chart review to access maternal vaccination status, and few have accessed IIS data, partly because of nationwide and statewide variation in use of IIS in adult populations [12,22,27,28]. While substantial gains have been made in the use of such systems in pediatric populations nationwide, use of such systems in adult populations has lagged [29]. IIS are confidential, computerized, population-based systems that collect and consolidate immunization data from multiple sources, including hospitals, clinics, and pharmacies. Increasing enrollment in IIS programs for adult immunizations is a national priority [27,30]. The ability to monitor and access real-time population-level information on adult vaccination status is crucial from a public health standpoint. This will become more important in the obstetric context with the development of additional maternal vaccinations meant to protect the neonate. The ability to access Vermont's IIS not only allowed us to demonstrate the fidelity of the IIS data, but also assisted in the identification of patient and provider characteristics which may impact immunization practices. Use of locally relevant data allowed us to identify and promote enrollment of provider groups not previously enrolled in the IIS, and creates the opportunity to improve local immunization practices in the future.

Our study has several limitations. First, chart review was used as the "gold standard" for evaluation of maternal Tdap coverage, though it is very likely that such data is not perfectly accurate. Second, we were unable to access maternal education, income, and other markers of socioeconomic status, which may have influenced Tdap immunization status. Insurance status was used as an indicator of socioeconomic status, though may not be a reliable predictor of true socioeconomic demographics. Furthermore, we were only able to collect insurance status for women being seen prenatally at the University-based practices. Finally, given the racial and ethnic homogeneity of our population in Vermont, we are unable to assess the impact of such diversity on Tdap vaccination uptake, resulting in limited generalizability to more racially and ethnically diverse populations. Future studies assessing the impact of provider type and training on maternal Tdap administration in different maternal populations are needed.

Conflict of interest

The authors have no competing interests to declare.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.01.001.

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