

Association of a Best-Practice Alert and Prenatal Administration With Tetanus Toxoid, Reduced Diphtheria Toxoid, and Acellular Pertussis Vaccination Rates

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OBJECTIVE: To evaluate how implementation of a best-practice alert, a reminder of clinical guidelines within the electronic medical record, in combination with the recommended change in immunization timing from postpartum to antepartum, affected tetanus toxoid, reduced diphtheria toxoid and acellular pertussis (Tdap) rates, and to examine the association of vaccination with local pertussis attack rates.

METHODS: A Tdap best-practice alert was introduced into the electronic prenatal charting system in June 2013. The best-practice alert was designed to appear starting at 32 weeks of gestation and to reappear at every subsequent encounter until vaccine acceptance was recorded or delivery occurred. The overall acceptance rate was then compared with postpartum vaccination rates at our institution from the previous year. Records of pertussis cases in children younger than 2 years of age diagnosed since 2012 in Dallas County were also reviewed to correlate local trends with vaccination efforts.

RESULTS: Of the 10,201 women offered Tdap during prenatal care, 9,879 (96.8%) ultimately accepted. This is compared with a 48% (5,064 of 10,600) Tdap postpartum immunization rate in the year prior, before introduction of the best-practice alert. The incidence of pertussis

among neonates born to mothers who received prenatal care at Parkland Hospital showed a nonsignificant decline from 13 cases per 10,000 deliveries (19 of 14,834, 95% confidence interval [CI] 7–19) between January 2012 and May 2013 to seven per 10,000 deliveries during the study period (eight of 11,788, 95% CI 2–11, $P=.174$).

CONCLUSION: The use of a best-practice alert, in concert with the recommended change in timing of maternal vaccination from postpartum to antepartum, was associated with an increase in the Tdap immunization rate to 97%.

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Pertussis or whooping cough, a highly communicable upper respiratory disease, was a common childhood illness and a significant cause of mortality in the United States until the introduction of the first whole cell vaccine in the mid-1940s.¹ However, epidemiologic trends in *Bordetella pertussis* infection have demonstrated alarming increases since the 1980s with a steady rise in reported cases as well as associated morbidity and mortality. This pertussis resurgence has disproportionately affected infants, particularly those younger than 3 months of age, who are too young for vaccination and account for the majority of hospitalization and deaths.²

Studies examining the contact source for infants hospitalized with severe pertussis have consistently documented the mother to be the most common vector, because adult pertussis cases frequently go undiagnosed as such.^{3,4} This recognition led the Advisory Committee on Immunization Practices to implement serial alterations to the tetanus toxoid, reduced

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diphtheria toxoid, and acellular pertussis (Tdap) recommendations centered around pregnancy with the goal of reducing disease transmission to vulnerable infants. In February of 2013, the Advisory Committee on Immunization Practices published the most recent Tdap immunization guidelines, which recommend routine antepartum Tdap administration between 27 and 36 weeks of gestation in each pregnancy, regardless of vaccination history.⁵

Although the recommendation for antepartum Tdap is relatively recent and uptake data are still forthcoming, pregnant women historically have poor vaccination rates, ranging from 13% to 34% nationally, according to the Centers for Disease Control and Prevention.^{6,7} In an effort to boost these dismal immunization compliance rates during pregnancy, several strategies have been suggested, including the use of an electronic reminder of clinical guidelines within the medical record.⁸ Our objective was to evaluate the association of Tdap rates during pregnancy with a best-practice alert installation within the electronic medical record and the 2012 recommended change to prenatal administration. Additionally, we sought to analyze whether our hypothesized increase in Tdap rates translated into a decline in infant pertussis cases reported in Dallas County.

MATERIALS AND METHODS

Beginning in June 2013, Parkland Hospital began offering routine antepartum Tdap to all pregnant women seen in our prenatal care system, in accordance with the 2012 Advisory Committee on Immunization Practices recommendations. A best-practice alert within the electronic charting system, which appeared starting at or after 32 weeks of gestation, prompted health care providers to offer Tdap. Each patient's response to the best-practice alert was recorded in the electronic medical record along with date and time of vaccine administration. If a patient declined Tdap vaccine in response to the best-practice alert, additional electronic reminders continued at each prenatal visit thereafter, either until vaccine acceptance was documented or until delivery occurred. These repeated prompts served as an opportunity for the health care provider to address patient concerns regarding vaccination and supply additional vaccine information. Before implementation of the best-practice alert in June 2013, women were routinely offered Tdap immunization only during the postpartum period.

The current quality assessment project was approved by the University of Texas Southwestern Medical School institutional review board. Best-practice alert responses and Tdap vaccine administration dates

were extracted from the electronic medical record between June 2013 and July 2014 (epoch 2). For women who ultimately delivered at our institution, demographic information and maternal medical complications were abstracted from a prospectively maintained departmental database and compared with that of women who did and did not receive antepartum Tdap. Additionally, the overall acceptance rates with the use of the Tdap best-practice alert were compared with postpartum vaccination rates from the year directly preceding best-practice alert installation.

Records of pertussis cases reported in children younger than 2 years of age diagnosed between January 2012 and September 2014 were obtained from the Dallas County Health Department so pertussis rates could be compared between the study period (epoch 2) and the preceding 17 months (epoch 1). The historical comparator (epoch 1=17 months) and intervention (epoch 2=13 months) time-frames were chosen based on the availability of complete pertussis ascertainment data from the Dallas County Health Department as well as the timing of best-practice alert implementation. If the affected child's mother delivered at our institution, her Tdap immunization status was reviewed to establish whether maternal vaccination occurred during the course of care at Parkland Hospital and, if so, whether the vaccine was administered antepartum or postpartum.

Statistical analyses were performed using Fisher's exact test for categorical data and Student's *t* test for continuous data. *P* values <.05 were considered significant.

RESULTS

Over a 13-month period (epoch 2), we identified 10,201 women who were offered the Tdap vaccine during prenatal care, of whom 9,879 (96.8%) ultimately accepted antenatal Tdap immunization. Of the 7,378 women who ultimately delivered at Parkland Hospital, the acceptance rate was similar: 7,152 accepted (97%) and 226 declined (3%). In comparison, 48% (5,064 of 10,600) of women who delivered at Parkland in the year before the best-practice alert's introduction received the Tdap vaccine postpartum.

In the cohort of women delivering at Parkland Hospital, the mean gestational age of vaccine administration was 34.3 ± 2.4 weeks. On average, patients delivered 35.3 ± 17.3 days after antenatal Tdap immunization. As reported in our previous article on pregnancy outcomes after Tdap, there was no significant difference in maternal age, nulliparity, or body mass index between women who accepted vaccination and



those who declined.⁹ However, women who declined vaccination were more likely to be black or white, enroll later in prenatal care, and necessitate referral to our high-risk obstetric clinic.

According to Dallas County Health Department records, 61 cases of pertussis in children younger than 2 years of age were reported between January 2012 and May 2013 (epoch 1). Over the course of our study from June 2013 to July 2014 (epoch 2), 22 cases of pertussis were reported in this same cohort. The incidence of pertussis among neonates born to mothers who delivered at Parkland Hospital declined from 13 cases per 10,000 deliveries (19 of 14,834, 95% confidence interval [CI] 7–19) during the first epoch from the beginning of 2012 to mid-2013 to seven per 10,000 deliveries during the second epoch (eight of 11,788, 95% CI 2–11, $P=.174$). Interestingly, all women who delivered a neonate subsequently diagnosed with pertussis during the second epoch ($n=8$) were vaccinated (seven antepartum, one postpartum) reflecting the known incomplete Tdap vaccine effectiveness (estimated to be 70% by the Centers for Disease Control and Prevention).¹⁰ Six of the eight cases were diagnosed within 90 days of birth and all eight cases occurred within the infant's first 4 months of life.

DISCUSSION

We found that implementation of a best-practice alert in the electronic medical record, in combination with a switch from postpartum to antepartum administration, was associated with an increase in the rate of Tdap to 97% compared with a 48% postpartum acceptance rate at our institution in the year before the best-practice alert introduction. This high acceptance level is particularly notable in our county hospital-based prenatal care setting where the majority of pregnant patients are indigent, medically underserved, and receive Medicaid benefits.

The effect of the Advisory Committee on Immunization Practices change in Tdap timing recommendations from postpartum to antepartum on maternal acceptance rates is yet uncertain. Generally speaking, the Advisory Committee on Immunization Practices' expanded recommendations for Tdap administration, both in pregnant and nonpregnant individuals, have led to modest increases in Tdap uptake over the past 5 years,¹¹ although actual immunization rates still vary widely. A 2011–2012 survey of 1,231 recently postpartum women noted a 2.6% Tdap rate during their antecedent pregnancy (Liang J. Considerations for recommendation of Tdap for every pregnancy. Presented to the Advisory Committee on Immunization Practices; Atlanta, Georgia; October 24, 2012), raising

significant concerns about adherence to antepartum vaccination guidelines. Such concerns were affirmed by a 2011–2013 report on Tdap uptake in Michigan Medicaid recipients, which again documented a low antepartum Tdap rate of 14.3%.¹² However, a comparatively high uptake rate of 81.6% was reported by Goldfarb et al¹³ in a cohort of 1,467 women receiving coordinated prenatal care with targeted health care provider and patient education at Massachusetts General Hospital. These reports are consistent with trends described for the previous postpartum “cocooning” strategy, which demonstrated significant improvement after health care provider education, streamlining of processes, and implementation of standing orders.^{14–16}

The use of the electronic medical record to improve adherence to national recommendations such as immunization schedules is, however, in its infancy. Although electronic charting systems boast the potential to improve health care quality, safety, and efficacy based on improved legibility, comprehensiveness, streamlined communication, and employment of clinical reminders, such improvements in quality and outcomes have been difficult to document.^{17–19} A recent systematic review of eHealth systems published in 2011 concluded that the evidence base in support of such technologies is “weak and inconsistent...particularly in relation to patient-level benefits.”¹⁹

The use of the electronic medical record has been shown to be associated with increased influenza vaccination rates in several high-risk groups.^{20–22} Klatt and Hopp recently examined the association of a best-practice alert implementation and pregnant women's acceptance of the influenza vaccine. They noted a significant increase in influenza immunization rates, from 42% to 61% after the best-practice alert was instituted.²² Using a best-practice alert, like other successful vaccine coverage strategies used to promote immunizations, targets underlying issues identified as vaccination barriers, namely deficits in health care provider vaccine awareness, patient and health care provider knowledge gaps, and a lack of health care provider–patient communication regarding the importance of preventive care measures.^{23,24} By installing an automated clinical reminder within the electronic medical record, our health care providers were prompted to discuss the importance of Tdap in a timely manner, educate patients on vaccine benefits, and address any underlying patient concerns about immunization, all of which have been shown to be associated with increased vaccine acceptance.²³ Multiple studies



have shown that vaccine recommendation by health care providers governs parental decisions about immunization.^{24–27} In our study, the consistent, programmed best-practice alert reminding our health care providers to make this highly valued recommendation, along with streamlined processes for ordering and administering the vaccine, may account for the success of our Tdap program.

This study has several limitations, the most significant of which is our inability to distinguish how the temporal shift in Tdap administration from postpartum to antepartum, which occurred concurrently with best-practice alert implementation, may have positively contributed to our increased Tdap uptake. Additionally, our institution, although large, boasts a well-coordinated network of prenatal clinics that practices relatively homogenized and regimented care. Therefore, a best-practice alert was easily instituted and health care provider compliance was high, which may not be the case in all health care settings. Unfortunately, the design of our best-practice alert did not allow us to further analyze what additional barriers prevented the remaining 3% of women from accepting Tdap. Although the health care provider was prompted to cite a reason for patient vaccine refusal within the best-practice alert platform, the overwhelming majority utilized either the “patient declines” or “other” options, and no further explanation was requested or required, thus providing no additional information for targeted vaccine education. We are, however, able to identify specific clinics and health care providers with lower than average vaccination rates to target health care provider education.

Implementation of the Tdap vaccine best-practice alert within the electronic medical record, in combination with a switch from postpartum to antepartum administration, was associated with a high vaccination rate of 97% at our institution, representing a doubling from our postpartum immunization rate in the previous year. By serving as a timely reminder to health care providers, this relatively simple, inexpensive, and easily reproducible strategy has the potential to significantly improve national vaccine coverage during pregnancy, ultimately with the goal of decreasing maternal and pediatric infectious morbidity.

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