Quality Improvement Project

Analysis of Vaccination Rates of 23-Valent Pneumococcal Polysaccharide Vaccine after Quality Improvement Project in Hospitalized Patients with Diabetes Mellitus

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Abstract

Introduction: Since 2014, the American Academy of Pediatrics has recommended that patients over two years with diabetes mellitus (DM) receive the 23-valent pneumococcal polysaccharide vaccine (PPSV23). Methods: Retrospective chart review was initiated by a quality improvement (QI) project to determine PPSV23 administration rates for inpatients with DM at Children’s Hospital of Orange County (CHOC). The QI project included education for staff and families regarding need for PPSV23 in patients with DM. Electronic medical record (EMR) order sets for DM were updated with PPSV23 vaccine. Data were collected from EMR to identify differences in subjects who were vaccinated with PPSV23 and unvaccinated from April 2015 to April 2016. Results: Before April 2015, PPSV23 was not being given to inpatients with DM. There were 199 individual subjects admitted to CHOC with DM from April 2015 to April 2016. Of those, 78 subjects (39.1%) received vaccine. Data were categorized to identify if vaccine was ordered (n = 152) or not (n = 47). Univariate logistic regression analysis performed on whether PPSV23 was ordered showed age, location (pediatric intensive care unit [PICU] vs. floor), hemoglobin A1c (HbA1c), primary DM admission, and insulin pump vs. injection usage were significant factors (P < 0.05). Multivariate logistic regression showed that those with higher HbA1c (P = 0.014), new-onset DM (P = 0.009), and those admitted for primary DM-related issues (P = 0.007) were more likely to have PPSV23 ordered. No significant subject factors identified differences in why vaccine was not administered (n = 74) once ordered. Conclusion: PPSV23 rates for pediatric inpatients with DM increased from 0% to 39% during one year following education and EMR modifications.

Keywords: Diabetes mellitus, hospitals, pediatric, pneumococcal vaccines

Introduction

In 2014, the American Academy of Pediatrics (AAP) published new recommendations regarding pneumococcal vaccinations including the recommendation that children over two years of age with diabetes mellitus (DM) receive one dose of the 23-valent pneumococcal polysaccharide vaccine (PPSV23).[1] Patients with DM have been shown to have increased rates and complications from infectious diseases.[2] Patients with DM have been shown to have higher rates of invasive pneumococcal disease and increased incidence of disease caused by pneumococcal serotypes not covered by the 7-valent pneumococcal conjugate vaccine.[3] However, at Children's Hospital of Orange County (CHOC), children with type 1 DM (T1DM) were not receiving the PPSV23 vaccine as part of their routine care despite guideline recommendations.

While little data are available about PPSV23 vaccination rates in children, studies have looked at vaccination rates in...
adults. The National Health Interview Survey found that 52.6% of adults with DM had received a pneumococcal vaccine with higher immunization rates in older patients.[6] A single-center cross-sectional study at an adult hospital in the US showed that 37% of adults with DM received the PPSV23 vaccine.[8] A study conducted at two family medicine clinics showed only 29.8% of patients with DM received the PPSV23 vaccine. The main reasons for not receiving the vaccine were the vaccine not being addressed during visit, incorrect classification of a high-risk patient as low-risk, and vaccine refusal by patient.[9]

The goals of this study were to determine and improve the vaccination rates of PPSV23 in subjects with DM hospitalized at CHOC from April 2015 to April 2016 after the initiation of a quality improvement (QI) project and to identify differences in characteristics of vaccinated and unvaccinated subjects. The results will enhance systems and education at CHOC and elsewhere to further increase vaccination rates of PPSV23 in patients with DM.

**METHODS**

**Intervention**

A QI project was initiated at CHOC in March 2015. CHOC is a 279-bed children’s hospital with over 236 inpatient DM admissions in 2016. In 2015–2016, the endocrinology division followed 1,239 active T1DM patients and 195 active T2DM patients. The QI project was designed using the Plan-Do-Study-Act (PDSA) cycle method. Lectures and educational materials were provided to the pediatric endocrinology department, pediatrics department, and nursing staff focusing on the most recent AAP, IDSA (Infectious Disease Society of America), and ADA (American Diabetes Association) recommendations for PPSV23 vaccination and the published research behind the recommended guidelines. A flyer was distributed to families of children admitted with DM and the inpatient team was instructed to discuss the recommendations for the vaccine with the families. The inpatient team comprised attending physician, resident physicians, medical students, and bedside nurses. Electronic medical record (EMR) order sets for patients with DM admitted to the hospital were updated to include PPSV23 vaccination as a preselected order so that it would be given prior to discharge. The project was discussed with the inpatient pharmacy to ensure sufficient PPSV23 vaccine was available. CHOC Institutional Review Board approval was not required as intervention was a QI project designed to improve standard of care.

Pediatric subjects at least two years of age with DM who were admitted to the hospital were eligible for the vaccine. Subjects with a history of a severe, life-threatening allergic reaction to any component of the vaccine were excluded. Subjects received information on the risks and benefits of the vaccine and a copy of the Vaccine Information Sheet provided by the Centers for Disease Control. Administered vaccines were entered into the California Immunization Registry. SQUIRE (Standards for Quality Improvement Reporting Excellence Guidelines) guidelines were used in writing of manuscript.[7]

**Measurements**

After one year of intervention in order to assess the impact of the intervention, a retrospective chart review was performed on all subjects admitted to CHOC with DM to determine PPSV23 administration rates. Subjects were categorized into different groups to determine if subject-specific characteristics could be identified as potential associations for vaccinated vs. unvaccinated status. Determining which specific characteristics are associated with receiving the vaccine allows us to select which patient populations to focus on in future cycles of the intervention.

Initially we categorized subjects based on if PPSV23 was ordered (n = 152) or not ordered (n = 47). Of those who had the vaccine ordered, then it was determined if the vaccine was administered or not. Univariate binomial logistic regression was then completed on the collected variables including both demographic and clinical data. Specifically, data included date of admission, gender, race, age, the location of admittance (floor vs. pediatric intensive care unit [PICU]), hemoglobin A1c (HbA1c), reason for hospital admission (primary diabetes reason vs. other medical concern), timing of diagnosis discovery (known DM or new-onset DM), diabetes type 1 or 2, and whether the subject was on an insulin pump or injections. Two variables, age and HbA1c, were divided into categories. The age ranges were ≥ 2 to < 5 years old, > 5 years old to 12 years old, and > 12 years old.

**Data Analysis**

All the statistical analyses were performed using Statistical Package for the Social Sciences software version 24 (SPSS, Chicago, IL). For the initial comprehensive multivariate binomial logistic regression model, all significant variables (reason for admission, diabetes status, HbA1c categories, insulin pump usage, and location admitted) were added to the model. Only statistically significant factors were refined to the final multivariate analysis. After a final logistical regression model was built for this study, an odds ratio (OR) was calculated and adjusted for level. The OR for each significant variable was then converted to relative risk using the following conversion equation: \( RR = \frac{OR}{(1 - p + (p \times OR))}. \)

**RESULTS**

Before April 2015, PPSV23 was not being given to inpatients with DM. There was a total of 211 admissions for patients with DM from April 2015 to April 2016.
However, eight patients were admitted two times, and two patients admitted three times, resulting 199 individual subjects admitted to CHOC within study period. The vaccine was ordered 161 times in 152 unique subjects. PPSV23 was administered 87 times in 78 unique patients, resulting in an administration rate 54% of the ordered vaccines [see Figure 1].

Data were categorized to identify if the vaccine was ordered \( (n = 152) \) or not \( (n = 47) \). There were 15 total variables used in the univariate analysis. Five of the 15 variables were found to be insignificant during univariate analysis including gender, race, age, diabetes type, and date of admission. Hospital location of admission (PICU vs. floor) \( (P < 0.05) \) and insulin pump use \( (P < 0.001) \) were significant in the univariate analysis. Multivariate logistic regression showed that those with higher HbA1c, new-onset DM, and those admitted for a DM-related issue were more likely to have received the vaccine \( (P < 0.05) \) [see Table 1].

A subgroup analysis evaluated whether the vaccine was administered after being ordered. Of the subjects for whom the vaccine was ordered and was not given, a reason was documented for only 11 subjects. No significant subject factors identified differences in why the vaccine was not administered \( (n = 74) \) once ordered. For patients with multiple admissions, they either received the vaccine during a prior admission or did not receive the vaccine during any of their admissions. There were eight vaccine errors, consisting of six subjects receiving the vaccine on more than one admission and two subjects under the age of 24 months receiving the vaccine. No adverse effects occurred due to administration of the PPSV23 vaccine in any patient.

### Discussion

The rates of PPSV23 vaccination in subjects with DM admitted to CHOC increased from 0% to 39% during one year following a QI project that included patient and staff education and EMR modifications. Similar QI projects have been carried out in different pediatric populations and have had similar results. A QI project which aimed to increase pneumococcal vaccination rates in pediatric patients with systemic lupus erythematosus had an increase in the 13-valent pneumococcal conjugate vaccine (PCV13) vaccination rate from 6.7% to 48.4% and PPSV23 vaccination rate from 8.9% to 28.4% after a 53-week period.\[8\] Another QI project that aimed increase pneumococcal vaccination rates in children after kidney transplant had an increase PCV13 and PPSV23 vaccination rate from 6% to 52% over a 12-month period.\[9\]

Subjects admitted with new-onset DM, higher hemoglobin HbA1c, and DM-related issues were significantly more likely to receive the PPSV23 vaccine. It is likely that DM order sets, which included PPSV23 administration, were used more often in those admitted for DM-related issue. For example, the PPSV23 vaccine order was added to the diabetic ketoacidosis (DKA) order set, which is used for all subjects admitted in DKA. Subjects with new-onset DM and higher HbA1c are more likely to develop DKA and have the DKA order set used. In contrast for patients with DM admitted for non-diabetes-related reasons, such as appendicitis, one of the diabetes order sets may not have been used and as a result the PPSV23 vaccine not ordered.

However, when the vaccine was ordered, it was not given to 46% of subjects. For subjects in whom vaccine was...
ordered but not administered, we were unable to discern subject specific factors leading to vaccination vs. non-vaccination. A reason for not administering the vaccine was only documented for a small proportion. After analysis was complete, EMR team noted that there was a deficiency in electronic order notification to nursing to ensure immunizations are timed to be given on day of discharge. Therefore, additional EMR modifications are in progress to correct this issue. There was a 9% rate of vaccine errors and these cases were discussed with pharmacy and safety reports were filed. This will need to be monitored and improved. Limitations of the study include lack of data about administration of vaccines in patients with DM prior to study and lack of data about reasons for not administering vaccine when ordered.

**Conclusion**

As no identifiable subject factors were identified for lack of vaccine delivery once ordered, it is clear that our inpatient vaccine delivery systems must be evaluated and improved. This may be due to parental refusal in the acute setting. Administration in the outpatient setting also needs to be addressed, where parental acceptance may be higher when patients are stable. In conclusion, immunization rates of PPSV23 in hospitalized patients with DM improved with use of EMR modifications and education directed materials. Future directions for inpatient use include emphasizing use of DM order sets and additional enhancements of EMR to ensure PPSV23 is ordered and administered on any patient with DM who is eligible and willing to receive the vaccine.

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**Conflicts of interest**

The authors disclosed no potential conflicts of interest related to this article.

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