JPPT | Single-Center Retrospective Study

Pneumococcal Polysaccharide Vaccination (PPSV23) in High-Risk Pediatric Patients With Diabetes

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OBJECTIVE The Advisory Committee on Immunization Practices recommends the pneumococcal polysaccharide vaccine (PPSV23) following the pneumococcal conjugate vaccine (PCV13) for pediatric patients aged 2 to 18 years with high-risk medical conditions. The PPSV23 is not a routine immunization for all pediatric patients and children who meet criteria for high-risk conditions may not consistently receive the PPSV23 vaccine, despite current recommendations. The goal of this study was to determine PPSV23 vaccination rates in the high-risk pediatric patients with type 1 or type 2 diabetes.

METHODS A single-center retrospective cohort study was conducted. Patients were included if they were 2 to 18 years of age on January 1, 2019, with a diagnosis of diabetes, and had ≥1 encounters within the health care system in 2019. The primary outcome was PPSV23 vaccination rates in the high-risk diabetic pediatric population. Secondary outcomes included identifying missed opportunities for vaccinations and the incidence of invasive pneumococcal infections.

RESULTS A total of 366 patients met criteria for study inclusion. Patients had a mean age of 13.3 years and were predominantly white (69.8%). A total of 32 (8.7%) patients had documentation of PPSV23 vaccination. Baseline characteristics were comparable between the two groups. There were 32 cases of pneumonia charted before patients received the PPSV23 and one case reported after patients received the PPSV23 vaccination.

CONCLUSIONS PPSV23 vaccination rates were low in this high-risk diabetic pediatric group, with many documented missed opportunities for vaccination. This may be attributed to the vaccine not being a routinely recommended for all pediatric patients.

ABBREVIATIONS A1c, laboratory value for hemoglobin A1c; ACIP, Advisory Committee on Immunization Practices; AOM, acute otitis media; ICD, International Classification of Diseases; IPD, invasive pneumococcal disease; NMSIIS, New Mexico Statewide Immunization Information System; PCV7, pneumococcal conjugate vaccine, 7-valent; PCV13, pneumococcal conjugate vaccine, 13-valent; PPSV23, pneumococcal polysaccharide vaccine, 23-valent; UNM, University of New Mexico

KEYWORDS child vaccination; diabetes; pediatrics; pneumococcal polysaccharide vaccine; PPSV23

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Introduction

Streptococcus pneumoniae is a leading cause of acute otitis media (AOM), sinusitis, bacteremia, meningitis, and pneumonia in the pediatric population.[1] The Advisory Committee on Immunization Practices (ACIP) recommends routine administration of the pneumococcal conjugate vaccine (PCV13) for all children < 2 years of age.[2] Substantial decreases in the incidence of invasive pneumococcal disease (IPD) in the pediatric population have been observed since routine infant vaccination for this disease began in 2000.[3] The PCV13 provides coverage against serotypes accounting for approximately 63% of IPD among children < 5 years of age and approximately 49% of IPD among children between ages 6 to 18.[4]

The pneumococcal polysaccharide vaccine (PPSV23) vaccine was approved in the United States in 1983 for adults and children older than 2 years of age. ACIP also has recommended use of the PPSV23, following the PCV13 vaccination series for children aged 2 to 18 years with various underlying medical conditions, such as diabetes, human immunodeficiency virus (HIV), oncology, and congenital lung disease.[5] Even with the recent updated recommendations by the US ACIP for PCV15 administration in pediatrics, the recommendations for PPSV23 have not changed in this high-risk group.[6]

The PPSV23 vaccine contains 12 of the serotypes included in PCV13, as well as an additional 11 serotypes.[5] However, pure polysaccharide vaccines do not produce good response rates in children younger than 2 years of age. It is theorized that this is due to the fact that pure polysaccharide vaccines do not induce the production of immunologic memory cells in children under 2 years of age.[7] PCV vaccinations contain a protein conjugated to a protein carrier, which induces better immune responses in this age group. However, children over the age of 2 years have better response rates to the PPSV23 vaccine.[8,9] Among immunocompromised children aged 6 to 18 years, 23% of IPD was caused by serotypes included in PPSV23 vaccine not covered by the PCV13 vaccine.[5]

Patients with diabetes mellitus have been identified as a high-risk group for pneumococcal infection and are at increased risk for morbidity and mortality.[10] Additionally, patients with diabetes are more likely to be hospitalized and have longer, complicated hospital stays.[10,11]

Vaccination is one of the most effective strategies to improve child survival and reduce morbidity due to IPD. Additional benefits include reduction in hospitalizations and preventing long-term disability.[12] Because the PPSV23 vaccine is not part of the routine immunization schedule in pediatrics, children meeting criteria for high-risk conditions may not consistently receive the PPSV23 vaccine, despite current recommendations by ACIP. The goal of this study was to describe PPSV23 vaccination rates in high-risk pediatric patients with type 1 or type 2 diabetes.

Materials and Methods

This was a single-center retrospective cohort study conducted at the University of New Mexico (UNM) Health System. Patients were identified via ICD 10 codes (type 1 diabetes mellitus with hyperglycemia, type 1 diabetes mellitus without complications, type 2 diabetes mellitus with hyperglycemia, and type 2 diabetes mellitus without complications) through the institution's electronic medical record. Patients were included if they were 2 to 18 years of age on January 1, 2019, with a diagnosis of diabetes and if they had at least one encounter at UNM between January 1, 2019, and December 31, 2019. Patients were excluded from the study if they were wards of the state, incarcerated, or pregnant during this time frame. Data collection included the following: patient demographics, vaccine administration records, socioeconomic factors, highest laboratory value for hemoglobin type A1c (A1c) test (used to measure glucose control) in 2019, type of diabetes, comorbidities, number and types of encounters (clinic appointments, inpatient hospitalizations, emergency department visits, and urgent care visits) during the study period, history of IPD (pneumonia and meningitis) or AOM, and vaccination history (PCV13 and influenza). Data were collected from both the 2018–2019 and 2019–2020 flu seasons to encompass the entire year of 2019. Data were compared between patients that received the PPSV23 vaccine and those that did not receive the vaccine. Patients' vaccination history was obtained utilizing the comprehensive statewide New Mexico State Immunization Information System (NMSIIS) through the Department of Health. All health care providers who administer vaccines in the state of NM are required to report to the registry.

The primary outcome of this study was to describe PPSV23 vaccination rates in pediatric patients with diabetes. Secondary outcomes of this study were evaluation of missed opportunities for vaccinations and the incidence of infections for AOM and pneumonia. IBM SPSS version 26 was utilized for statistical analysis. Descriptive statistics, Pearson χ^2 and Student t test were used to analyze the study.

Results

From January 2019 through December 2019, a total of 405 pediatric patients were assessed for eligibility, with a total of 366 pediatric patients with diabetes meeting study criteria (see Supplemental Figure). There were 39 patients that were excluded due to not having a diagnosis of diabetes in their patient chart or not having a patient encounter at UNMH in the year 2019. Included patients had a mean age of 13.3 ± 3.7 years, were predominantly white (69.8%), and were diagnosed with type 1 diabetes (79%). Baseline subject characteristics are described in Table 1.

Of the 366 patients indicated to receive the PPSV23 vaccine, only a total of 32 (8.7%) of patients had a PPSV23 vaccination documented. Patients who had received the PPSV23 vaccine were older with a mean age of 14.5 ± 3.0 years during evaluation period versus 13.2 ± 3.7 years for patients who had not received the vaccine ($p = 0.05$). Gender and ethnicity were comparable between the two groups. Patients who identified as American Indian or Alaska Native had the highest rate of PPSV23 vaccination (15.3%; 6/39 patients). The majority of patients received the full PCV13 series (71.3%). All 32 patients (8.7%) who received the PPSV23 vaccine had received either a full or partial PCV13 series. A total of 332 patients (90.7%) had received ≥1 influenza vaccinations during their lifetime; 264 patients (72.1%) had documented influenza vaccination in the 2018–2019 and/or 2019/2020 seasons. PPSV23 vaccination rates were not different between patients who had recently received the influenza vaccine (2018–2019 and/or 2019/2020 seasons) versus those who did not (9.5% vs 6.8%, $p = 0.43$).

In patients who received PPSV23 vaccine, the rate of type 2 diabetes was higher (28.1% vs 18.0%, $p = 0.08$). Hemoglobin A1c was compared to determine if a higher A1c predicted PPSV23 vaccination status. Overall, the A1c was not statistically significantly different for patients who received the PPSV23 vaccine vs those who did

Table 1. Demographics and Clinical Characteristics of the Participants at Baseline

Characteristics	Received PPSV23 (n = 32)	Did Not Receive PPSV23 (n = 334)	p value
Mean age during evaluation period in years ± SD	14.50 ± 3.037	13.19 ± 3.721	0.054
Sex, no. (%)			0.905
Male	15 (46.9)	158 (47.3)	
Female	17 (53.1)	174 (52.1)	
Other	0 (0.0)	2 (0.6)	
Ethnicity, no. (%)			0.437
Hispanic or Latino	13 (40.6)	141 (42.4)	
Non-Hispanic and non-Latino	19 (59.4)	178 (53.3)	
Unknown	0 (0.0)	15 (100.0)	
Race, no. (%)			
White	21 (65.6)	250 (74.9)	0.449
American Indian or Alaska Native	6 (18.8)	33 (9.9)	
Asian	0 (0.0)	5 (1.5)	
African American	3 (9.4)	15 (4.5)	
Native Hawaiian or Pacific Islander	0 (0.0)	1 (0.3)	
Unknown	2 (6.3)	30 (9.0)	
Place of birth, no. (%)			0.666
United States	21 (65.6)	221 (66.2)	
Not in the United States	1 (20.0)	4 (80.0)	
Unknown	10 (31.3)	109 (32.6)	
Types of diabetes, no. (%)			0.080
Type 1 diabetes	21 (65.6)	268 (80.2)	
Type 2 diabetes	9 (28.1)	60 (18.0)	
Unknown	2 (6.3)	6 (1.8)	
Siblings, no. (%)			0.083
Siblings present	23 (74.2)	257 (77.2)	
No siblings present	6 (19.4)	28 (8.4)	
Unknown	2 (6.5)	48 (14.4)	
Religion, no. (%)			0.543
Christian	16 (50.0)	189 (56.8)	
Buddhism	1 (3.1)	2 (0.6)	
Muslim	0 (0.0)	2 (0.6)	
Atheism	0 (0.0)	7 (2.1)	
Hinduism	0 (0.0)	0 (0.0)	
Judaism	0 (0.0)	1 (0.3)	
Spiritual	2 (6.3)	9 (2.7)	
No preference	12 (37.5)	99 (29.7)	
Other	1 (3.1)	24 (7.2)	
Mean hemoglobin A1c percentage ± SD	11.13 ± 3.3	10.07 ± 2.6	0.110
Comorbidities			
Cancer, no. (%)	0 (0.0)	6 (100.0)	0.575
Asthma, no. (%)	6 (14.0)	37 (86.0)	0.157
HIV, no. (%)	0 (0.0)	1 (100.0)	0.913
Received PCV13 vaccination series			0.077
Full series, no. (%)	26 (10.0)	235 (90.0)	
Partial series, no. (%)	6 (13.3)	39 (86.7)	
No vaccination, no. (%)	0 (0.0)	40 (100.0)	

Table 2. Missed Opportunities for Vaccination

Healthcare Visit	Received PPSV23 Vaccine (n = 32)	Did Not Receive PPSV23 Vaccine (n = 334)	p value
≥3 Outpatient visits	17 (53.1)	201 (60.2)	0.44
≥1 Urgent care visits	5 (15.6)	20 (5.8)	0.06
≥1 Emergency department visits	7 (21.9)	46 (13.8)	0.21
≥1 Hospital admissions	10 (31.3)	72 (21.6)	0.21

Data are presented as n (%).

not (11.13 ± 3.3 vs 10.07 ± 2.6, p = 0.110). Patients with diabetes plus another high-risk comorbidities such as HIV (n = 1) and cancer (n = 6) did not receive the vaccine. Of the 43 patients who had both diabetes and asthma documented in their chart, 6 patients (14%) had received the PPSV23 vaccine (p = 0.157).

Of the 334 patients who did not receive the PPSV23 vaccine, 60.2% had ≥3 outpatient clinic appointments, 21.6% had ≥1 hospital admissions, 13.4% had ≥1 emergency department visits, and 6% had ≥1 urgent care visits (Table 2). There were 32 cases of pneumonia charted before patients received the PPSV23 and 1 case reported after patients received the PPSV23 vaccination; similarly 71 cases of AOM charted prior to patients receiving the PPSV23 vaccine and 1 case reported in patients after they received the PPSV23 vaccine (Table 3). Note that causative organism was not confirmed in these cases.

Discussion

Within our study population, only 8.7% of high-risk children with diabetes had received the PPSV23 vaccine. In addition, patients had multiple encounters with the health care system in a short timeframe, resulting in numerous missed opportunities for vaccination and prevention of infection. Our findings are consistent with a previous study that evaluated PPSV23 vaccination status of pediatric patients presenting to a pediatric rheumatology clinic.[13] Out of 90 eligible patients included in that study, 8.9% had received the PPSV23 vaccination prior to intervention methods such as education to providers and nurses, pre-visit planning, placing reminders on patient clinic forms, and sending letters to out-of-state patients.[13] After interventions were made, 22.2% of patients received the PPSV23 vaccine (p < 0.003).[13]

PPSV23 is not a routine childhood vaccination and is only recommended in high-risk pediatric populations.

Table 3. Incidence of Infections

Infection Occurrences	Before Receiving PPSV23 Vaccination (n = 366)	After Receiving PPSV23 Vaccination (n = 32)
Pneumonia	32 (8.7)	1 (3.1)
Acute otitis media	71 (19.4)	1 (1.4)

Data are presented as n (%).

Our study results highlight the importance of provider recommendations in promoting PPSV23 vaccination in this high-risk group and demonstrates that processes need to be in place to reduce missed opportunities for vaccinations in the pediatric population. Provider recommendations carry weight in vaccination decisions amongst parents, and parents rely on guidance from providers when making decisions about vaccinations.[14]

A likely barrier to nonroutine vaccines such as the PPSV23 vaccination is the lack of parental and provider knowledge. A national representative study similarly found that only 43% of parents were aware of MenB vaccine, which is a nonroutine vaccine like the PPSV23 vaccine that is recommended in adolescents. Parents who were aware were 4.8 times more likely to have their adolescent vaccinated after receiving a recommendation from a health care provider.[15] Additionally, a study done in 1999, evaluated predictors of childhood immunization completion in rural populations where they found that "living in health professional shortage areas, lack of health insurance, negative beliefs and attitudes regarding childhood immunizations, problems accessing the immunization clinic, and a perception of inadequate support from the immunization clinics" were the most significant in addressing.[16] Furthermore, a small study conducted in 2011 showed that in a rural clinic where supportive staff, convenient wait times, and robust vaccine knowledge was present resulted in fully immunized children.[17] To increase adherence with the recommendations, parents and clinicians need to be educated of the recommendation and benefits to patients indicated to receive the PPSV23 vaccine.

PPSV23 vaccination has been shown to reduce IPD in the pediatric patient population with high-risk medical conditions.[1,13] Though not statistically significant, this study demonstrated those results as well, considering that there were 32 cases of pneumonia in patients who had not previously received the PPSV23 vaccine; however, there was only 1 case of pneumonia in a patient who had received the PPSV23 vaccine. Additionally, though it did not reach statistical significance, there were 71 cases of AOM reported prior to patients receiving the PPSV23 vaccine and only one case after receiving the vaccine.

Our study also demonstrated that patients had multiple missed opportunities for vaccination in the year of 2019 alone. Though the difference in healthcare utilization was not statistically significant between patients who received the PPSV23 vaccine and those who did not, the amount of missed opportunities displays many potential future interventions to vaccinate pediatric patients with diabetes. By incorporating a process for PPSV23 vaccination in either the hospital or clinic setting, the majority of high-risk pediatric patients would have been vaccinated. This provides an opportunity for increasing rates of PPSV23 vaccination in pediatric patients with diabetes.

Other comorbidities, such as HIV, cancer, and asthma, were included to evaluate if different specialties other than endocrinology had processes in place to vaccinate high-risk pediatric patients that are indicated to receive the vaccine. Out of the six patients that were identified to have cancer as a comorbidity, none of these patients received the PPSV23 vaccine. Only one patient was identified with HIV in our study, and that patient did not receive the PPSV23 vaccine. Patients with asthma were assessed regardless of corticosteroid use. Of the 43 patients that had asthma documented in their chart, 14% (n = 6) had received the PPSV23 vaccine. Recommendations surrounding pediatric patients with asthma are unclear as there are no definitions to clarify what a high-dose oral corticosteroid is and what duration of treatment qualifies these patients to receive the vaccine. In this study, 18.8% of patients that received the PPSV23 vaccine additionally were diagnosed with asthma. The inclusion of these comorbidities demonstrates that a hospital-wide education including specialty clinics would be beneficial to providers.

Educational interventions are beneficial but are often not sustainable long-term. Structural implementation processes will need to be implemented to increase PPSV23 vaccination rates in the pediatric population. A potential intervention may be to provide an alert in the electronic medical record when a pediatric patient with a high-risk medical condition that qualifies for the PPSV23 vaccine is admitted or checks in for an appointment.

Limitations of this study included that this was a retrospective analysis. Additionally, data did not include vaccination records from other states. If the PCV13 or PPSV23 vaccines were not recorded in NMSIIS or the patient's electronic medical chart, then that patient was labeled as not receiving the vaccination, which may not always be the case especially if patients received these vaccinations in other states. Another limitation of this study is that cultures are rarely obtained in AOM and pneumonia. This study was unable to report if *S pneumoniae* was the causative pathogen in infections reported in this study. This study looked specifically at pediatric patients with diabetes and not at all high-risk medical conditions indicated to receive the PPSV23 vaccine. These vaccination rates found in patients with diabetes may not be able to be generalized to all high-risk medical conditions that are indicated to receive the PPSV23 vaccine. Finally, this study had unexpectedly low vaccination rates, which made it difficult to determine factors associated with vaccination in this study.

Conclusion

PPSV23 vaccination rates were low in our high-risk pediatric patients with type 1 or type 2 diabetes. There were many missed opportunities for PPSV23 vaccination. This may be attributed to the vaccine not being a routine vaccination for pediatric patients. Structural implementation processes, including electronic alerts, should be implemented to increase PPSV23 vaccination rates in the pediatric population. In addition, further studies need to be conducted to evaluate other potential interventions that may improve rates of PPSV23 vaccination in high-risk patient populations.

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