Improving Pneumococcal Vaccination in Pediatric Rheumatology Patients

Julia G. Harris, MD\textsuperscript{a}, Kristyn I. Maletta, BA\textsuperscript{b}, Bixiang Ren, MS\textsuperscript{b}, Judyann C. Olson, MD\textsuperscript{c}

**Abstract**

**Background and Objective:** Many pediatric rheumatology patients are at increased risk of pneumococcal disease secondary to a deficient immune system and/or immunosuppressive medications. The goal of this study was to improve pneumococcal vaccination rates in this high-risk population.

**Methods:** Eligible patients included children at least 2 years old and adults with systemic lupus erythematosus and/or currently on immunosuppressive medication. Interventions included a presentation to rheumatology providers, creation of immunization algorithm, previsit planning, placing reminders on clinic forms, and sending reminder e-mails to providers. Chart reviews were performed, and control charts were established to portray change in immunization rates.

**Results:** The preintervention immunization rates for 90 patient visits compared with the immunization rates for the 53-week postintervention period with 1033 patient visits and 299 separate patients were all statistically significant. The 13-valent pneumococcal conjugate vaccine rate increased from 6.7\% to 48.4\% ($\chi^2 = 58.3$, $P < .001$), 23-valent pneumococcal polysaccharide vaccine rate increased from 8.9\% to 28.4\% ($\chi^2 = 16.0$, $P < .001$), and combined rate increased from 0\% to 23.2\% ($\chi^2 = 25.2$, $P < .001$). The improvement was sustained with shifts in the data for each vaccine and combined immunizations for final average rates of 60.9\% for 13-valent pneumococcal conjugate vaccine, 39.2\% for 23-valent pneumococcal polysaccharide vaccine, and 33.7\% for combined.

**Conclusions:** Pneumococcal vaccination is an important part of the care for systemic lupus erythematosus patients and patients on immunosuppressive medications. Simple interventions through this quality improvement project led to a marked increase in pneumococcal vaccination rates in this vulnerable population.

_S. pneumoniae_ is a leading cause of bacteremia, meningitis, pneumonia, sinusitis, and acute otitis media.\textsuperscript{1} Many pediatric rheumatology patients are at increased risk of pneumococcal disease secondary to a deficient immune system and/or immunosuppressive medications. Infections can be a significant complication in certain rheumatic diseases that can lead to hospitalization and death.\textsuperscript{2–7} One retrospective review of patients with systemic lupus erythematosus (SLE) revealed infection was the second most common cause for hospitalization after a disease flare, with the most common type of infection leading to hospitalization being pneumonia.\textsuperscript{2} Another study reviewed a cohort of 1000 patients with SLE from 7 European countries to assess frequency and cause of morbidity and mortality over a 10-year period from 1990 to 2000.\textsuperscript{3} Twenty-five
percent of the 68 deaths were secondary to an infection, which was an equivalent percentage of patients who died of active SLE and thrombosis. The most common infection leading to death was bacterial sepsis of pulmonary origin. Another article analyzing Medicaid data on juvenile idiopathic arthritis patients from 2000 to 2005 demonstrated an adjusted relative hazard ratio of 2.0 for hospitalized bacterial infections compared with patients with attention-deficit/ hyperactivity disorder, which was used as their control group. This hazard ratio was significant even though patients were not on any immunosuppressive therapy. Lastly, an article by Wotton and Goldacre discussed record linkage cohort analyses to determine risk of invasive pneumococcal disease in patients admitted to the hospital with immune-mediated diseases. Significant rate ratios compared with individuals without an immune-mediated disease were noted in at least 1 data set for SLE, scleroderma, polyarteritis nodosa, Sjogren syndrome, rheumatoid arthritis, dermatomyositis/polymyositis, and ankylosing spondylitis.

Pneumococcal vaccination was included in recently published quality indicators for management of children with SLE indicating this vaccine should be prescribed unless contraindicated. It is also part of 2 adult SLE quality indicator sets. The Centers for Disease Control and Prevention (CDC) recommends the 13-valent pneumococcal conjugate vaccine (PCV13) followed by the 23-valent pneumococcal polysaccharide vaccine (PPSV23) for high-risk populations. The Infectious Diseases Society of America also has clinical practice guidelines for the immunocompromised host, including patients with chronic inflammatory diseases on immunosuppressive therapies, that are similar to the CDC recommendations. The American Academy of Pediatrics subsequently endorsed these guidelines and recently generated a policy statement for pneumococcal immunization in children at high risk.

This quality improvement project was conducted to increase pneumococcal vaccination rates in eligible pediatric rheumatology clinic patients. Our initial aim was to increase PCV13 rates to 30% after 4 months. However, our study continued after the initial 4 months because of positive responses and continued improvement.

METHODS

Vaccines

The CDC recommends PCV13 4 times during early childhood. For high-risk patients age 2 to 5, patients need at least 1 PCV13 with the exact number depending on the previous number of pneumococcal conjugate vaccines received. For 6- to 18-year-olds at high risk, patients need 1 PCV13 if they did not previously receive this immunization as part of their routine vaccination series during early childhood. Regarding the PPSV23, patients should receive this vaccine if at high risk and at least 2 years old. This vaccine should be repeated once after 5 years if patient remains high risk. The vaccines should be given at least 8 weeks apart, and the PCV13 should be given first if the patient is naïve to both vaccines. The CDC has similar recommendations in adults 19 and older. Recommendations are to give adults the PCV13 vaccine once if they are at high risk and have not received it before. The PPSV23 should be given if high risk and repeated once after 5 years if it remains in that category.

High-risk children and adults relevant to pediatric rheumatology include persons with functional or anatomic asplenia and immunocompromised persons, which includes diseases requiring treatment with immunosuppressive drugs. Additional high-risk groups include patients with chronic heart disease, chronic lung disease, diabetes mellitus, sickle cell disease, and chronic renal failure, among others.

Patients

Eligible rheumatology patients included all patients with SLE and patients on an immunosuppressive medication who were at least 2 years old and seen in the Children’s Hospital of Wisconsin Rheumatology Clinic. Immunosuppressive medications in our population included methotrexate, etanercept, adalimumab, infliximab, abatacept, mycophenolate, cyclophosphamide, azathioprine, anakinra, rilonacept, tocilizumab, canakinumab, and rituximab. Exempt status from our institutional review board was obtained.

Interventions

This project ran from September 2012 to October 2013. A baseline preintervention immunization rate for eligible clinic patients was determined over a 4-week time period via retrospective chart review. The Wisconsin Immunization Registry was primarily used, which is a computerized database application that records and tracks immunizations for children and adults in Wisconsin, and is linked to our electronic health record. Scanned immunization records were also used if available, and these were transferred into the Wisconsin Immunization Registry for ease in visualizing information.

Multiple interventions occurred throughout the study period (Figs 1, 2, and 3). A discussion during a division meeting led to consensus of the providers in proceeding with this quality improvement project. Nurses obtained stock of the PCV13 and PPSV23 to be stored in clinic. Shortly thereafter, a formal presentation was given during a division meeting to providers and nurses reviewing the current recommendations for giving
pneumococcal vaccines and a brief literature overview. An immunization algorithm (Fig 4) was made and displayed throughout the clinic that allowed providers to determine if a pneumococcal vaccine was indicated. Weekly previsit planning was initiated shortly after the start of interventions and continued throughout the study period. Previsit planning was largely done by a single individual who reviewed all of the clinic patients 1 week before scheduled appointments. The medical chart was reviewed for diagnosis and medication use. If a patient had SLE or was on an immunosuppressive medication, further review of their immunization record was done.

All eligible clinic patients who were in need of a pneumococcal vaccine were compiled into a weekly e-mail that was sent to all providers and nurses informing them of this information. The rheumatology clinic nurses then began placing reminders on clinic encounter forms, which is a paper that is generated for every visit encounter in all of our institution’s clinics and passed on to the provider when the patient is ready to be seen. From the weekly e-mails, the nurses wrote “PCV13” or “PPSV23” on small pieces of brightly colored construction paper, which was stapled to clinic encounter forms the morning of the patient’s visit. Clinic flow would include the providers discussing the vaccine with the patient and family, placing an order for the particular vaccine needed, and notifying the nurse if a vaccine should be administered.

Pneumococcal vaccines were often administered in clinic, and nurses provided an educational document regarding the specific vaccine to the patient and family.

**FIGURE 1**
Control chart demonstrating percent of patients up to date on PCV13 out of total eligible clinic patients. Interventions are noted. A shift was present in the data resulting in an increased center line starting on May 13, 2013. Other special cause includes a trend and data point above the upper control limit.

**FIGURE 2**
Control chart demonstrating percent of patients up to date on PPSV23 out of total number of eligible clinic patients. Interventions are noted. A shift was present in the data resulting in an increased center line starting on July 8, 2013. Other special cause includes 3 data points above the upper control limit.
Another intervention included sending letters to out-of-state patients and/or patients who had no immunization record or an incomplete record in the Wisconsin Immunization Registry. The letter explained the need for a copy of the patient’s immunization record to determine if a pneumococcal vaccine was indicated. In addition, updates of pneumococcal immunization rates were provided intermittently at division meetings or via e-mail.

**Data Analysis**

Chart reviews continued after initiation of interventions to determine PCV13 and PPSV23 rates.

Control charts with upper and lower control limits (3 SDs above and below the mean) were created to display vaccination rates over time for each vaccine and combined vaccines. Nonrandom distribution or special cause was assessed. Rules for special cause include the following: a shift (8 consecutive data points on 1 side of the center line), a trend (6 consecutive data points steadily increasing or decreasing), and a data point outside of the control limits. The center line was adjusted and recalculated if a shift was present in the data. \( \chi^2 \) test and Fisher’s exact test were used to compare preintervention immunization rates to postintervention rates.

**RESULTS**

A total of 1123 patient visits and 305 separate patients were reviewed. Patients were primarily female (75.0%) and from Wisconsin (88.9%) based on clinic visits. Diseases represented during clinic visits include the following: juvenile idiopathic arthritis, 48.8%; SLE, 22.7%; uveitis, 6.7%; juvenile dermatomyositis, 5.9%; and/or vasculitides, 4.4%, among others.

The 4-week preintervention period identified 88 eligible clinic patients and 90 patient visits. Overall, 6.7% of
patients were up to date on PCV13, 8.9% for PPSV23, and 0% for both vaccines. Between the time of implementation of the first intervention to the end of the study period, 53 weeks were analyzed with 299 separate patients and 1033 patient visits. Average vaccination rates in the postintervention period were all statistically increased compared with the preintervention period: 48.4% for PCV13 ($\chi^2 = 58.3, P < .001$), 28.4% for PPSV23 ($\chi^2 = 16.0, P < .001$), and 23.2% for both vaccines ($\chi^2 = 25.2, P < .001$). The number and percent of patients up to date on pneumococcal immunizations by disease (juvenile idiopathic arthritis, SLE, and all other diagnoses) are shown in Table 1.

Figure 1 is a control chart that depicts the change in PCV13 rates over time. A trend was noted from October 15, 2012, to November 19, 2012, during implementation of initial interventions. Due to a shift in data, the center line was recalculated. Overall average PCV13 rate was 45.8%, with the center line increasing from 32.9% to 60.9%. Similarly, Fig 2 is a control chart demonstrating PPSV23 rates over time. There was also a shift in data leading to an increased PPSV23 rate from 21.5% to 39.2% with an overall average rate of 27.5%. Patients who were up to date on both PCV13 and PPSV23 are shown in the control chart in Fig 3. Total average combined immunization rate was 21.8%, with the center line increasing from 11.3% to 33.7% after a shift in the data. There were also data points above the upper control limits in each of the 3 charts.

**DISCUSSION**

This single-center quality improvement project to increase pneumococcal vaccination rates in eligible pediatric rheumatology clinic patients was a success that can serve as a model for other hospitals and divisions. Through simple quality improvement initiatives, our vaccination rates statistically increased over time and were sustained indicating a true change in practice. Although pediatric rheumatology patients make up a minority of patients seen in general pediatric offices and subspecialty clinics, the quality improvement interventions from this project can be extrapolated to any immunosuppressed patient or patient at high risk for pneumococcal disease. Key points to improve pneumococcal vaccination rates on the basis of our experience are highlighted in Table 2. Similar quality improvement studies in our specific population are lacking. However, a quality improvement project in adult rheumatology practices used a point-of-care paper reminder form to significantly increase the rate of pneumococcal vaccination in immunosuppressed patients. An additional project used a 1-page vaccine questionnaire in clinic for patients to fill out to improve influenza and pneumococcal vaccination rates in immunosuppressed patients with inflammatory bowel disease.

There are no known articles describing pneumococcal vaccination rates in the pediatric rheumatology population, although preliminary data from our center revealed 25.3% of patients with childhood-onset SLE in a small cohort received the PPSV23. In addition, 52.5% of immunocompromised adults and 60% to 69% of adults with SLE self-reported receipt of the PPSV23. Direct comparison of these studies to our population cannot be done because the older age of some of the patients may have been the primary reason for getting the pneumococcal vaccine. Receipt of PCV13 was also not obtained in these studies.

Our results should be interpreted in the context of important limitations. First, due to having multiple interventions that overlap in time, it is difficult to determine causal relationship of any 1 of these initiatives to improvement. Also, having a single person at our center in charge of previsit planning and other initiatives was a limitation because work absences could lead to a brief lapse in continuation of quality improvement efforts. It is important to note our total population changed over time as new patients became eligible for the vaccines and others became ineligible if transitioned to an adult provider or if their immunosuppressive medication was discontinued. Therefore, the results may have differed if the denominator of eligible patients remained

### Table 1: Vaccination Rates by Disease and Type of Pneumococcal Vaccine

<table>
<thead>
<tr>
<th>Disease</th>
<th>Baseline</th>
<th>Original Cohort After Baseline</th>
<th>All Patients After Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>%</td>
<td>n/N</td>
</tr>
<tr>
<td>JIA and PCV13a</td>
<td>2/35</td>
<td>5.6</td>
<td>11/35</td>
</tr>
<tr>
<td>JIA and PPSV23b</td>
<td>2/35</td>
<td>5.6</td>
<td>10/35</td>
</tr>
<tr>
<td>SLE and PCV13</td>
<td>1/19</td>
<td>5.3</td>
<td>12/19</td>
</tr>
<tr>
<td>SLE and PPSV23</td>
<td>3/18</td>
<td>16.7</td>
<td>11/19</td>
</tr>
<tr>
<td>Other and PCV13c</td>
<td>3/30</td>
<td>10.0</td>
<td>16/30</td>
</tr>
<tr>
<td>Other and PPSV23c</td>
<td>3/30</td>
<td>10.0</td>
<td>15/30</td>
</tr>
</tbody>
</table>

a: patients may be listed more than once if a primary diagnosis changed during study period.  
b: two patients were only in the original cohort.  
c: Four patients were only in the original cohort.
constant. Lastly, providers may have demonstrated quality improvement “fatigue” due to the prolonged nature of our project. To address this limitation, occasional discussion about our success and/or showing our control chart progress in increasing immunization rates was done via e-mail or at division meetings.

The initial increasing trend in PCV13 rates was likely due to mere discussion of this project and start of previst planning. There were instances of special cause variation with data points above the upper control limits, but it was unclear what specifically caused this. PCV13 rates are higher than PPSV23 rates because this vaccine is a routine immunization of childhood and it is recommended first in the series of pneumococcal vaccines if the patient is naïve to both of them. Continued quality initiatives throughout the study period, in particular previst planning and reminders to providers, likely contributed to the sustained improvement in vaccination rates. A plateau in vaccination rates for each pneumococcal immunization and combined immunization rate may have been due to change in patient population contributing to a different denominator of patients as described above. In addition, no new quality initiatives were implemented in the last several weeks of data collection. Furthermore, patients were not vaccinated due to lack of vaccination records, provider forgetting to discuss vaccinations, patient being acutely ill, patient/parent refusal, and family preference to get vaccine elsewhere.

To improve and maintain future performance, a team approach is highly recommended because relying on a single individual to do certain initiatives is not sustainable. However, a team leader or “champion” is essential for a project like this to continue. Further improvements in vaccination rates may be obtained if focus shifts to the patients and families as our initiatives were directed primarily to the providers. This may include sending letters to all eligible clinic patients and providing an educational document explaining the importance of pneumococcal vaccination as part of the care of their disease. In addition, visual reminders to both providers and patients in clinic rooms may be of benefit.

CONCLUSIONS

Pneumococcal vaccination is an important part of the care for patients with SLE and patients with other pediatric rheumatologic conditions on immunosuppressive medications. Simple quality interventions were performed, which evolved around provider education and reminders. This led to a marked and sustained increase in pneumococcal vaccination rate in this vulnerable population.

ACKNOWLEDGMENTS

We thank all of the pediatric rheumatology clinic providers and nurses at the Children's Hospital of Wisconsin, especially Jan Lemke, RN, and Sarah Thomson, RN. Thank you to Dr Edward Oberle for his review of the article.

REFERENCES


Improving Pneumococcal Vaccination in Pediatric Rheumatology Patients
Julia G. Harris, Kristyn I. Maletta, Bixiang Ren and Judyann C. Olson
*Pediatrics* 2015;136;e680
DOI: 10.1542/peds.2014-2512 originally published online August 24, 2015;

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://pediatrics.aappublications.org/content/136/3/e680