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A quality improvement initiative to increase pneumococcal vaccination coverage among children after kidney transplant

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Abstract

Pneumococcal vaccination rates among children receiving a kidney transplant remain suboptimal. Current practice guidelines in the United States recommend giving the 23-valent pneumococcal polysaccharide vaccine (PPSV23) after priming with the 13-valent pneumococcal conjugate vaccine (PCV13). We conducted a quality improvement initiative to increase pneumococcal vaccine rates in our kidney transplant recipients by developing an age-based vaccine algorithm, obtaining vaccine records, and generating reminders for patients and clinicians. A monthly report from the electronic health record tracked outcomes. The process metric was missed vaccine opportunities and the overall objective was to improve coverage with both the PCV13 and PPSV23. Over the first six months, we increased the percentage of visits where the vaccine was given from a baseline of 4% to 33%. However, by the end of the 12 month period, the percentage of eligible visits where the vaccine was given decreased to 8.7%. Nevertheless, over the 12 month observation period, we were able to increase the percentage of transplant patients receiving the PCV13 and PPSV23 from 6% to 52%. Utilizing an age-based algorithm and the electronic medical record, vaccine champions can track both missed visit opportunities and the number of vaccinated patients to improve pneumococcal immunization coverage for these high-risk patients.

Keywords

kidney transplant; infection; vaccine; children

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INTRODUCTION

Pneumococcal disease most commonly presents as acute otitis media but can also result in more severe, life threatening illnesses such as pneumonia, sepsis, and meningitis (1). Immune compromised children, including those after kidney transplant, are at particular risk for significant morbidity and mortality from invasive pneumococcal infections (2). Accordingly, the Advisory Committee on Immunization Practices (ACIP) to the Centers for Disease Control (CDC), the American Academy of Pediatrics (AAP), and the American Society of Transplantation (AST) recommend pneumococcal vaccination after solid organ transplantation (2–6).

Before 2010, vaccine recommendations in the United States were limited to administration of the 23-valent pneumococcal polysaccharide vaccine (PPSV23) to transplant recipients 2 years of age (4). Despite this relatively straightforward recommendation, adherence in clinical practice has been inadequate. An examination of Medicare claims data from the 2013 United States Renal Data System (USRDS) found that fewer than 10% of children 2–19 years of age with a kidney transplant had received the PPSV23 (7). In 2010, the ACIP developed a more comprehensive pneumococcal vaccination recommendation for immune compromised children that includes priming with the 13-valent pneumococcal conjugate vaccine (PCV13), followed by PPSV23. While this new recommendation may result in better protection against pneumococcal infection, the algorithm is complex and requires accurate knowledge of a patient's age, prior PCV7, PCV13, and PPSV23 immunization history, and time interval between doses (4–6). We anticipated that establishing a local infrastructure to support pneumococcal vaccination was necessary to optimize adherence to these complicated recommendations.

Motivated by the new guidelines, we began a quality improvement (QI) initiative at our center to increase pneumococcal vaccine rates in our kidney transplant recipients. The objectives of this report are to describe our efforts to 1) decrease missed vaccine opportunities in a pediatric subspecialty setting and 2) improve PCV13 and PPSV23 coverage for these high-risk patients. Ultimately, we established a process that clinicians caring for pediatric solid organ transplant recipients can adopt to optimize adherence to the new pneumococcal vaccination guidelines, and potentially for future vaccination recommendations.

METHODS

Ethics statement

The Children's Hospital of Philadelphia Institutional Review Board determined that this QI study was exempt and it was approved by the Division of Nephrology, whose experience is described. We report our QI efforts using the Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines framework (8).

Setting

We targeted kidney transplant recipients followed in the Division of Nephrology because their baseline rates of pneumococcal vaccine coverage were low (<10%), both at our center

and nationally, as reported by the USRDS (7). Additionally, kidney transplant recipients at our center are seen in clinic at least every three months, which provided patients with multiple opportunities to receive pneumococcal vaccination over the one year period (January–December 2014) during which we tracked the success of our QI efforts.

Intervention planning and implementation

In 2013, the ACIP recommended that children who had received a solid organ transplant be given both the PCV13 and PPSV23 (6). The number of doses of each vaccine and the time interval between vaccinations depend on the age of the child and the child's prior vaccine history. In September 2013, we began planning our QI initiative to improve vaccination rates. The project was led by a nephrology registered nurse who dedicated, on average, three hours per week obtaining vaccine records, reminding providers to give the vaccines to eligible patients, and administering the vaccines in clinic. Additionally, two kidney transplant nurse practitioners assisted with obtaining vaccine records and administering the vaccine to patients. For timeliness and ease of administration, the PCV13 and PPSV23 vaccines were stored in the clinic.

Interventions to improve vaccination rates

In an effort to standardize the work of the nephrology nurse and nurse practitioners, we developed a vaccine algorithm that summarized the complex, current recommendations for administering the PCV13 and PPSV23. The most recent version of this algorithm is shown in Figure 1 and was distributed to the providers in the Division of Nephrology, displayed in the clinical workroom, and also uploaded to our Nephrology Intranet Clinical Resources Page.

We began requesting vaccine records for our transplant recipients in January 2014. Patient immunization records were obtained via the Pennsylvania State Immunization Registry, which was accessible within the electronic health record (EHR), or more commonly, directly from pediatricians using a faxed request form. These vaccine records were scanned into patients' charts, and the dates of prior PCV13 and PPSV23 immunizations were manually entered into the immunization section of our center's EHR for ease of reporting.

In February 2014, information about the importance of pneumococcal vaccination was added to the Patient Instruction Sheet given to all patients at the end of each transplant clinic visit and a table of recommended pneumococcal vaccinations was provided to patients and their primary care physicians via the clinic follow-up letter.

We created a monthly report from the EHR to track vaccination rates. These rates were shared with the transplant nurse practitioners to provide feedback on the success of their efforts starting in March 2014. As a general reminder to providers seeing transplant patients, our Division's transplant progress note template was updated in June 2014 to include a section in which providers could manually enter each patient's last pneumococcal PCV13 and PPSV23 vaccines. We also developed a best practice advisory (BPA) alert that was added to our EHR. The BPA stated, "Please consider pneumococcal vaccination for this patient. Please verify vaccine history and consider administration as appropriate." We used the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-*

CM) V42.0 code to identify patients with a kidney transplant. The BPA alert fired for patients who were 2 years of age, had the V42.0 ICD-9-CM diagnosis code captured in the problem list, and did not have documentation of receiving a PPSV23. Due to an unanticipated delay by information technology, we were unable to add the PCV13 to the BPA alert until October 2014.

Outcomes

To assess the effectiveness of the interventions, we tracked two metrics: a process metric of missed vaccine opportunities each month and an outcome metric of the percentage of renal transplant recipients 2 years of age who had been vaccinated with at least one PCV13 and PPSV23 during the observation period.

We calculated missed vaccine opportunities by tracking eligible *visits* each month. A visit was defined as “not eligible” and excluded from the denominator if it occurred <6 months after transplant (9), <12 months after chemotherapy, <8 weeks after a prior PCV13 or PPSV23 vaccine (2), if a patient refused the vaccine, or if a patient had already completed their pneumococcal vaccines in compliance with the new guidelines. All other visits were considered “eligible” and defined the denominator each month. An encounter was defined as “missed” if a patient was seen for an eligible pre-transplant (and subsequently transplanted in 2014) or post-transplant visit and did not receive either a recommended PCV13 or PPSV23. The encounter was defined as “missed” even if the patient had previously received one of the vaccines but was not appropriately given the second. A visit was defined as “given” if either the PPSV23 or PCV13 was appropriately given at the visit or within four weeks by their primary care physician. To determine the percentage of patients fully vaccinated with the PCV13 and PPSV23, we calculated the number of eligible transplant *patients* actively followed each month, regardless of whether they were actually seen in clinic that month or not. We excluded patients who were <6 months after transplant (9) and those who had transitioned to adult care each month. A patient was defined as fully vaccinated if they had received at least one PCV13 and had also received a PPSV23 within the last five years or two total doses of PPSV23. A patient was also defined as fully vaccinated if they had recently received the PPSV23 or PCV13 <8 weeks prior and were therefore not ready to receive the second vaccine.

Analysis

We retrospectively graphed the percentage of eligible *visits* where a transplant patient was successfully vaccinated monthly from January 1 to December 31, 2014. For example, if 10 eligible visits occurred in January 2014 but either the PCV13 or PPSV23 vaccine was not given at seven of these visits, the success rate was 30%. Our goal was to increase the *visit* level success rate (and therefore decrease the percentage of missed opportunities) while increasing the percentage of *patients* who were fully vaccinated. Using Microsoft EXCEL, we created a run chart depicting the percentage of eligible *visits* where a vaccine was given each month, plotted the median value, and assessed for evidence of change by examining shifts in the data above or below the median value (10).

RESULTS

There were 122 kidney transplant patients who were seen for 909 total visits, of which 462 visits were eligible for vaccination, during the 1 year observation period. Two patients refused vaccination. A summary of the interventions we used to improve vaccination rates is shown in Figure 2, along with the percentage of eligible clinic visits where a patient was successfully vaccinated.

In January 2014, 66 individual kidney transplant patients had 72 eligible clinic visits where a vaccination was recommended, but only 3/72 (4%) of these visits resulted in a patient receiving the appropriate vaccine. During the next six months, we were able to increase the percentage of visits where the vaccine was given—and thus decrease our rate of missed vaccine opportunities—to a high of 33% (12 vaccines given to patients during 36 eligible visits comprising 32 individual patients) by June 2014. As more patients were vaccinated and had to wait eight weeks before receiving the second vaccine (if needed), the total number of eligible visits (the denominator) decreased over the observation period.

Our initial success in improving our vaccination rates was driven by a dedicated nephrology nurse working closely with two renal transplant nurse practitioners. Missed vaccine opportunities decreased over the first six months as vaccine guidelines were added to the patient discharge materials, letters were sent to primary care physicians asking for vaccine records or recommending vaccination to eligible patients, and vaccine rates were shared with the transplant nurse practitioners each month, motivating further improvement. Finally, vaccine reminders were added to the progress note templates for each clinic visit. As shown in Figure 2, six monthly data points were above the median value during the observation period, signaling nonrandom evidence of change (10).

However, towards the end of 2014, we noticed a decrease in vaccination rates—and thus an increase in missed vaccine opportunities—as our dedicated nurse was no longer able to focus time and effort on this QI initiative. Although the BPA alert in the electronic record became fully functional in October 2014 to include both the PCV13 and PPSV23 and automatically reminded providers in real-time to vaccinate eligible patients, we did not notice an increase in vaccination, and in December 2014, 22 individual kidney transplant patients had 23 eligible clinic visits where a vaccination was recommended, but only 2/23 (8.7%) of these visits resulted in a patient receiving the appropriate vaccine. In discussion with providers, it was noted that the BPA alerts were resulting in “alert fatigue” in the electronic medical record, and were typically being ignored during clinic visits.

When our nurse no longer focused on this QI initiative, the rate of missed vaccine opportunities returned to its baseline level. However, an overall improvement in the percentage of kidney transplant patients who were vaccinated during the course of the observation period occurred. As shown in Figure 3, in any given month, approximately 100 kidney transplant recipients 2 years of age who are 6 months post-transplant are actively followed in our Division. At baseline (December 2013), only 6% of these patients had received the appropriate pneumococcal vaccination. One year later, by December 2014, 52% of kidney transplant patients were up to date/fully vaccinated against pneumococcus.

DISCUSSION

We implemented a QI initiative at our center to optimize pneumococcal vaccination rates among pediatric renal transplant recipients. At baseline and consistent with data from the United States (7), <10% of our patients had received the recommended pneumococcal vaccine regimen. One year later, 52% of our patients were up to date/fully vaccinated against pneumococcus. While the rate of missed opportunities decreased during the first six months of the study, the rate of missed vaccine opportunities returned to baseline at the end of observation. Having a dedicated nephrology nurse, or vaccine champion, was critical to implement the interventions, as vaccination rates decreased in temporal association with the renal nurse no longer able to focus on this QI initiative. Along with identifying a local vaccine champion, we suggest that the most important additional interventions to increase vaccine rates include obtaining accurate vaccine records from primary care physicians, storing the actual vaccine in the clinic area, and providing at least monthly feedback to providers on the success of the intervention (11).

Our QI initiative was aided by the EHR to identify and track eligible patients. Not all vaccine records could be obtained from the primary care physician or state registries via the EHR so vaccine records were manually abstracted into the EHR for the majority of our kidney transplant patients. Identifying patients through the EHR can “trigger” providers to perform certain tasks, such as decreasing adverse events (12). We developed a BPA alert trigger through our center’s EHR to remind providers to consider giving a pneumococcal vaccine to eligible patients. Similar methods have been used to improve pneumococcal vaccination rates in adult generalist settings (13, 14).

However, we observed that our BPA alert was not associated with improved vaccination rates, most likely because providers were ignoring the alerts and were not given specific information regarding which exact vaccination—the PPSV23 or the PCV13—the patient needed. Going forward, we have now revised our BPA to alert providers to the exact vaccination needed and have linked this with an order set for the vaccine. Nevertheless, similar to our findings, Ledwich et al. noted that an automated BPA alert improved pneumococcal and influenza vaccination among adults receiving immunosuppression for rheumatologic disease, but that a nurse-driven process provided even better results (15). Relying on a single vaccine champion also has its limitations, as shown by our findings. Therefore, we support that all transplant providers should be actively involved in processes to ensure adequate vaccination using EHR-generated reminders to identify eligible patients before their clinic visit (i.e. pre-visit planning), progress note templates with built-in documentation reminders, and an annual update of each patient’s vaccine status at either their transplant anniversary or when annual influenza vaccines are given.

To our knowledge, this is the first report on QI efforts to include both the pneumococcal conjugate vaccine (PCV13) and the polysaccharide vaccine (PPSV23) in a transplant population, as recommended by current ACIP vaccine guidelines (6). A 2015 study by Harris et al. demonstrated an improvement in pneumococcal vaccination rates among pediatric rheumatology patients using an algorithm and QI process similar to ours. However, combined vaccination rates, defined as having received PCV13 and PPSV23, only increased

to 23% by the end of their year-long QI initiative and missed opportunities at the visit level were not evaluated (11). The experience of QI projects focused on PPSV23 administration to high-risk populations has also been reported. Parker et al. administered a vaccine questionnaire to patients with inflammatory bowel disease who were receiving immunosuppression and were able to increase PPSV23 rates from 31% to 54% over a 10-week period (16). Over a six month period, a paper reminder form used by rheumatologists seeing adults taking immunosuppressive medications increased the PPSV23 rate from 68% to 80% (17).

Notably, many national registries and reporting agencies, including the USRDS, only track administration of the PPSV23 (7). Therefore, we hope that our QI experience and outcome definitions, which include measuring both missed opportunities at the clinic visit level and vaccination with both vaccines at the patient level, provides a framework for institutions and reporting agencies to implement and track the success of QI initiatives. At our center, efforts are ongoing to expand this QI project to target all children who have received a solid organ transplant (heart, lung, kidney, or liver transplant).

The actual number of recommended doses for both the PCV13 and PPSV23 vaccines varies by age and prior vaccine history. In planning our QI project, it became apparent that the interpretation of the published recommendations was time consuming. Therefore, we developed an algorithm to summarize the current recommendations, identifying variations in dosing frequency by age group, prior vaccination status, and the proper timing between doses (Figure 1) (4–6). We anticipate that this summary figure will help further improve pneumococcal vaccination rates, both at our center and others.

Importantly, there are limited data to support sequential administration of the pneumococcal conjugate vaccine (PCV13) and 23-valent polysaccharide vaccine (PSV23). The rationale behind this approach is that the PCV13 acts as a primer that is boosted by the PSV23. This priming and boosting strategy is based on a small study of 23 children and young adults with sickle cell disease (18). In that study (19), subjects (<30 years of age) receiving two priming doses of PCV7 and a PPSV23 boost eight weeks later had higher pneumococcal antibody concentrations compared to those only receiving the PPSV23. Limited data are available on the potential benefits of priming and boosting in children receiving a solid organ transplant. Lin et al. (18), found that among 25 children receiving liver, heart, or multivisceral transplants, a second dose of the PCV7, given 6–8 weeks before the PPSV23, did not increase antibody concentrations compared to the first PCV7 dose. Conversely, Barton et al. (20) reported 81 children receiving a solid organ transplant had increasing antibody concentrations with 2 PCV7 doses and a PPSV23 boost, especially among the heart transplant recipients. In adult liver (21) and kidney (22) transplant recipients, randomized trials have failed to show any immunological benefit to the prime and boost strategy as compared to only receiving a PPSV23 without priming.

Despite the limited evidence, guidelines from the ACIP (4–6), AAP (2), Infectious Diseases Society of America (23), and the AST (3) recommend priming with the PCV13 and boosting with the PPSV23 in all solid organ transplant recipients ≥ 2 years of age, likely because of the potential benefits in reducing severe disease (9). For now this is a logical approach,

however, further research is warranted to determine the most effective vaccine strategy, including formulation and timing, in pediatric solid organ transplant recipients (3, 18, 24). Additionally, it is important to vaccinate patients prior to solid organ transplant, so they are protected before receiving immunosuppression.

If future research demonstrates that the prime and boost strategy is not needed in high-risk patients, as has been suggested by others (21, 22), it would reduce the complexity of vaccine recommendations, which may in turn help boost vaccine adherence rates. We acknowledge that the complexity of the present United States vaccine recommendations may be a barrier to optimal immunization. Accordingly, some countries (Switzerland and Finland), do not support giving both the PPSV23 and PCV13 to high-risk patients, while most other countries in Europe have complex vaccine recommendations similar to the United States (25, 26). A 2016 study from Canada found that 27% of pneumococcal serotypes causing invasive disease in immunosuppressed patients were included in the PPSV23, but not the PCV13, supporting recommendations for giving both vaccines at the current time (27).

In conclusion, pneumococcal infection remains a source of morbidity and mortality in children after solid organ transplant. Therefore, providers need to improve immunization rates for these high-risk patients. We advocate identifying vaccine champions, obtaining vaccine records on all transplant patients, and working on tests of change that will improve vaccination rates with the resources available to each individual center. Until more evidence becomes available, the goal of a transplant center should be to implement processes that ensure all solid organ transplant recipients 2 years receive the appropriate number of PCV13 and PPSV23 doses.

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Figure 1. Vaccine algorithm summarizing the current guidelines for children who have received a solid organ transplant

Guidelines are age-based, for those who are ≥6 months post-transplant, and derived from recommendations by the Advisory Committee on Immunization Practices to the Centers for Disease Control, the American Academy of Pediatrics, and the American Society of Transplantation (2–6). PCV, pneumococcal conjugate vaccine; PPSV23, 23-valent pneumococcal polysaccharide vaccine.

Figure 2. Pneumococcal immunization improvement in children receiving a kidney transplant, tracked at the clinic visit level

The x-axis shows the number of eligible visits to the transplant clinic over time where a kidney transplant recipient was 2 years of age, 6 months post-transplant, and 8 weeks from a prior pneumococcal vaccine. The y-axis shows the percentage of eligible clinic visits where a patient was successfully vaccinated with either the PCV13 or PPSV23, as indicated. The annotations show the tests of change implemented during the observation period and other factors affecting the outcomes. PCP, primary care provider; EHR, electronic health record; NP, nurse practitioner; PCV13, 13-valent pneumococcal conjugate vaccine; PPSV23, 23-valent pneumococcal polysaccharide vaccine.

Figure 3. Pneumococcal immunization improvement in children receiving a kidney transplant, tracked at the patient level

The x-axis shows the number of active transplant patients followed, but not necessarily seen in clinic, each month. Active patients had to be 2 years of age and 6 months post-transplant to be included. The y-axis shows the percentage of eligible, actively followed patients successfully vaccinated with both the PCV13 and PPSV23 vaccine.