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Improving Pneumococcal Vaccination Rates in Rheumatology Patients by Using Best Practice Alerts in the Electronic Health Records

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ABSTRACT. ***Objective.*** To improve pneumococcal vaccination (PV) rates among rheumatology clinic patients on immunosuppressive therapy in the outpatient settings.

Methods. This quality improvement project was based on the pre–post intervention design. Phase I of the project targeted patients with rheumatoid arthritis from 13 rheumatology clinics (January 2013– July 2015) on immunosuppressive therapy to receive the pneumococcal polysaccharide vaccine (PPSV23). In the Phase II study (January 2016–October 2017), all patients on immunosuppressive medications regardless of diagnosis were targeted to receive PPSV23 and the pneumococcal conjugate vaccine (PCV13). The best practice alerts (BPAs) for both PVs were developed based on the Centers for Disease Control and Prevention guidelines, which appeared on electronic medical records for eligible patients at the time of assessment by the medical assistant. The BPA was designed to inform the vaccination status and enable the physician to order the PV, or to document refusal or deferral reasons. Education regarding vaccine guidelines, BPAs, vaccination process, and regular feedback of results were important project interventions. The vaccination rates during pre–post intervention for each study phase were compared using chi-square test.

Results. During phase I, PPSV23 vaccination rates improved from a 28% preintervention rate to 61.5% ($P < 0.0001$). During phase II, 77.4% of patients had received either PPSV23, PCV13, or both, compared to 49.6% of patients in the preintervention period ($P < 0.0001$). The documentation rates (vaccine received, ordered, patient refusal and deferral reasons) increased significantly in both phases.

Conclusion. Electronic identification of vaccine eligibility and implementation of BPAs with capabilities to order and document resulted in significantly improved PV rates. The process has potential for self-sustainability and generalizability.

Key Indexing Terms: best practice alert, electronic medical record, PCV13, pneumococcal infection, PPSV23, vaccination

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Streptococcus pneumoniae (pneumococcus) remains a leading cause of serious illness in adults, with an estimated 4,000 deaths attributed to pneumococcal infections in the United States each year.[1] The incidence of invasive pneumococcal disease (IPD) is alarming among those aged 65 years and older (36.4/100,000). Adults with high-risk medical conditions, such as hematologic cancers and HIV, and patients on immunosuppressive therapies, have up to 20-fold higher risk for IPD.[2,3] The administration of both pneumococcal vaccines (PV; PCV13 and PPSV23) have demonstrated efficacy to reduce incidence of pneumonia and IPD in all age groups and disease states.[1] The Centers for Disease Control and Prevention (CDC) recommends PCV13 and PPSV23 vaccinations in all patients age 65 years and older, and those aged 18–64 years at high risk due to their comorbidities or immunocompromised status, such as renal disease, immunosuppressive therapy, lung disease, asplenia, HIV, immunodeficiency, and malignancies.[4] Despite these clear recommendations, the PV rates remain low across the nation among all age groups, including high-risk patients.[5] Some of the barriers to improving vaccination rates are lack of awareness of the disease and vaccines

among patients and healthcare providers, failure to assume responsibility for vaccination, competing priorities, incomplete or inaccessible documentation of vaccination status, and healthcare delivery system challenges.[6] Initial conversations between the study team and rheumatologists also identified barriers at our institute, such as guidelines for vaccine being too complex, particularly in knowing which vaccine to give, what the appropriate interval is between the 2 vaccines, and how to assess patient risk. Additional barriers perceived were preventive care being the primary care physician's (PCP) responsibility, lack of time, and incomplete electronic medical record (EMR) for historical vaccination.

Patients with rheumatic disease, particularly those with inflammatory diseases like rheumatoid arthritis (RA) and those receiving immunosuppressive therapy, are at high risk for pneumococcal disease and IPD.[5,7] The PV rates in these patients remain suboptimal due to several barriers. Many rheumatology patients may not visit their PCP on a regular basis, thus failing to receive appropriate vaccinations. Rheumatologists might assume that the patients' PCP would address the vaccination, or they may not have up-to-date knowledge or time in a busy practice to assess eligibility and prescribe PVs. On the other hand, PCPs might focus on the elderly and may not be knowledgeable of disease specific recommendations for high-risk patients aged 18–64 years. The aim of this quality improvement (QI) study was to improve the rates of PV administration and documentation in high-risk patients with rheumatic diseases on immunosuppressive medications in rheumatology clinics. The study proposed to use a best practice alert (BPA) in EMRs, which would identify eligible patients based on predetermined criteria, prompt clinic staff or providers during the clinic visit, and provide an easy way to order and document vaccination.

METHODS

This QI initiative was approved by the institutional quality council (QIIRB2097). The projects approved as QI initiatives did not require informed patient consent as per the institutional policy. The guidelines for the vaccine administration were based on the American College of Rheumatology,[8,9] the CDC, and Advisory Committee on Immunization Practice guidelines.[3,10] It followed the QI Plan, Do, Study, Act methodology.[11]

Eligibility criteria included RA diagnosis and high risk due to immunosuppressive medications. Phase I of the study was conducted on RA patients with at least 1 clinic visit and diagnosis of RA as per International Classification of Diseases, 9th and 10th revisions (ICD-9/10) codes with the focus on improving rates for only PPSV23 administration. Phase II of the project included all patients with rheumatic disease, regardless of specific diagnosis, and targeted both PPSV23 and PCV13 vaccines. In both phases, patients aged 65 years and older were included regardless of immunosuppressive medications, whereas patients aged 18–64 years were included only if they were on immunosuppressive medications.

Immunosuppressive medications are high-dose steroids, biologics, targeted small molecules, and oral disease-modifying antirheumatic drugs (DMARDs). RA and many other rheumatic diseases with immunologic and inflammatory pathophysiology require treatment with these medications.[8] The medication list, derived from EMR query of all immunosuppressive medications prescribed in the prior year by rheumatologists, was used to identify high-risk patients.

Phase I. The Phase I study, implemented from January 2014 to July 2015, was a pre–post intervention comparison of PV rates in patients with RA. Target population included patients with eligibility criteria as above, focusing on PPSV23 vaccine improvement.

Intervention. The major components were (1) an EMR-based BPA development; (2) clinic workflow adjustment; (3) education of physicians, staff, and patients; and (4) quarterly feedback of the results.

BPA development. The PPSV23 BPA was developed in the EpicCare EMR system (Epic Systems) used by rheumatology clinics. The EMR team programmed BPA to identify eligible patients based on the eligibility criteria: ICD 9 codes for RA in phase I or rheumatic disease ICD 10 codes in phase II, clinic visit, age, immunosuppressive medication and prior vaccination status.

The BPAs for PV and rheumatology clinic workflow change (Figure 1) were implemented to facilitate vaccination administration and documentation without significantly increasing time and burden on the clinical staff or physicians. The BPA was designed to trigger during the initial assessment of the vital signs and medication review by the medical assistant (MA) during clinic visit. The BPA was retrieving prior vaccination data from EMR health maintenance fields and completed vaccine orders. However, the information on vaccines received from external sources was available from the Pennsylvania Statewide Immunization Information System (PASIIS) registry that was not linked to the alert automatically. This information and the patient-reported vaccine status were required to be reviewed and updated in the EMR, which could be linked to the BPA for the subsequent visit. From the BPA, the user could prescribe the vaccine, or document prior vaccination or patient refusal and deferral reasons. The BPA was programmed to turn off for 6 months for subsequent visits when vaccination was prescribed or deferral reasons appropriately documented, and for a year if the patient refused vaccination. If the BPA was ignored, it continued to reappear on the subsequent visit. This ensured the opportunity to encourage vaccination at each visit, increasing the likelihood of patient vaccination over time.

Rheumatology clinic workflow. During the visit, the MA received the BPA while assessing the eligible patient. If the patient reported prior PV, staff accessed the health maintenance field from a link in the BPA to document the data. If the patient had not received PV, then an order was placed through the BPA if the patient agreed to PV. If the patient was not agreeable to PV, the staff would defer the BPA so that it would notify the physician during the same clinic visit. The physician addressed the patient's concerns about PV and subsequently would either order the vaccine, document refusal, or defer. If the vaccine was ordered, the clinic registered nurse was alerted through vaccination orders and would then administer and document PV at the same visit.

Patient, physician, and staff education. Patients, physicians, and staff were educated regarding the importance, safety, and evidence-based recommendations for PV in patients with rheumatic disease. Rheumatologists were provided education in formal presentations at rheumatology grand rounds at the start of the project. The clinic physician and staff education was provided every 6 months, consisting of small group interactive sessions addressing concerns and clarifying misconceptions. Clinic managers and staff were queried periodically to report any issues with the vaccination process, such as insurance and adverse events. All clinic staff members were asked to complete an online assessment module, which emphasized learning objectives, clinic workflow, and BPA information. Finally, posters displaying step-by-step flowcharts for the vaccination workflow were posted in all clinical areas and examination rooms (Figure 1). Patient education material describing vaccine information, instructions, and clarification of common misconceptions was posted in patient rooms and waiting areas, as well as handed out to every eligible patient. A Web-based survey was conducted for physicians and staff to receive feedback for the process and its barriers.

Quarterly feedback. Quarterly reports of vaccination and documentation rates for each clinic and individual provider were provided with anonymous peer comparison. Following the presentation of quarterly results to the

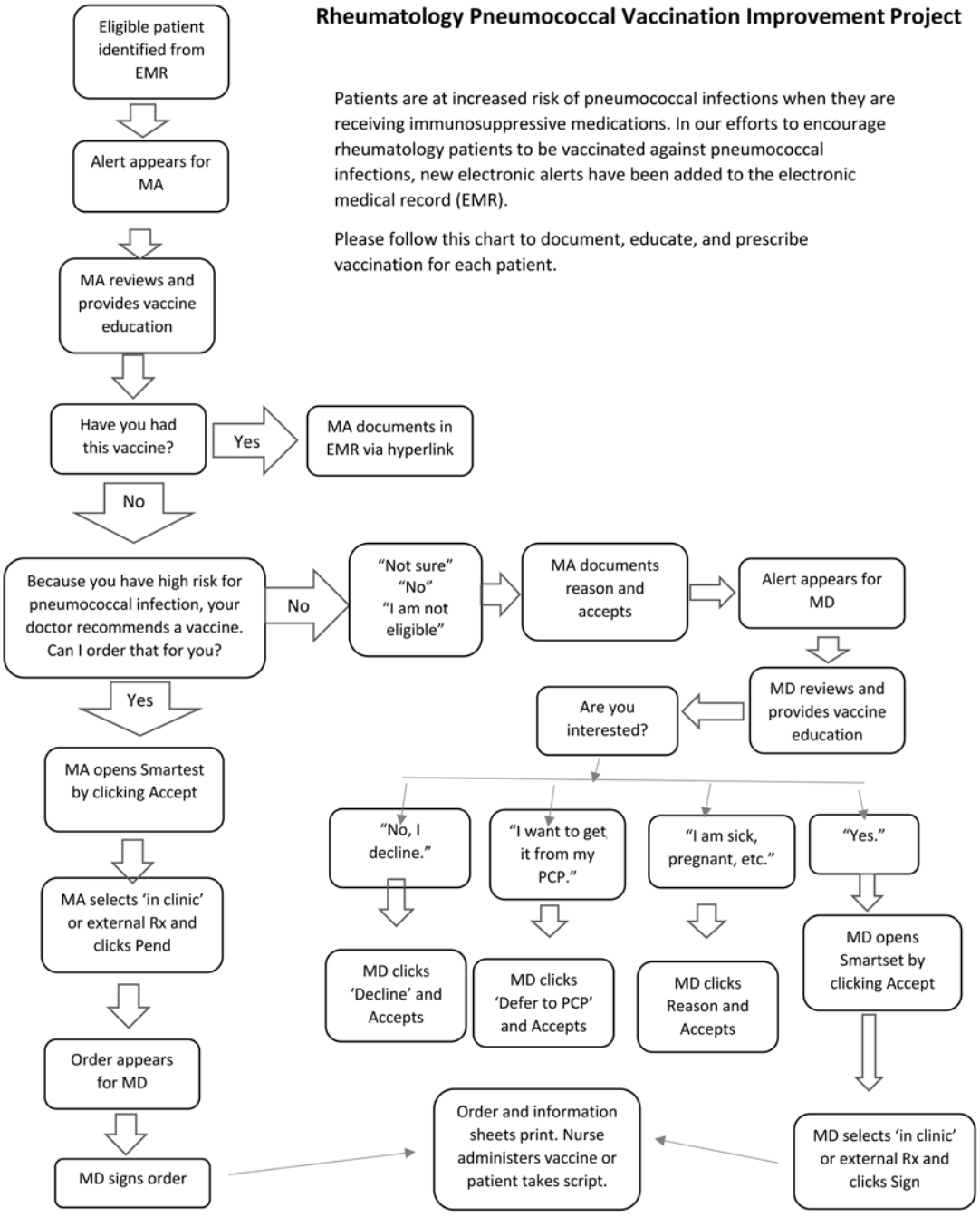

Figure 1. Rheumatology pneumococcal vaccination improvement project. EMR: electronic medical record; MA: medical assistant; PCP: primary care physician.

clinic, physicians and clinic managers were encouraged to review their data, identify barriers, and provide solutions that may improve compliance. The study team attended the clinic meetings to support the effort and provide education as needed.

Phase I analysis. The PV and documentation rates were compared during the pre- and postintervention phases for overall rates, and by clinics and providers. The preintervention data for demographic characteristics and vaccination information were collected from the EMR query, using the same eligibility criteria for patients seen at rheumatology clinics from January to December 2013. The postintervention data for 18 months (February 2014–July 2015) were collected for the same variables, with additional information regarding frequency of the BPA occurrence and actions taken by the providers. Vaccination compliance was recorded as administered, prescribed, or documented reasons for deferral or refusal.

Phase II project. After a lag period of 8 months from phase I, the phase II project was expanded to include all rheumatologic disease patients targeting both PCV13 and PPSV23 rates, and followed phase I eligibility criteria for age, visit, and medications. The phase II intervention period was February 2016 to October 2017. The baseline comparison PV rates were obtained for the year 2015. The BPA was modified to include the complex decision tree algorithm (Figure 2) for determining whether the patient should receive PCV13 or PPSV23 at the visit. The BPA mitigated the need for complex

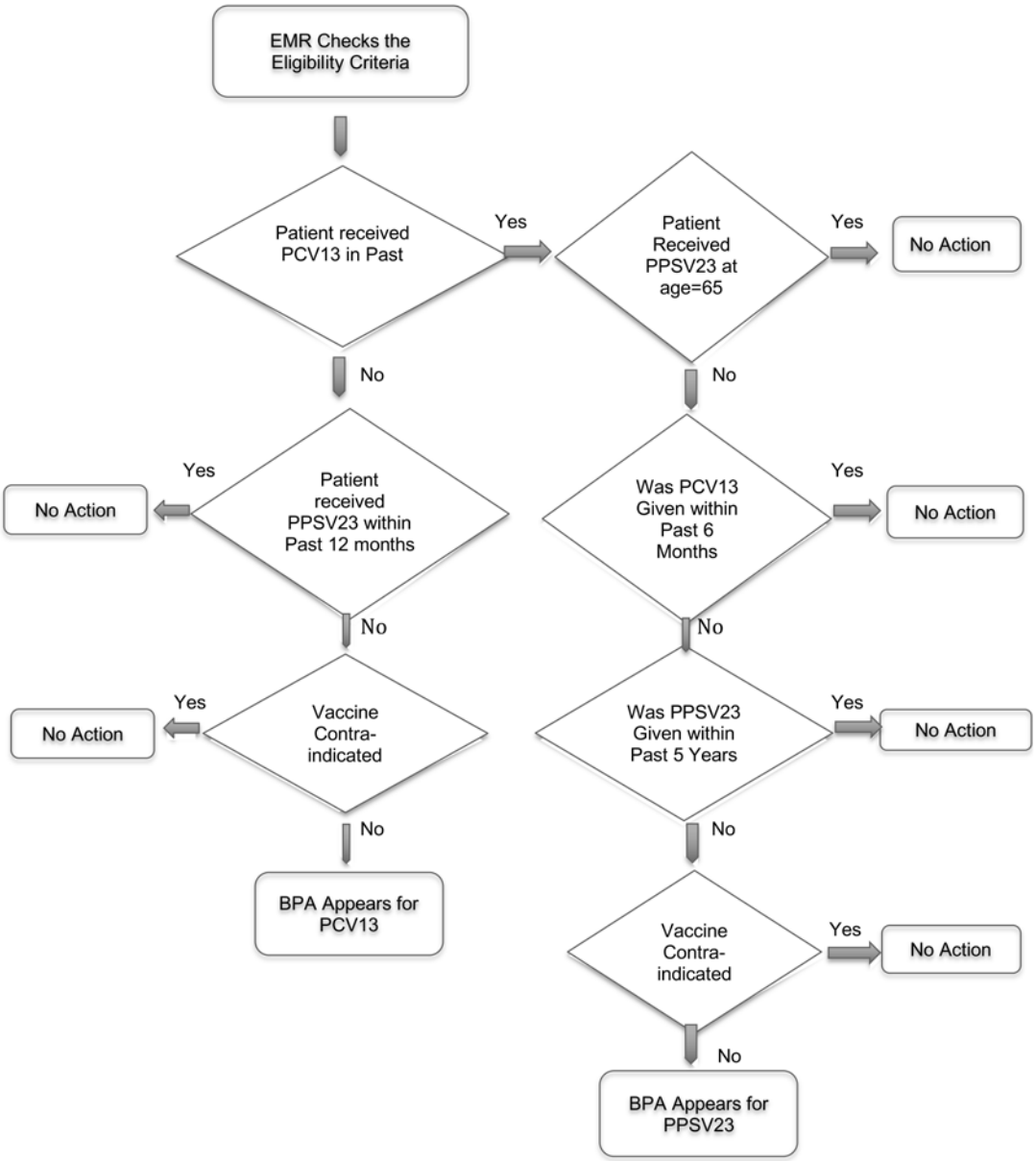

Figure 2. Process diagram of the EMR decision tree built for vaccine selection; PCV13 or PPSV23 for patients ≥ 65 years. BPA: best practice alert; EMR: electronic medical record; PCV13: pneumococcal conjugate vaccine; PPSV23: pneumococcal polysaccharide vaccine.

decision making by clinic staff or physicians about which PV is appropriate at the clinic visit. The clinic staff and the rheumatologists were educated about the changes in the process and encouraged to prescribe the vaccine. Phase II analysis followed the same steps as phase I. In addition, logistic regression analysis for the vaccine received was conducted to evaluate association with age at the visit, sex, race, and clinic type (academic or community clinic). All analyses were performed using Stata software, version 12 (Stata Corp). Frequency and rates were compared using chi-square test or incident rate ratio analysis.

RESULTS

Basic demographics are reported in Table 1, which represented comparable pre- and postintervention groups. In both phases, the majority of patients were female (73–75%) and White (83–85%). The mean age in phase I (only RA patients) was 73–74 years, whereas phase II (all rheumatic diseases) was 58–60 years. The prescribed immunosuppressive medications were biologics (25.2%), DMARDs (42.5%), high-dose steroids (86.7%), and others (2.8%). Many of these patients were on > 1 immunosuppressive medication.

Phase I. Baseline preintervention data identified 2990 patients with diagnosis of RA on immunosuppressive medication. Among those patients, only 837 (28%) patients had received PPSV23, and 448 (15%) had documented refusals or deferral reasons for not receiving PPSV23. Thus, a total of 1285 patients accounted

Table 1. Demographic characteristics of eligible patients.

	Phase I		Phase II	
	Preintervention	Postintervention	Preintervention	Postintervention
Total N	2990	5292	14,109	26,717
Age, yrs, mean (range)	73 (65–98)	74.4 (65–101)	58 (18–99.8)	59.5 (18–101)
Female sex, n (%)	2242 (75)	3863 (73)	10,384 (73.6)	19,770 (74)
Race, White, n (%)	2481 (83)	4529 (85.6)	11,993 (85)	22,442 (84)
Clinic visits, median (range)	2 (1–3)	2 (2–4)	2 (1–3)	3 (2–5)
Disease states, %				
RA	100	100	31.7	31.1
OA			26.2	23.6
SLE			9.7	9.3
Myositis			9	5.4
Gout			6.6	7.2
PsA			5.4	8.1
SS			4.7	4.3
PMR			1.9	2.5
AS			1.2	4.6
Vasculitis			1.4	1.2
SSc			1.0	1.1
Other			1.2	1.6

AS: ankylosing spondylitis; OA: osteoarthritis; PMR: polymyalgia rheumatica; PsA: psoriatic arthritis; RA: rheumatoid arthritis; SLE: systemic lupus erythematosus; SS: Sjögren syndrome; SSc: systemic sclerosis.

for 43% documented vaccine compliance rate. During 18 months of intervention, 7145 patients were electronically screened, of which 5292 (74.1%) were eligible for PV as per the eligibility criteria. A total of 3254 (61.5%) eligible patients had received PV during the intervention period, which was significantly better than the preintervention rate of 28% ($P < 0.0001$). Documentation rate significantly increased to 87.5% (4630 patients, $P < 0.0001$; Figure 3). Moreover, physician and staff surveys suggested that the BPA made the vaccine compliance process much easier and did not significantly increase their work burden.

Phase II. The preintervention PV rates for phase II were obtained for patients seen in rheumatology clinics during 2015. A total of 14,109 patients were eligible in the baseline period. Among these, 3211 patients (22.8%) had received PCV13, 5812 (41.2%) had received PPSV23, and 6,999 (49.6%) had received at least 1 of the 2 PVs. The documentation for vaccination completed, or patient refusals and deferrals was present in 7901 (56%) patients (Figure 3). Figure 4 shows vaccination and documentation rate improvement over time.

During the intervention period, a total of 26,717 eligible high-risk patients with rheumatic disease were identified. Among these patients, 12,779 (47.8%) had received PCV13, 17,047 (63.8%) had received PPSV23, and 20,682 (77.4%) had received either PCV13, PPSV23, or both. There were 22,211 (83%) patient charts with documentation for vaccines received, prescribed, deferred, or refused. This accounted for 27.8% vaccination improvement overall, and 27.1% documentation improvement from 2015 baseline rates, which were significant at $P < 0.0001$. The PCV13 vaccine rate improved by 25% in the intervention period, and the PPSV23 rate improved over time by 22.6% (both rates at $P < 0.0001$). The physician responses to the BPA are shown in Figure 5. Among the 7976 patients for whom the BPA appeared, 1941 (24.3%) patients were vaccinated, 757 (9.5%) were prescribed PV, 554 (7%) refused, and 218 (2.7%) were deferred. Physicians did not take any action for 4506 (56.5%) BPAs. Additionally, quarterly results by clinics and anonymous results by providers comparing to peers were provided in graphic form for both phases. If patients required

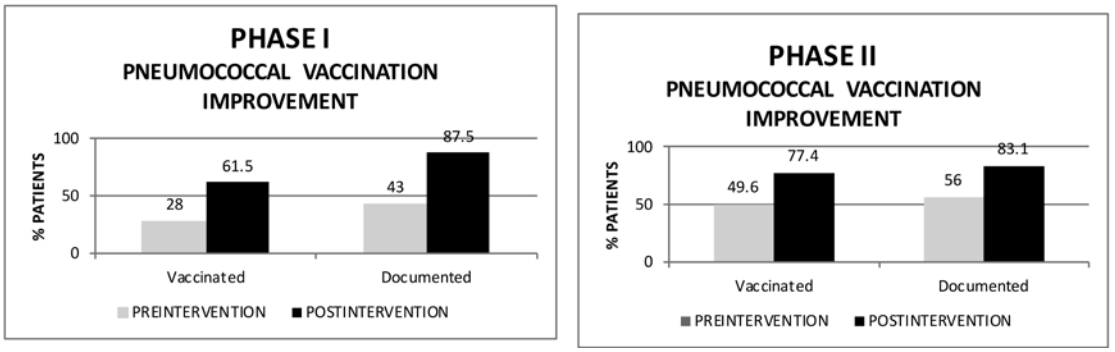

Figure 3. Vaccination and documentation rates at pre- and postintervention in phase I and phase II of the project.

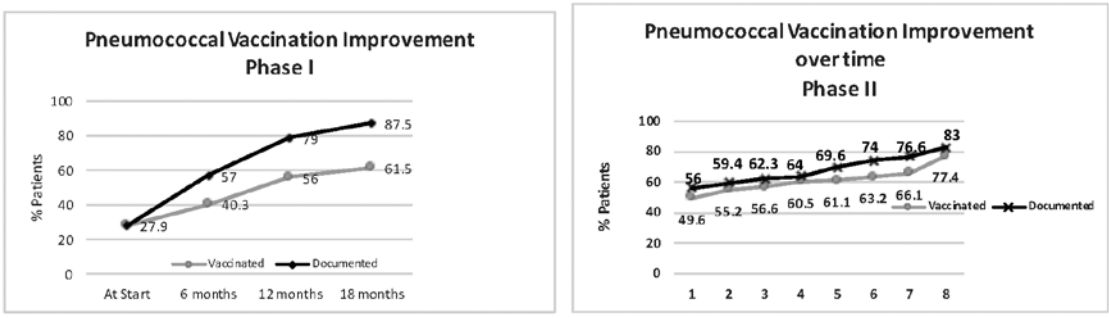

Figure 4. Pneumococcal vaccination improvement over time.

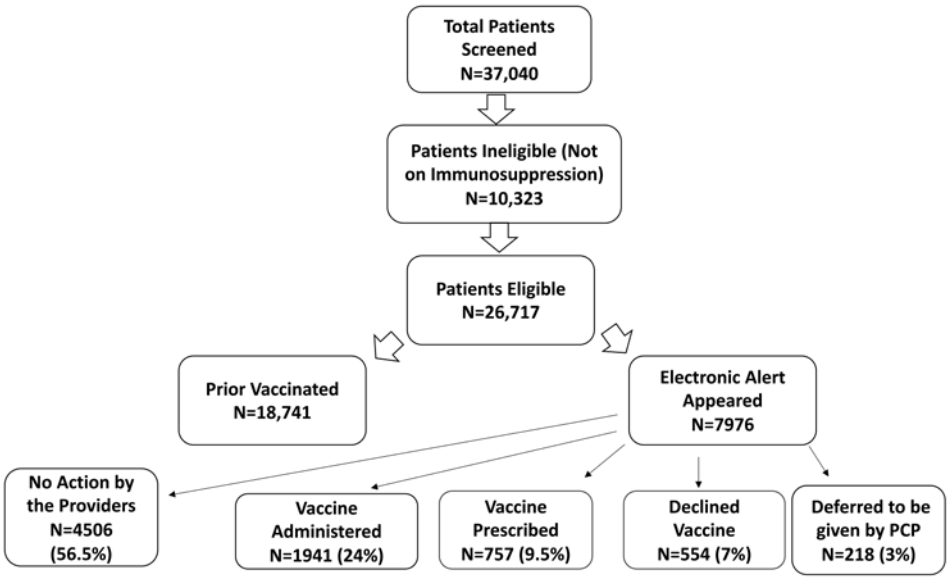

Figure 5. Physician responses to the best practice alerts. PCP: primary care physician.

additional vaccinations (e.g., influenza or herpes zoster), the physician decided to administer both vaccines in the clinic, or give one in the clinic and provide a prescription for the other to be received later. The logistic regression analysis showed the likelihood of patients receiving at least 1 vaccine was associated with age ≥ 65 years (OR 3.0, 95% CI 2.7–3.3, $P < 0.0001$) and if cared for at the academic center (OR 1.9, 95% CI 1.7–2.1, $P < 0.0001$). Sex (OR 0.9, 95% CI 0.8–1.2, $P = 0.1$), and race (OR 1.04, 95% CI 0.9–1.2, $P = 0.6$) were not significant contributing factors.

During the study, there were no reported adverse events after the vaccine administration and no hospitalizations due to pneumococcal infection. However, we did not investigate infections, postvaccine symptoms, or other systemic complications. There were minor issues reported with implementing BPA in different clinics, such as delays in going live, lack of vaccine availability, and turnover of office staff, requiring additional training sessions for new staff.

DISCUSSION

Our study demonstrated that the preintervention PV rates were suboptimal, which mirrored the national average PV rates.[5] There was a significant improvement in PV and documentation rates during phase I, and the improvement was sustained when the project was expanded in phase II to include all diagnoses with minimal staff re-education.

The success of this project required minimal input from rheumatologists. Earlier studies have shown that prevention strategies involving ancillary healthcare personnel are effective.[12,13] Time constraints in the outpatient setting are a major barrier for preventative healthcare delivery[14] and was adequately addressed in this study. Another factor contributing to the success of this EMR-based project was automation of eligibility for the specific vaccine based on CDC guidelines, addressing the barrier of time constraints in busy clinics and lack of knowledge. Once the EMR process was established, it was efficient and easy to sustain as the standard of care. It did not increase the time spent by MAs by much, as the alert was easy to navigate after proper orientation, patient eligibility was accurately identified, and if external vaccines were not documented, the BPA had the capability to address this as well. Although we did not specifically measure

the effect of the project on the staff assessment time, the general perception from the surveys was that the time spent in assessment did not significantly increase. The EMR prescription included patient education that could be printed and given to the patient. Above all, MAs expressed satisfaction with being involved in patient care, feeling empowered to initiate the prescription and thus owning the process. The EMR-based decision support systems have demonstrated success in improving preventive care[15] and chronic care delivery, such as in diabetes.[16] They have also been proven to improve patient safety; for example, alerts for drug interactions reduce medication errors and adverse events in pediatric hospitals.[17] Previous studies in rheumatology outpatients on immunosuppressive medications observed suboptimal PV rates at baseline. They reported substantial improvement over time, using decision support in the form of reminders to the provider for the PV.[18,19] Our study emphasizes the effective implementation of BPAs to improve vaccination rates, which can be generalized and sustained for many aspects of preventative care, particularly other types of vaccines. This methodology has also demonstrated improvement for the herpes zoster vaccine compliance in rheumatology patients at our institute.[20]

A previous study in providers caring for patients with chronic obstructive pulmonary disease showed that physician performance for patient care was better, resulting in better patient outcomes, after a COPD-related continuing education activity was completed by the providers.[21] Education for PV guidelines and training in the BPA process played a significant role in our study as well. Regular feedback of the results was an effective strategy, as has been also shown in published studies.[22,23] Following the feedback of quarterly results, the clinic physicians and managers were encouraged to review their data, identify the barriers, and provide solutions that may improve the compliance. The study team attended clinic meetings as required to support the effort and provide education. According to the survey feedback, the PV EMR-based BPA process positively influenced staff satisfaction and patient care without significantly increasing the workload. Along with BPA, a possible contribution to the improvement in compliance was the ability to administer vaccines in clinics, which was a major factor in the failure of a previous education intervention study that utilized patient survey and education, rheumatology providers' education, and provided paper reminders for PCPs to administer PV depending on patient preference.[24] Our study results of regression analysis also demonstrated that older patients at high risk were 3 times more likely to be vaccinated than younger patients. The patients from the academic center were also ~2 times more likely to be vaccinated. These results emphasize the importance of perceived patient risk, and of the availability of resources in academic centers in improving vaccination compliance.

Our study had some limitations. First, a major barrier for any EMR alert-based intervention is alert fatigue and providers ignoring alerts with their busy schedules. This has been reported in literature. A survey of PCPs to assess the EMR alert–related workload reported significant physical ($P = 0.02$) and cognitive ($P = 0.04$) weariness. The physicians suggested steps to reduce workload by allowing protected time for alert management, removing unnecessary alerts, and improving EMR.[25] In general, EMR was one of the major contributing factors in physician dissatisfaction, with its issues such as increased workload for data entry, inefficient interfacing among EMR systems, and loss of face-to-face patient care time reported by Friedberg, *et al*.[26] Our study addressed this barrier by the appearance of the BPA for high-risk patients who needed the specific vaccine, the initial BPA being addressed by the MA, periodic reinforcement of education, and involvement of the leadership from each clinic. We also report more than 50% of alerts were ignored. This noncompliance was probably due to provider-related factors, including perception of project's importance, EMR management skills, and physician availability on any particular day. Despite high noncompliance with BPA, significant improvement was demonstrated in vaccinating the high-risk population. One of the reasons could be that if the BPA was ignored, it would appear again at the subsequent visit, thus increasing chances of it being addressed in the near future. Second, the eligibility criteria were different between the 2 phases of the project. In both phases, eligible patients were targeted based on predetermined criteria for the BPAs, and physicians and staff intervened, responding to these alerts. Thus, change in eligibility criteria should not have affected the results in any significant manner, even though the preintervention phase II PV rates were higher than usual, which may be due to the phase I effect. However, we were able to attain a significant improvement in phase II as well. Third, the actual PV rates may be slightly higher if eligible patients received vaccines elsewhere. Fourth, given that our clinic staff did not regularly review and integrate outside immunization information available from the PASIIS[27] in our EMR, the actual baseline PV rates may be higher than reported in our study. Nevertheless, improvements in documentation of prior vaccination and correct identification of patients in need of immunization are important benefits of the intervention. Insurance approval and vaccine availability barriers for PV rates were not identified in our study.

Currently, the project has been expanded to other medicine subspecialties and is easily generalizable and sustainable in our medical center.

The changes in guidelines for PV that add unique challenges in determining eligibility and appropriate vaccination are addressed efficiently by the BPA. Our positive experience with this quality project improving PV rate is an ideal example of the importance of education, awareness, automation, involvement of ancillary staff, and reduction of physician burden to improve preventive care. The key components of the project that led to success were selecting the high-risk patient group with definite recommendations for the vaccine, the automated identification of eligibility, developing decision support through a BPA with prescribing and documenting capabilities, and empowering ancillary staff as first responders to the alert system. Education and feedback of results to frontline providers enhanced awareness and motivation. In addition, individual clinic teams were empowered to structure their own workflow modification to facilitate the project, giving them autonomy and ownership. These principles of EMR-based projects may be generalizable

and sustainable at many other institutions with EMR availability, although the type of EMR, buy-in from leadership and providers, as well as governance of vaccines are important factors for successful implementation.

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