

A. COVER PAGE

Improving Pneumococcal Vaccination Rates in Sub-Specialty clinics (ImPreSS)

Grant ID:
20087413

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Abstract

The **ImPreSS** goal is to improve pneumococcal vaccination rates in all UPMC medical subspecialty outpatient clinics by educating patients and providers, by creating sophisticated, novel algorithms to identify eligible patients and document their current vaccination status, and by creating unique workflow changes for each subspecialty to ensure eligible patients are receiving the appropriate vaccine. **ImPreSS** will target all eligible patients (over 310,000) and 372 physicians in 99 clinics. As part of our academic mission, we will include the 291 residents and clinical fellows who are currently training in the Department of Medicine. **ImPreSS** will create an automated, electronic medical record (EMR)-based, system-wide program, which will provide an electronic algorithm for identification and management of high-risk patients who are eligible by national standards for pneumococcal vaccination. To facilitate adoption of this process, **ImPreSS** will make education of patients, providers, and clinic staff a key objective. Regular feedback will include quarterly vaccination rates of providers and clinics, with anonymous peer-to-peer comparisons to drive change. Feedback provided to the Steering Committee will illuminate barriers and areas for improvement. Based on our collective experience with quality improvement initiatives like this, **we expect to achieve ≥90% pneumococcal vaccination rates using education of all healthcare staff, logic-driven decision trees that are seamless with current clinic workflows, and rapid cycling of feedback.** By developing this as a module in Epic, a widely used EMR, and by involving nearly 300 trainees, we expect that **ImPreSS** will have a very strong impact on national pneumococcal vaccination rates.

C. REVIEWER COMMENTS

We thank the reviewers for their interest and their constructive feedback.

C.1. “Some panel members were worried that these sub-specialty clinics do not have the vaccinations in stock.”

Response: We surveyed our subspecialty clinics and learned that 100% of these clinics have suitable facilities to stock the vaccines. Each Steering Committee member will be responsible for ensuring that his/her facilities stock the vaccine. We have gotten a high level of commitment from leadership to change the vaccination rates using the opportunity provided by this award. The electronic alerts will be designed to order the vaccine in the clinic or provide a prescription for vaccination at a pharmacy.

C.2. “Please elaborate on the connection with the work done through the other Pfizer supported project titled "UPMC Rheumatology Vaccination Improvement Project (**URVIP**).”

Response: **ImPreSS** builds on the pilot work done in the **URVIP** project.

- a. The **URVIP** project was the initial project, which developed strong working relationships among the teams in *Rheumatology*. In **ImPreSS**, we involve this multi-disciplinary team of diverse leaders to develop processes for all subspecialties and their patients.
- b. The **URVIP** project developed *early-phase* electronic medical record (EMR) capabilities as best-practice alerts for identification, documentation, and vaccination *for one disease population* (immunosuppressed rheumatoid arthritis patients). **This study team has learned a great deal in the process of developing URVIP, which will be used to develop the next phase: a more comprehensive and automated process involving different subspecialties and affecting over 300,000 in our network alone.**
- c. **ImPreSS makes 4 substantial improvements to the EMR system based on the URVIP experiences:** 1) greatly expands the function of best-practice alerts into complex algorithms to handle indications between 2 different pneumococcal vaccines and different indications by subspecialty; 2) enhances documentation and ordering functions; 3) enables cross-talk between clinics and subspecialties; and 4) provides an automated process, customizable to the unique needs of each high-risk patient population.
- d. **Regular, incremental improvements to each aspect are necessary for the success of quality improvement (QI) projects.** In **URVIP**, we learned that motivation and success improved with feedback reports to the providers and *when modifications to the process occurred often*, with quarterly meetings occurring for a full, thorough review. We will develop a more sophisticated feedback system, using graphs and longitudinal trends. Follow-up of feedback reports will be done regularly to help underperformers. Feedback reports will be tailored to each subspecialty and each clinic, keeping in mind the unique needs of their population and workflow.
- e. The **URVIP** project taught us the best ways to meet and educate. Smaller groups were more useful in creating meaningful improvements and changes. Training and re-training based upon assessment results are important. We will apply this knowledge to the various subspecialties and modify them based on the needs and knowledge gap.

C.3. “A few panel members felt this LOI was very hard to read because of the acronyms.”

Response: We apologize for this burden. We have substantially decreased the acronyms in the full proposal. We hope the reviewers will have an easier time with our full proposal.

D. MAIN PROPOSAL

D.1. Overall Goal and Objectives

The overall goal is to improve pneumococcal vaccination rates in eligible patients in all UPMC internal medicine subspecialty outpatient clinics. QI measures are very important to UPMC leadership, and **ImPreSS** has broad institutional support.¹ **ImPreSS** has already been reviewed and approved by the Quality Council at UPMC, which is an endorsement by UPMC of the quality and potential impact of the current proposal. It demonstrates the interest of the UPMC QI team in participating **ImPreSS** (see letters). Specifically, we aim

- 1) To educate providers and patients on the Advisory Committee on Immunization Practices and Center for Disease Control recommendations on pneumococcal vaccination;
- 2) To create clinic workflow changes using a multi-disciplinary team and EMR-based decision trees designed to identify eligible patients and document their vaccination status in all subspecialty clinics;
- 3) To create system-wide changes to ensure that eligible patients are receiving the appropriate, recommended pneumococcal vaccination without racial or ethnic disparities; and
- 4) To disseminate our system to other healthcare providers at UPMC and at other institutions.

We expect to reach $\geq 90\%$ of the subspecialty patients at UPMC, by either vaccination or documentation of a refusal reason, within the award timeline. We will maintain $\geq 90\%$ by involving UPMC leadership in using pneumococcal vaccination rates in the quality matrix for clinicians.

D.2 Technical Approach

The **ImPreSS** project will use the validated, continuous, quality improvement method developed by the *Institute for Healthcare Improvement* for use in their "Methods and Tools for Breakthrough Improvement" course.² This method uses quarterly cycles to Plan-Do-Study-Act, and the method has been used successfully by hundreds of health care organizations for similar QI projects as well as by Dr. Aggarwal for previous projects.^{2, 3} **ImPreSS** incorporates provider education, EMR-based tools, smart clinic workflows involving ancillary staff, and regular feedback leading to continuous improvement until the desired results are achieved and approved by all.

Following the invitation for a full proposal, Dr. Aggarwal initiated discussions with various clinical leaders in all medical subspecialties and sensed a lot of enthusiasm and support for the project. The multi-disciplinary Steering Committee evolved from these discussions. Dr. Aggarwal quickly received approval and support from UPMC (Dr. Shapiro, see letter) and Department of Medicine clinical leaders (Dr. Gladwin and Dr. Fischer, see letters) for this important project. The institution understands and supports this initiative; This is evident by the Vice-Chair for Patient Safety and Quality Improvement as well as the Senior Director of Outpatient Clinical Operations being a members of the Steering Committee. Additionally, our Information Technology, EMR, and QI groups are equally enthusiastic about **ImPreSS** and assured us their support (see letters).

ImPreSS will be led by a Steering Committee of key leaders from each subspecialty. Dr. Aggarwal, PI, will chair this committee. The committee will consist of 9 subspecialty leaders, representing each subspecialty (Drs. Aiyer, Bernardo, Brufsky, Faber, Griffith, Petrov, Rustgi, Viehman, and Yadav); Dr. Gary Fischer, Vice-Chair for Patient Safety and Quality Improvement in the Department of Medicine; Ms. Anna Marano, Senior Director of Outpatient Clinical Operations; Ms. Susan Della Toffalo, Manager of the UPMC EpicCare Reporting Analytics and Decision Support Team; Ms. Tamra Minnier, UPMC Chief Quality Officer; and Dr. Heena Sheth, Patient Safety and Quality Improvement team (biosketches and commitment letters are in Sections G and H). The Steering Committee has met to develop this proposal and will be the final authority on decisions during the award period. Several members of this committee were involved in **URVIP**, and that history will be important for success with **ImPreSS**.

Current National Assessment

Pfizer's Request for Proposals to develop sustainable solutions to address the disparities in adult pneumococcal vaccination arises from recent data that indicate that significantly fewer than 90% of eligible patients are being vaccinated, despite approved vaccines and longstanding national recommendations. *Streptococcus pneumoniae* (a.k.a., pneumococcus) remains a leading cause of serious, preventable illness among adults in the US. An estimated 4,000 deaths occur annually, and the incidence of invasive disease among those aged ≥ 65 years is alarming (36.4 per 100,000).⁴ The disease rates for adults in high-risk populations (e.g., immunocompromised patients, heart failure patients) can be more than 20-times the risk for adults without high-risk medical conditions.

As an example, the rates of invasive pneumococcal disease in hematologic cancer in 2010 were 186 per 100,000 and for human immunodeficiency virus (HIV), the rate was 173 per 100,000 (CDC, unpublished data, 2012). Additionally, pneumococcal vaccination significantly decreases the risk of pneumococcal infections and hospitalizations in patients with various high-risk conditions. For example, the relative risk of pneumococcal infections in unvaccinated rheumatoid arthritis patients on immunosuppressive therapy is 9.7.⁵ One-time immunization with pneumococcal vaccine in rheumatoid arthritis patients offers up to 10 years of protection.⁵ Similarly, efficacy among persons with diabetes mellitus was 84%; with coronary vascular disease was 73%; with congestive heart failure was 69%; and with chronic pulmonary diseases was 65%.⁶

A recent study suggested that the traditional pneumococcal vaccine, i.e., 23-valent pneumococcal polysaccharide vaccine (PPSV23 or Pneumovax), is effective in preventing bacteremia, but does not prevent non-bacteremic infections, which are more frequent in elderly patients.⁷ The incidence of invasive and non-invasive pneumococcal disease remained high, even after the use of Pneumovax for patients with high-risk conditions due to a prevalence of serotypes not targeted by the Pneumovax vaccine.^{8,9} Additionally, 50% of invasive pneumococcal disease cases among immunocompromised adults in 2010 were caused by serotypes contained in PCV13 and an additional 21% were caused by serotypes only contained in PPSV23.¹⁰ Based on these data, the Advisory Committee on Immunization Practices has recently included the 13-valent pneumococcal conjugate vaccine (PCV13 or

Prevnar) in series with Pneumovax in their recommendations, adding an additional level of complexity.⁴

Current Regional Assessment

UPMC is one of the largest healthcare networks in the US, with more than 3.9 million outpatient visits annually.¹¹ UPMC's Department of Medicine is one of the largest in the country, with all of the recognized subspecialties, including many recognized for excellence in the *U.S. News and World Report* rankings. Three subspecialties are in the top-ten: gastroenterology; pulmonology; and rheumatology. Quality improvements receive system-wide support with objectives that cascade downward through the institution. The UPMC Department of Medicine has a Vice-Chair for Patient Safety and Quality Improvement (Dr. Gary Fischer) and each division has a Director of Quality Improvement for that division. Dr. Rohit Aggarwal, PI of this proposal, is Director of QI in the Division of Rheumatology and Clinical Immunology.

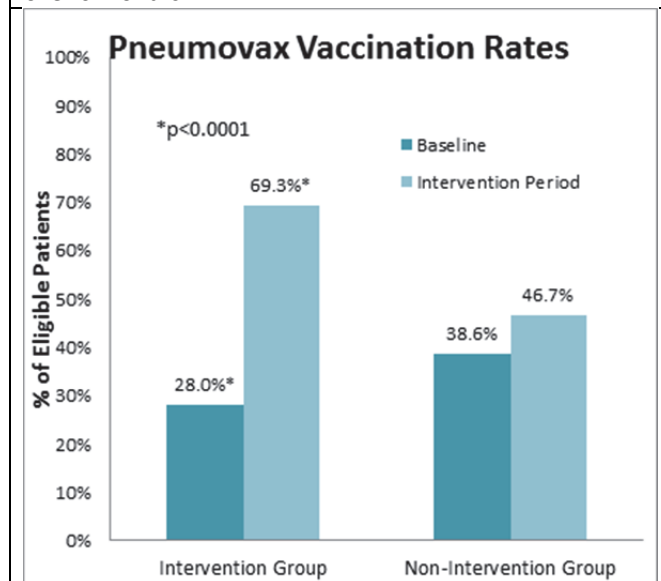
As part of the UPMC QI initiatives, Dr. Aggarwal studied the baseline rates of pneumococcal vaccination in high-risk rheumatoid arthritis patients receiving immunosuppressive therapies; the rate was dismal at only 28% of eligible patients. Subsequently, Dr. Aggarwal, with Dr. Larry Moreland, Division Chief, convened a series of meetings of UPMC rheumatologists in 2011-2012 to understand the barriers and ways to improve this rate. One of the key messages from these meetings was a need for education regarding current vaccination recommendations and a need for EMR tools and ancillary support to boost immunization levels. Using the American College of Rheumatology's 2012 recommendations¹², Dr. Aggarwal set out to improve the pneumococcal vaccination rate in high-risk RA patients on immunosuppressive medication at UPMC Rheumatology clinics.¹³ The "UPMC Rheumatology Vaccination Improvement Project or **URVIP**" was then funded by Pfizer in 2013 to address vaccination rates in UPMC Rheumatology clinics (Pfizer, **URVIP** grant, 8407367).

In **URVIP**, rheumatoid arthritis patients on immunosuppressive medications were identified to the clinic staff during the rooming procedure through an EMR-based best-practice alert system. Patients that were not vaccinated for pneumococcus were flagged. Flagged patients received counseling and written educational materials regarding vaccination. The clinic staff confirmed the EMR information regarding vaccine status and completed the EMR health maintenance documentation through alert itself (i.e., vaccine had already been administered). If an eligible patient had not been vaccinated, then an order was placed by the clinic staff using the same alert and a nurse administered and documented the pneumococcal vaccine. Within 6-months of this intervention, there was a 146% relative increase in pneumococcal vaccination rates, and a total of 69% of rheumatoid arthritis patients on immunosuppression therapies had received the pneumococcal vaccine during the intervention period, which was a significant improvement from the pre-intervention rate of 28% ($p < 0.0001$).¹⁴ In contrast, a non-intervention group with other rheumatic diagnoses having the same risk profile for pneumococcal infection and the same recommendation to vaccinate, only had a relative increase of 21% (38.6% to 46.7%). See **Figure 1**. This pilot **URVIP** project is ongoing and expected to achieve its goal of >80% vaccination in 2 years; thus far **URVIP** has impacted more than 2,000 rheumatoid arthritis

patients. Importantly, physician and staff surveys suggest that the process was easy and did not noticeably increase their work burden because the intervention was integrated within the regular clinic workflow. **This work demonstrates that implementation of an EMR- and ancillary-staff-based intervention can significantly improve both vaccination and documentation rates, with minimal input from rheumatologist.** Although this project was highly successful and informative, it was nevertheless a small project, limited to only one disease high-risk medical disease in one subspecialty clinic. There continues to be a need for implementing a similar, but more sophisticated and comprehensive, model in all UPMC subspecialty clinics and in the entire UPMC infrastructure, with increased automation and efficiency using the knowledge gained from the **URVIP** pilot project.

URVIP Preliminary Data Summary: URVIP establishes that our EMR- and ancillary-staff-based model is successful and that rapid, bidirectional feedback drives increased levels of success. It also established a successful collaborative effort with clinicians, administrators, EMR programmers, and QI teams. We will bring this experience, our multi-disciplinary collaboration, and the knowledge gained to bear on this larger project, **ImPRESS**.

Figure 1: Pneumococcal Vaccination Improvement in high risk intervention group versus non-intervention group over 6 months



URVIP also taught us generalities. In Steering Committee meetings, we discussed which generalities apply across all of the subspecialty clinics in internal medicine. Preliminary survey suggests that many patients undergoing care for chronic diseases at subspecialty clinics do not visit their primary care physicians on a regular basis, if at all (e.g., no vaccination with primary care then). Often, patients view their subspecialist as their primary doctor and trust them for all of their health concerns. Additionally, a large number of these subspecialty patients are elderly (30% or more in some clinics) and have high-risk conditionings requiring pneumococcal immunization even at ages less than 65 years. However, subspecialists may not see

immunization as his/her responsibility, despite their high-risk population, thus highlighting the need to target the provider and subspecialty clinic in a systematic and comprehensive manner. Despite UPMC-wide efforts in quality improvement in general, UPMC subspecialty medical clinics (e.g., renal, hemoncology, gastroenterology, cardiology, pulmonology, endocrinology, etc.) had suboptimal vaccination rates, ranging from as low as 15% to no higher than 40% (excluding **URVIP** clinics), which mirrors the national data. These rates are far from the Healthy People 2020 goal of 90%.¹⁵ We have taken the view that these findings, in one of the largest healthcare networks nationally, highlights an urgent need to target the providers, clinics, and patients in subspecialty areas using an innovative intervention, without an increasing burden.

As noted in Pfizer’s Request for Proposals, the ethnic and racial disparity is also a major area of concern for pneumococcal vaccination coverage among adults. Preliminary data from the ImPreSS Steering Committee shows lower baseline rates for ethnic or racial minority patients with chronic diseases patients managed in our subspecialty clinics at UPMC. For example, Caucasian patients with a diagnosis of congestive heart failure treated in our cardiology clinics had an overall pneumococcal vaccination rate of 40%, which was low; however, Hispanics and other minorities had a significantly lower rate at 27% (P=0.003) compared to Caucasians. Similarly, Hispanic and other minorities at high risk for pneumococcal disease due to a diagnosis of diabetes mellitus in endocrinology clinics or chronic kidney disease in renal clinics also had lower vaccination rates (37% and 45%, respectively). **ImPreSS** will benefit these minority patient populations with focused, targeted initiatives to improve education and automated processes for efficient recognition.

The above issues are compounded by the nature of pneumococcal vaccination recommendations themselves. The Advisory Committee on Immunization Practices recommends Prevnar (PCV13) **and** Pneumovax (PPSV23) vaccination series in patients over 65-years-old and in patients 19-to-64-years-old with high-risk medical conditions (e.g., renal disease, immunosuppressive therapy, lung disease, asplenia, HIV positivity, immunodeficiency, malignancies, etc).^{4, 17} See the summary in **Table 1**. When encountered in the context of busy outpatient clinics, with chronically ill, high-risk patients, these recommendations were deemed complex by the Steering Committee, and the recommendations lead to a substantial time commitment to determine which vaccine is appropriate at a given time.

Table 1. Indication of PCV13 and PPSV23 vaccination by age and subspecialty					
Risk Group	Subspecialty	High Risk Condition	PCV13	PPSV23	PPSV23 revaccination every 5yrs
Age ≥ 65 years	All	Irrespective of diagnosis or condition	Yes	Yes	
Age 19-64 years					
	Cardiology	CHF and cardiomyopathy		Yes	
	Pulmonary	COPD, Emphysema, asthma		Yes	
		ILD and lung transplant			
	Endocrinology	Diabetes Mellitus with complications		Yes	
		Adrenal insufficiency on chronic steroids			
	Hepatology	Chronic liver disease, cirrhosis		Yes	
	Hematology	Sickle cell disease	Yes	Yes	yes
		Hemoglobinopathies	Yes	Yes	yes
	Immunology	Congenital/acquired asplenia	Yes	Yes	yes

		Congenital/acquired immunodeficiency	Yes	Yes	yes
	Oncology	Leukemia	Yes	Yes	yes
		Lymphoma	Yes	Yes	yes
		Hodgkin's disease	Yes	Yes	yes
		Generalized malignancy	Yes	Yes	yes
		multiple myeloma	Yes	Yes	yes
	Renal	Chronic renal failure	Yes	Yes	yes
		Nephrotic syndrome	Yes	Yes	yes
		Renal disease requiring immunosuppression			
	Infectious disease	HIV disease	Yes	Yes	yes
	Gastroenterology	Inflammatory bowel syndrome on immunosuppression	Yes	Yes	yes
	Rheumatology	Immunosuppressive medication	Yes	Yes	Yes
	Any Specialty	Alcoholism/smoking		Yes	
		Iatrogenic immunosuppression	Yes	Yes	yes
		Solid organ transplant	Yes	Yes	yes
* CHF : Congestive heart failure; COPD : Chronic obstructive pulmonary disease; ILD : Interstitial lung disease; HIV : human immunodeficiency virus.					

In summary, based on collected data and our **URVIP** pilot project, we have determined that low pneumococcal vaccination rates are the result of at least 5 key barriers: 1) lack of awareness and knowledge about current Advisory Committee on Immunization Practices, recommendations, and an individual physician's actual percentage of vaccinated eligible patients; 2) lack of trained ancillary staff who had no easy way to identify eligible patients without intense physician intervention; 3) lack of an efficient system for pneumococcal ordering and documentation in the EMR; 4) assumption by the patients that their subspecialist was also their primary care physician and assumption by the subspecialist that high-risk patients had a primary care physician who was tracking their vaccinations; and 5) a complex set of recommendations involving two vaccines and recommendations based on disease and age.

The **ImPreSS** project will address each of those barriers. Given the complexity, the only sustainable solution is to develop an integrated EMR-based approach with unique clinic workflow changes using ancillary staff to identify, document, and order appropriate vaccinations. This complex decision-making algorithm can be automated in the EMR to identify eligible patients who meet either age or high-risk criteria or both and advise the physician as to which vaccine is most appropriate. This will maintain awareness of the recommendations, use ancillary staff to avoid physician burden, and decrease clinic burden using EMR automation and

efficient workflows. All providers will take responsibility for achieving recommended vaccination rates and documentation.

Regional Preliminary Data Summary: Despite 1) the risks of pneumococcal infections, 2) the availability of effective vaccines, 3) the presence of national guidelines that call for more effective vaccination of elderly patients as well as high-risk patients (e.g., immunocompromised patients), and 4) the National Vaccine Advisory Committee's recent report clearly stating that every healthcare provider has a fundamental responsibility to ensure that all patients are up-to-date with respect to recommended immunizations, the current rates of vaccination in medical subspecialties are dismal, even in a large, well-respected, technology-savvy healthcare system such as UPMC. With funding for ImPreSS, we have the ability to change the paradigm and make a positive impact on health care by using education, assessment, our proven clinic workflow changes, and EMR-based tools to identify, document, and vaccinate our vulnerable elderly and high-risk patient population.

Primary Regional Target Audience

ImPreSS will target over 310,000 eligible adult (age ≥ 18 years) patients managed by more than 372 internal medicine subspecialists in nearly 100 UPMC subspecialty medical clinics. **ImPreSS** will positively impact and benefit the large, regional population at UPMC by improving pneumococcal vaccination rates. In the final stages, when the process is ported to other Epic-using healthcare networks, ImPreSS will benefit millions of high-risk and elderly patients with our innovative technique.

Project Design and Methods

Each subspecialty and each subspecialty outpatient clinic poses its own, unique challenges, which need to be addressed with input from the physicians and clinic staff. **ImPreSS** will require workflow changes and customization of the Epic EMR to suit each subspecialty. Moreover, we have learned that proper education and active engagement of all personnel in the clinics is required to achieve desired results. Recent changes in recommendations for pneumococcal vaccination have added additional complexities to determination the appropriate vaccination and the timing for administration. Complex decision trees such as this are best handled by EMR.

The proposed project will use a multi-disciplinary team to generate system-wide changes to ensure that eligible patients are receiving the appropriate vaccines. We will tackle the problem in three areas.

- 1) Education of providers and patients;
- 2) System-wide clinic workflow changes; and
- 3) EMR-programmed algorithms and alerts (best-practice alerts) to automate the decision process and regular feedback reports.

Pre- and Post-intervention comparisons and rapid cycling of feedback to providers and enhancement of the process (Plan-Do-Study-Act^{2,3}) on quarterly basis to continuously improve the process ultimately leading to desired outcome.

Detailed Plan of the Project

Pre-intervention phase, 8/1/2015-10/31/2015: We will determine baseline rates of pneumococcal vaccination in the previous fiscal year (7/1/2014 – 6/30/2015) for eligible patients according to inclusion criteria and stratified by indications, especially high-risk indications, subspecialist physicians, and clinics. The vaccination compliance rate will be determined by the percentage of patients who received the vaccination, who have an EMR-documented refusal, or whose physician deferred because of a contraindication. We will obtain demographic and clinical information (e.g., age, gender, race, specific indication for vaccination, subspecialty, subspecialist physician, clinic) from the EMR. Pneumococcal infection rates will also be determined. These data will be analyzed by the Steering Committee to understand the factors leading to our high level of deficiency and will be used to develop intervention strategies. The information gained in this phase is critical for appropriate development of efficient best-practice alerts and clinic workflows during the intervention phase.

Figure 2. Example of a Best-Practice Alert for Pneumococcal Vaccination.

This patient is at high risk for pneumonia infection due to age ≥ 65 . He/She is eligible for Prevnar (PCV13) vaccination.

Acknowledge reason for not vaccinating:

Pt declined Acute illness/fever Allergic Defer to MD

Click to **Order** vaccination

Click to **Document** vaccination

ACCEPT Cancel

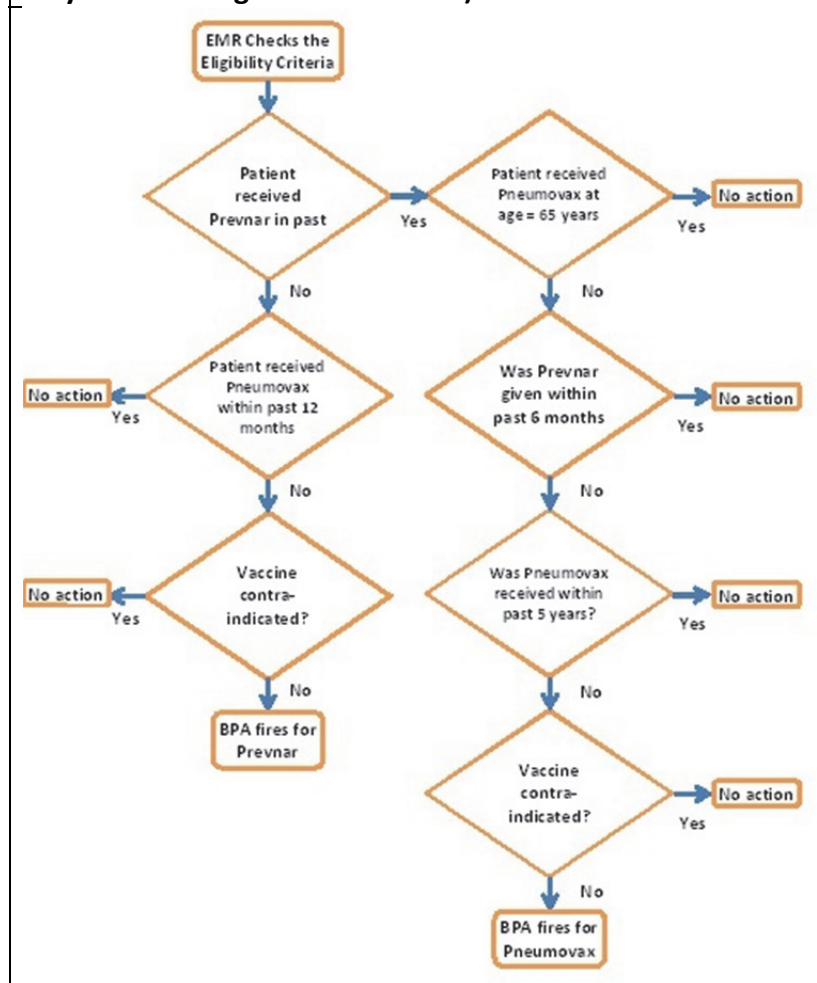
Intervention phase, 11/1/2015 to 4/30/2017:

Develop and implement EMR-based best practice alerts and ancillary-staff-based clinic workflows: We will develop an EMR-based best-practice alert algorithm, which will integrate vaccine eligibility verification for each individual patient, documentation of vaccination (example, **Figure 2**), and vaccine order capability. Best-practice alert algorithms will be developed in consultation with subspecialists to provide for the unique requirements of each subspecialty. The algorithm will distinguish between the Prevnar and Pneumovax vaccines and their differing recommendation criteria (**Figure 3**), so that only the appropriate best-practice alerts will fire.

Risk factors, indications, and criteria^{4,18} in the EMR will identify high-risk patients and their appropriate alerts. Current procedures in all UPMC outpatient clinics require that clinic staff perform a reconciliation of all medicines during the rooming process at each visit. If a patient meets the national criteria and recommendations, then the appropriate pneumococcal vaccine

best-practice alert will appear at this time, prompting the ancillary staff to engage a decision tree to verify eligibility, document previous vaccination, and/or order the vaccine. This is entirely done through the best-practice alert window itself (see **Figures 2 and 4**). Staff will read from the onscreen prompt, “Based on the criteria set forth by your physician, you should receive the pneumococcal vaccination.” Agreeable patients will receive the vaccine from the nurse at the end of the visit, who will then document the vaccination in the EMR. Eligible patients may receive a written prescription for vaccination at a preferred, local pharmacy if that is the patient’s preference. If eligible patients received a vaccination elsewhere, staff will

Figure 3. Process diagram of the EMR decision tree to be built for Prevnar vs. Pneumovax administration for patients ≥ 65 years (a similar decision tree is developed for adults < 65 years with high-risk indication).



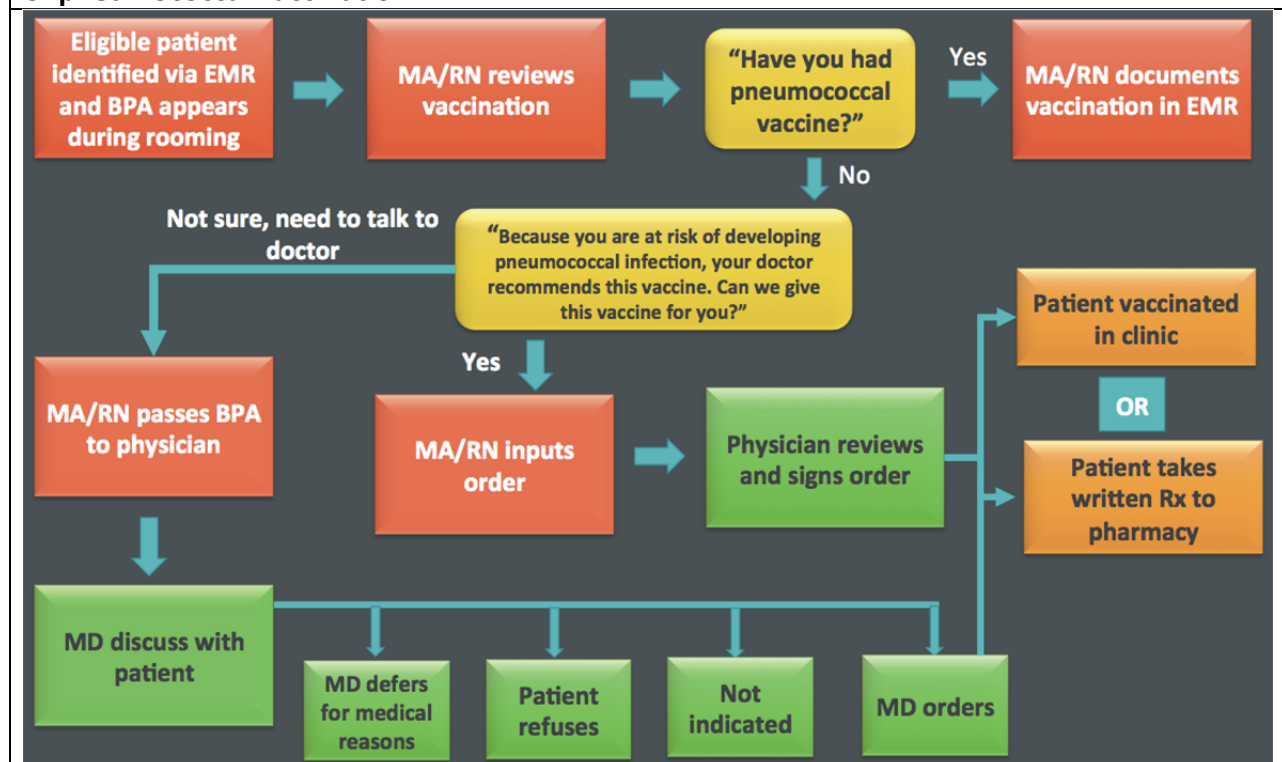
document that status. If a patient has additional questions or declines, the alert will be passed to the physician for resolution at that visit. The subspecialist will then discuss the vaccine recommendations and either order the vaccine for agreeable patients or document the refusal or deferral reasons in the best-practice alert window. The process will be repeated at each subsequent clinic visit until the pneumococcal vaccine is received and documented. **Subsequent Clinic Visits:** Best-practice alerts will not fire on subsequent visits if the patient was vaccinated and that was documented in EMR. If refusal or deferral were documented, then the algorithm will fire again, provided the patient continues to be eligible per the criteria. The process is automated until the patient receives an appropriate vaccination.

Proactive Vaccination: The best time and opportunity to give vaccination is at the time of diagnosis of a condition which is indicated for vaccination, or at the start of medications for which the vaccine is indicated (e.g., immunosuppressive drug). This is a unique opportunity to give the vaccine, as patient is motivated to prevent disease-related complications. Immune responses to vaccination might be best before any immunosuppressive medications are given. For these reasons, we will design the decision trees such that best-practice alerts will also

appear if the physician adds a new diagnosis or medication that meets the eligibility criteria for vaccination during the visit. The physician can order the appropriate vaccination so that the patient will get vaccinated at the time of diagnosis and/or before starting certain medications which is most ideal.

Bidirectional Feedback, 1/1/2016 to 12/31/2017: We will generate quarterly data reports starting from 1/1/2016 to 12/31/2017 to track compliance and improvement in vaccine administration and documentation rates. These quarterly reports will provide the necessary feedback to physicians and clinics (feedback to providers). They will compare peer-to-peer anonymously at the provider and at the clinic level. We have found that these reports **greatly incentivize physicians** to provide better quality care through a peer group effect. Each provider will strive to show better results in subsequent reports to be at par with his/her colleagues. Moreover, Steering Committee members will discuss the quarterly results with their respective subspecialist teams to understand barriers and solutions which will provide unique ways to improve the intervention in the next quarter (feedback to Steering Committee). These rapid cycles of quarterly data-extraction, evaluations, planning, and improvement of the intervention generates unique, appropriate solutions for each subspecialty clinic and population. Based on our pilot results, this will lead to continuous improvement over the grant period to achieve vaccination or documentation rates $\geq 90\%$.

Figure 4. Process diagram for EMR-based identification, administration, and documentation of pneumococcal vaccination.



Continuous improvement: Any improvement opportunities based on provider and/or staff feedback will be reviewed by the Steering Committee. Clinics and physicians will be presented by changes favored by the Steering Committee. Acceptable changes will be implemented on a quarterly basis.

Educational Intervention:

1. Formal education with discussion: We will follow the model described by Moore *et al.*¹⁹, which has proved successful in changing behaviors. Our efforts will be targeted at each of the 5 stages of learning: recognizing an opportunity for learning, searching for resources for learning, engaging in learning to address an opportunity for improvement, trying out what was learned, incorporating what was learned. All physicians will receive annual education in the form of a formal presentation with pertinent disease- and vaccine-related information tailored to their respective subspecialties, followed by interactive discussions geared to alleviate misconceptions, identify barriers and issues with workflow, and assess the need for further education. Based on the needs assessments, we will invite national experts in the field of vaccination in various subspecialty areas (e.g., vaccination in immunosuppressed patients or vaccination in HIV or chronic renal insufficiency patients) to present during Grand Rounds. We will measure knowledge by pre- and post-activity assessments. The Steering Committee will have complete oversight of this stage of education.

2. Education on the process and importance of the vaccination: Education on the national recommendations for pneumococcal vaccination and on the **ImPreSS** workflow and best-practice alerts will be implemented in small group sessions, at each clinic, conducted by the Steering Committee member. Steering Committee leaders in each subspecialty will regularly interact with their respective clinic staff and providers and will work to re-train staff or answer other questions or concerns. The program will target clinic staff and providers. These sessions will happen before the institution of the intervention and every 6 months thereafter. When required, one-to-one counseling will be provided to a provider or staff member. Sessions will be interactive with opportunities to address concerns and misconceptions and to clarify and/or update recommendations. The clinic manager at each clinic will assist in this process as well as help reinforce the process during their regular staff meetings. Small group meetings will benefit the troubleshooting to improve vaccination rates at each clinic. Specific pneumococcal vaccination knowledge and clinic workflow processes will be assessed with modules developed in the University of Pittsburgh Health Sciences eLearning Environment for Internet-Based Studies in Education and Research. All clinic staff will be expected to complete the module. The module will be updated and mandated annually (and for all new hires) as vaccination recommendations and clinic staff change. Finally, step-by-step flow charts with pneumococcal vaccine information specific for each subspecialty clinic and patient-education materials will be designed and posted in all clinical areas. A training guide will be available in each clinic and will include contact information for troubleshooting. We found those items to be particularly useful in the pilot project.

3. Education by feedback: Per the Moore model¹⁹, we will provide feedback to physicians and clinics regarding their pneumococcal vaccination rates through quarterly reports, anonymously

comparing peers and clinics. This will incentivize physicians to provide better, quality care. Steering Committee leaders in each subspecialty will discuss the quarterly results with their respective faculty to identify additional barriers and solutions, eliminate misconceptions, reinforce importance of vaccination, and provide education. Overall Department-wide reports will demonstrate successful scenarios and the overall impact on patient care.

4. Survey the user: Surveys will seek feedback from the physicians and staff, which will assist in developing further education or workflow modifications. Surveys will be reviewed by the Steering Committee and used constructively to improve **ImPreSS**.

5. Patient education: Patient-education pamphlets will be designed and will be used in the waiting areas. Moreover, pneumococcal vaccine education will be imparted by clinic staff during the rooming process through verbal review of these pamphlets. These pamphlets will be developed with key layman language and information regarding the benefits of pneumococcal vaccination. This information will help relieve any misconceptions that patients may have regarding vaccination. Pneumococcal vaccination educational material will print out with pneumococcal orders and will contain clear instructions on do's and don'ts and on handling a fever or any reaction post-vaccination. We will use port these educational materials to the interactive UPMC patient portal, "MyUPMC," to educate all patients who have scheduled appointments at one of the subspecialty clinics. MyUPMC is part of the Epic EMR suite of software, so other hospitals have the ability to use this aspect as well. As an institution, UPMC is pushing patients to use MyUPMC, and currently over 50% of our patients are registered to use it. All patients using MyUPMC receive appointment reminders which provide an opportunity for the patient to update their demographics and history in an effort to keep this information up-to-date. Changes are reviewed by the staff and physician before they become a permanent part of the medical record. All patients eligible for pneumococcal vaccine will be provided additional information in this reminder to inform them about their risk for pneumococcal disease and their eligibility for vaccination at the upcoming appointment. They will be provided links to the education module for the salient facts about the vaccine. This promotes active participation of the patients, prepares them for the visit, and facilitates informed consent and discussion of any concerns. We have found that this saves time during the visit and results in better educated patients.

Evaluation Design

Intervention Assessment: We will commence collection of the pre-intervention data at the start of this award, and will include data from fiscal year 2015. Each eligible patient's baseline demographics, vaccination status, subspecialist, clinic, vaccine indication (as per national guidelines⁴), and pneumococcal infection historical data will be collected from the EMR or the eligible patients. We will determine the baseline vaccination rates at all UPMC subspecialty clinics by evaluating the percentage of patients who are eligible, but are unvaccinated with pneumococcal vaccine and the percentage of patients who were vaccinated or have documented refusal or deferral in the EMR. The reason for being unvaccinated will be recorded when it is available. This data will be studied, stratified by subspecialists, clinic, demographic

characteristics, vaccine indications, and other clinical data derived from EMR. The same data elements will be reported quarterly throughout the intervention study period. We plan to collect this baseline information with the help of our quality improvement team and information technology team at UPMC using our Epic EMR-based report generation system. Our pilot pneumococcal vaccine project has demonstrated our collaborative effort with these teams and our ability to get quarterly data for reporting. These reports can be ported to other Epic platforms.

Quarterly, we will perform a pre- and post-intervention comparison to determine if vaccination rates are improving as a result of the intervention. The pre- and post-intervention comparison will be stratified by subspecialist, clinic, demographic factors, vaccine indications, especially to track compliance and improvement. Quarterly comparisons will be used to demonstrate trends and identify barriers, and to help adjust the intervention to drive continuous improvement. Data from web-based surveys and quarterly clinic meetings will be analyzed to understand the road blocks in the process. Quarterly adjustments to the workflow and intervention will be focused on making the process more practical, easy, efficient, and sustainable. We will determine what factors (e.g., certain indications, certain physicians, certain clinics, etc.) lead to lower vaccination rates and will intensify our efforts in those areas. We will provide more support and education to units and/or physicians not performing well. Patients and providers will be identified by code and not by names in these reports.

The regular data analysis, followed by modifications in the workflow or interventions, will allow continuous improvements every quarter and will drive better immunization practices and rates.

Assessment of the Engagement of the Target Population: Biannually, providers will be surveyed anonymously, via a web-based instrument, to determine engagement, identify barriers, and provide resolution to problems and to solicit feedback. Subspecialists and the clinic staff will have opportunities to provide feedback to Steering Committee members at the regular, small group meetings held in each clinic. Issues discussed will inform us of their level of engagement. The best indicator of an engaged clinic is a significant increase in that clinic's rate of pneumococcal vaccination from one quarter to the next.

Statistical analyses: Summary statistics (using either mean \pm standard deviation; range for continuous variables, or counts and percentages or rates for categorical variables) of baseline and quarterly post intervention data of vaccination status by subspecialist, clinic, vaccine indication, clinical infections, and numbers of patient visits will be presented. Pre- and post-intervention comparison of rates of vaccination will be performed using incident rate ratio for vaccination rates, overall and stratified by various factors like subspecialty, clinic, indication, etc. Demographic and clinical characteristics will be compared in pre- and post-intervention patient groups using Chi-Square, t-test, or Mann-Whitney U test, depending upon the variable distribution. Statistical control charts will be used to track vaccination trends and graphically provide longitudinal feedback to each provider and clinic and increase awareness using comparative best-practice benchmarks. Univariate and multivariate logistic regression analysis

will be conducted to identify risk factors for non-vaccination status. Risk factors for non-vaccination may include patient demographics (age, gender, race), insurance coverage, indication, subspecialty, type of clinic (academic vs. community), and provider experience (years of practice). We will also fit a Poisson model of the rates over time, with time as the predictor variable and a random effects term to account for within subspecialty correlation. Results of the coefficient for time will be used to describe the general trend over time. We will also compare the percentage of pneumococcal infections (assessed by ICD-9 or -10 codes) by subspecialty at baseline and at 6-month intervals during the intervention phase and determine potential associations vaccination rate trends.

Quantifiable Improvement Outcomes

1. % change in vaccination rates over time for all medicine subspecialties.
2. % change in provider or clinic performance for vaccination rates with peer comparison.

Based upon the pilot project and the enthusiasm generated by it, we expect to achieve a **sustainable** > 90% pneumococcal vaccination rate (which can include deferral or refusal) in all UPMC subspecialty clinics over 2 years as well as to educate providers and the subspecialist community. The percentage change in vaccination rates will necessarily demonstrate if the target audience (healthcare teams and patients) was fully engaged in the intervention.

Innovation: ImPreSS is innovative for several reasons:

- 1) EMR decision tree algorithms are integrated into the current clinic rooming procedure, using ancillary staff to provide a sustainable, time- and cost-effective solution;
- 2) EMR alerts provide an integrated, one-stop solution for identifying eligible patients, documenting status, vaccinating, and follow-up.
- 3) ImPreSS minimizes the physician time requirement without undermining shared decision-making between patients and their physicians.
- 4) Multi-disciplinary approach recognizes the unique needs and skills of each Steering Committee member.
- 5) Quarterly feedback reports provided to physicians comparing his or her performance to peers motivates compliance.
- 6) Final programming algorithms and reports can be easily ported to other medical centers using Epic, one of the most widely-used EMRs in the U.S.
- 7) The *Wolff Center* at UPMC will assist in disseminating these changes to other clinics and hospitals.
- 8) UPMC leadership is committed to including vaccination rates in the quality matrix for physician incentive plans and annual reviews (see letters).

Broad Dissemination

Dissemination will occur by: 1) including our almost 400 medical trainees in all phases of the project; 2) presenting preliminary results at national and international conferences; 3) submitting results to peer-reviewed journals; 4) using the *Wolff Center* to bring the developed process to all UPMC clinics, and 5) working with the Epic vendor to provide this technology to other healthcare systems across the nation.

Impact on Medical Trainees

UPMC is a major academic hospital network. Each outpatient clinic is associated with the University of Pittsburgh School of Medicine and UPMC. We have several fellows in each subspecialty, as well as several rotating internal medicine or primary care residents. Most fellows have their own unique continuity clinic, which is supervised by an attending physician. We currently have 291 fellows and residents in our subspecialties. A breakdown by subspecialty can be found in the Organizational Detail, Section E. **By involving these trainees, ImPreSS will educate trainees in decision tree algorithms and best-practice alerts. They will learn the most current information regarding vaccination recommendations. They will be exposed to a simple-to-use, computerized algorithm that doesn't increase their workload or cause them to become numb to alerts. This will be an important way for our program to develop in other networks as these trainees leave UPMC for their next position.**

Sustainability in the Long-Term

Continuous adjustments and improvements at each step over the 29 months of the funding will lead to a final process that is efficient and user-friendly. A process with those attributes easily becomes a routine **standard-of-practice** as we have seen in the **URVIP** pilot project.

D.3. Detailed Workplan and Deliverables Schedule

Table 2. Goals and Deliverables for the ImPreSS Project	
Goals and Deliverables	Expected completion (Month/Year)
To educate providers and patients on the Advisory Committee on Immunization Practices and Center for Disease Control recommendations on pneumococcal vaccination.	
1. Develop physician education workshops/lectures (broad and subspecialty-specific) for continuing education. These will include Department-wide Grand Rounds presentations by external speakers on pneumococcal immunization. Grand Rounds is recorded and uses electronic audience involvement; both faculty and trainees attend. The educational content will be dictated by the need-assessment (milestone 16 below) and will include presentations for each subspecialty.	
2. Develop assessment modules in the University of Pittsburgh Health Sciences eLearning Environment for Internet-Based Studies in Education and Research to assess knowledge of recommendations and pedagogical objectives.	
3. All physicians and ancillary staff complete the assessment module with a minimum score of 80% correct. New personnel will complete this at the time of hire.	

4. Develop and hold regular meetings for each clinic for education and assessment. Tailor subsequent meetings to each clinic's weakness(es) or barrier(s).	
5. Develop paper patient education materials. Additionally, develop and implement patient education via UPMC's patient portal to the EMR, "MyUPMC." Patients can access this educational material before a clinic visit. Approximately 50% of our patients have MyUPMC accounts.	
6. Use patient education materials online and in clinic.	
7. Refine patient education materials as warranted.	
8. Design, print, and post step-by-step flow charts in clinical areas and exam rooms.	
To create clinic workflow changes using a multi-disciplinary team and electronic medical record (EMR) based decision trees alerts designed to identify eligible patients and document their vaccination status in internal medicine subspecialty clinics.	
9. Develop inclusion and exclusion criteria for each subspecialty based on national recommendations and develop decision-tree logic for identifying eligible patients and determining vaccination indication.	
10. Program decision trees into the Epic EMR.	
11. Develop a clinic workflow for each subspecialty clinic.	
12. Develop and test the decision-tree best-practice alert for each subspecialty. Refine decision tree alerts and the Epic EMR programming based on the bidirectional feedback.	
13. Monthly meetings of the Steering Committee, run by Dr. Aggarwal.	
14. Regular meetings with the multi-disciplinary team (Steering Committee physicians, UPMC IT teams, QI teams, and EpicCare teams).	
15. Regular meetings with the clinic managers before and during implementation, run by the subspecialist co-investigator on the Steering Committee.	
To create system-wide changes to ensure that eligible patients are receiving the appropriate, recommended pneumococcal vaccination without racial or ethnic disparities.	
16. Develop assessment material for physicians and staff for pre- and post-intervention. Survey the providers pre-intervention for initial feedback and thoughts. Identify providers' perceived barriers.	
17. Survey physicians and staff anonymously to assess barriers and progress.	

18. Quarterly meetings to inform clinic staff of workflow changes and to solicit feedback for subsequent improvements in workflow and refinements in educational materials. Discussions with physicians and ancillary staff regarding the feedback reports, especially with under-performers (specialist or clinic under-performers) to understand barriers and develop plans for resolution. Steering Committee subspecialist leaders will present results in various subspecialist meetings to educate the providers and encourage continued improvement.	
19. Develop, disseminate, and discuss feedback reports for providers and clinics. Reports generated quarterly from Epic and the QI teams. Analysis of the quarterly and cumulative reports in clinic meetings.	
20. Implement changes in the decision tree (best-practice) alerts and clinic workflows to ensure continuous improvement based on patient, physician, and staff feedback and the feedback reports generated.	
To disseminate our system to other healthcare providers at UPMC and at other institutions.	
21. Meet regularly with UPMC and Department of Medicine leadership to use pneumococcal vaccination rates as one of the quality matrices for patient care at UPMC.	
22. Meet with UPMC and Department of Medicine leadership to disseminate the deliverables system-wide.	
23. Engage the Wolff Center to assist in disseminating the deliverables at UPMC and other healthcare networks.	
24. Present results at UPMC Quality Council meetings, Clinic Director meetings, Faculty meetings, Clinical Leadership meetings, and at various internal QI conferences and external research conferences.	
25. Perform final statistical analysis.	
26. Final abstract presentation at national conference.	
27. Publication in peer-reviewed journal.	

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