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Improving Immunization Rates Using Lean Six Sigma Processes: Alliance of Independent Academic Medical Centers National Initiative III Project

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ABSTRACT

Background: Quality improvement education and work in interdisciplinary teams is a healthcare priority. Healthcare systems are trying to meet core measures and provide excellent patient care, thus improving their Hospital Consumer Assessment of Healthcare Providers & Systems scores. Crittenton Hospital Medical Center in Rochester Hills, MI, aligned educational and clinical objectives, focusing on improving immunization rates against pneumonia and influenza prior to the rates being implemented as core measures. Improving immunization rates prevents infections, minimizes hospitalizations, and results in overall improved patient care. Teaching hospitals offer an effective way to work on clinical projects by bringing together the skill sets of residents, faculty, and hospital staff to achieve superior results.

Methods: We designed and implemented a structured curriculum in which interdisciplinary teams acquired knowledge on quality improvement and teamwork, while focusing on a specific clinical project: improving global immunization rates. We used the Lean Six Sigma process tools to quantify the initial process capability to immunize against pneumococcus and influenza.

Results: The hospital's process to vaccinate against pneumonia overall was operating at a Z score of 3.13, and the influenza vaccination Z score was 2.53. However, the process to vaccinate high-risk patients against pneumonia operated at a Z score of 1.96. Improvement in immunization rates of high-risk patients became the focus of the project. After the implementation of solutions, the process to vaccinate high-risk patients against pneumonia operated at a Z score of 3.9 with a defects/million opportunities rate of 9,346 and a yield of 93.5%. Revisions to the adult assessment form fixed 80% of the problems identified.

Conclusions: This process improvement project was not only beneficial in terms of improved quality of patient care but was also a positive learning experience for the interdisciplinary team, particularly for the residents. The hospital has completed quality improvement projects in the past; however, this project was the first in which residents were actively involved. The didactic components and experiential learning were powerfully synergistic. This and similar projects can have far-reaching implications in terms of promoting patient health and improving the quality of care delivered by the healthcare systems and teaching hospitals.

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INTRODUCTION

The public and the medical profession acknowledge that quality and safety in healthcare need improvement.[1] The Institute of Medicine has advocated for interventions[1] and followed up with a strategy for health system and medical education redesign.[2,3]

Resident quality improvement (QI) efforts have the potential to improve care quickly and effectively.[4] Residents are often involved in QI projects, but few programs have a systematic approach for integrating these projects with the hospitals' strategic initiatives.

One national healthcare issue receiving attention is the approximately 50,000 adults who die each year from vaccine-preventable diseases in the United States.[5] Among these preventable diseases are pneumonia and influenza. Combined, these 2 diseases are the nation's eighth leading cause of death overall and the fifth leading cause of death in older adults.[6] Pneumococcal infections cause an estimated 5,000 deaths from invasive disease annually in the United States.[7] All pneumococcal infections, including invasive and noninvasive disease, result in approximately 2.4 million days of hospitalization yearly. The overall case-fatality rate for invasive pneumococcal disease is 10%-18% among adults.[8] Each year, approximately 226,000 people in the United States are hospitalized with complications from influenza, and 3,000-4,900 die from the disease and its complications.[9] Up to two-thirds of all deaths attributed to pneumonia and influenza occur in patients who are hospitalized during the flu season regardless of age.[10]

A sizable proportion of these cases and deaths is potentially preventable through vaccination. In addition to providing substantial healthcare benefits, such as preventing infections and minimizing hospitalizations, vaccination is also a criterion for Centers for Medicare & Medicaid Services (CMS) reimbursement. Healthcare systems are trying to meet CMS core measures such as proper vaccination and to provide excellent patient care, thus improving their Hospital Consumer Assessment of Healthcare Providers & Systems scores.

Crittenton Hospital Medical Center (CHMC) is a 290-bed hospital located in the Metro Detroit area that provides a full continuum of clinical programs. It is nationally ranked for quality excellence and has a medical staff of nearly 500 physicians who represent a wide range of medical specialties and provide primary, secondary, and tertiary care. CHMC is the primary hospital for 4 residency programs (family medicine, internal medicine, transitional year, and otolaryngology). CHMC and its educational partner, Wayne State University Graduate Medical Education, aligned their educational and clinical initiatives. One of the clinical projects identified was to improve immunization rates against pneumonia and influenza prior to immunization being implemented as a core measure. This project was accepted as a Alliance of Independent Academic Medical Centers (AIAMC) National Initiative (NI) III project.

The AIAMC NI is the first national multiinstitutional effort that focuses on the alignment of medical education with hospital quality and safety strategies. The NI provides critical education, team training, and support to participating hospitals and equips participants with the tools and infrastructure necessary to accomplish meaningful improvements within their home institutions.

CHMC's intended clinical improvement was to immunize 100% of hospitalized patients against pneumococcal and influenza infections. The educational objective was to engage the residents in the family medicine residency program to work in interprofessional teams. The teams focused on understanding their workplace, collecting and presenting data, and proposing interventions to improve care. A curriculum was designed to combine QI knowledge acquisition, team building, and experience-based strategies.

METHODS

Planning the Intervention

The leadership team—composed of the designated institutional official, the hospital's chief medical officer, the director for quality improvement, and the residency program director—began meeting in November 2011 to establish goals and objectives for the initiative. The team identified the immunization project as aligning with the hospital's strategic initiatives. The initial project timeline was set for January 2012 to June 2012. CHMC was an ideal setting in which to assess the need for the 2 vaccinations because nurses assess each patient at the time of admission, documentation is accessible via electronic medical record (EMR), the pharmacy stocks the vaccines, and the quality department monitors compliance with CMS guidelines. Team membership, tailored to the multidisciplinary nature of the project, included 3 resident champions, a nursing manager, a member of the information technology (IT) committee, and a quality coordinator. Everyone had a role to play and was held accountable through weekly team meetings and monthly reporting sessions.

Developing the Curriculum

Our educational strategy included theoretical teaching of QI principles and teamwork/leadership strategies, as well as experiential learning through the completion of the QI project. To help ensure the teams' successful completion of their QI project, we developed 5 days of organized training sessions, including didactics and team exercises for all members. The training sessions were led by the hospital's director of quality improvement, a black belt Six

Table 1. Pneumonia Vaccination Process Capability at Baseline

	Z score	DPMO	Yield
Overall	3.13	51,903	94.8%
Age 65+	3.28	37,313	96.3%
High Risk	1.96	322,581	67.7%

DPMO, defects/million opportunities.

Sigma. Participants were expected to meet the following learning objectives:

- Define objectives (Day 1)
  - Understand how to gather information about a process.
  - Identify the Y and Xs of a process.
  - Develop the deliverables for a process improvement (PI) project.
  - Understand what value is to a customer.
  - Organize a team to address a process problem.
  - Use PI tools to help a project team define a process.
- Measure objectives (Day 2)
  - Determine which data to collect for a project.
  - Develop a data collection plan.
  - Develop a case for the return on investment of a project.
  - Assess the progress of a project.
- Analyze objectives (Day 3)
  - Assist in team facilitation.
  - Analyze project data collected.
  - Demonstrate knowledge of analysis tools for PI projects.
- Improve objectives (Day 4)
  - Identify improvement strategies: workout, rapid improvement event, infrastructure/education, IT process.
  - Develop standard procedures.
  - Identify visual cue opportunities in the improvement strategy.
  - Error-proof the improvement strategy: failure mode and effects analysis (FMEA), poka-yoke (Japanese mistake-proofing), human factor considerations.

Table 2. Influenza Vaccination Process Capability at Baseline

	Z score	DPMO	Yield
Overall	2.53	152,344	84.8%

DPMO, defects/million opportunities.

- Control objectives (Day 5)
  - Implement a plan to monitor and control the new process using control charts.
  - Transition the new process to the appropriate process owner.
  - Identify strategies to sustain improvement.
  - Prepare a final report on how the structured curriculum was designed.

Each step of the process was designed to help the team move along with the specific QI project. Initially, the team identified their customers: the federal government, patients, residents' and teams' education, and the hospital. The clinical objectives were clearly defined. The project scope included all inpatients admitted from January 2012 to May 2012 and analysis of adherence to the CMS guidelines for appropriate immunizations.[11] We excluded all patients treated through the emergency department, those listed as outpatients, and those under observation. The potential benefits were an improved CMS core measures rating and improved quality of patient healthcare. Also, the project aligned with the hospital's strategic plan to ensure financial viability, the quality and safety of patient care, and service excellence.

Information was measured through data abstraction and analyses. Data sources included patient charting in the Cerner Millennium EMR (Kansas City, KS) and information retrieved through the Midas+ software program (MidasPlus, Inc., Tucson, AZ); together, these provided the core measure indicators. Nursing staff entered patient information into Cerner; the quality department then abstracted and reviewed these data on a daily basis. The goal was to ensure that 100% of inpatients were immunized against pneumonia and influenza or that declination was recorded per CMS guidelines. None of the individuals participating in this QI project, including the authors, had any conflicts of interest. Privacy of the patients' health data was maintained in accordance with Health Insurance Portability and Accountability Act guidelines. The institutional review board exempted the project as an educational intervention.

Evaluating the Outcomes

The project used Lean Six Sigma processes to evaluate the immunization process. The Y was tracking whether 100% of the hospital's inpatients were immunized with pneumococcal and influenza vaccines or whether a patient's or caregiver's refusal of the vaccine(s) had been documented per the CMS guidelines. The goal of Lean Six Sigma is to perfect a process so only 3.4 defects/million opportunities (DPMO) occur. Lean Six Sigma is implemented by continual, incremental improvement that always

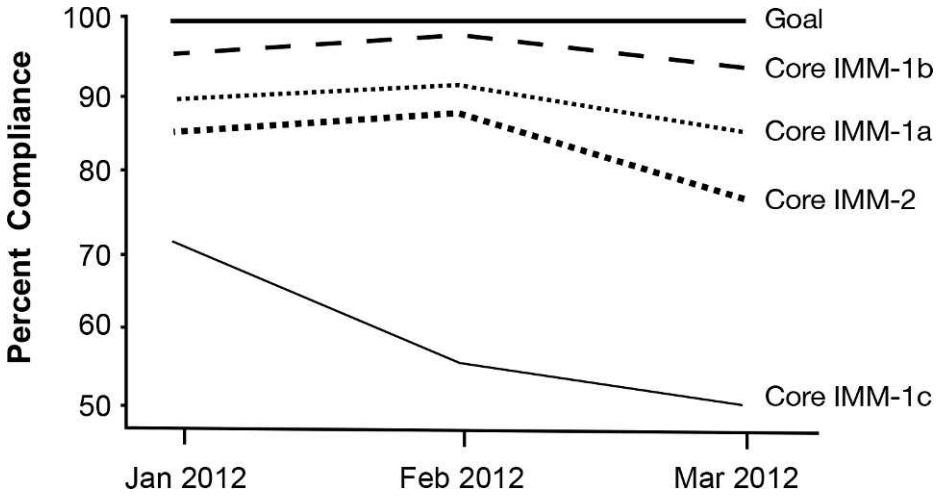

Figure 1. Baseline data showing immunization core measure compliance rates prior to intervention.
Core IMM-1a – Pneumococcal Immunization (PPV23) – Overall Rate.
Core IMM-1b – Pneumococcal Immunization (PPV23) – Age 65 and Older.
Core IMM-1c – Pneumo Immunization (PPV23) – High-Risk Population (6-64 years).
Core IMM-2 – Influenza Immunization.

maintains respect for the associates. The process consists of looking at variations, studying value-added and non–value-added steps, using specific tools to improve flow, and reducing waste. Combining Lean and Six Sigma involves utilizing value stream mapping with data as the driver. The Lean Six Sigma process tools of Z score, DPMO, and % yield helped to quantify the initial process capability. The Z score in the Lean Six Sigma process indicates how well a process is performing. Operating at a Z score of 6 means that the process is near perfect. DPMO reflects the amount of failures that will occur if the process runs 1 million times. Percent yield is simply the proportion of correctly performed operations to operation opportunities.

The hospital's process to vaccinate against pneumonia overall was operating at a Z score of 3.13, a DPMO of 51,903, and a yield of 94.8%. For influenza, the process was operating at a Z score of 2.53, a DPMO of 152,344, and a yield of 84.8%. Both of these processes needed improvement. However, the process to vaccinate high-risk patients against pneumonia operated at a Z score of 1.96, a DPMO of 322,581, and a yield of 67.7%. Improvement in the immunization rate of high-risk patients against pneumonia ultimately became the focus of the project. Tables 1 and 2 summarize the pneumonia and influenza vaccination process capabilities, and the baseline data are graphed in Figure 1. The time period encompassing January through March was used as our baseline; we collected data while planning our interventions. April and May then served as our outcome timeline. The drop in compliance in administering the pneumococcal vaccination to our high-risk population during our baseline period was noted; no explanation for this decline is apparent.

The analysis tool used for value stream mapping of opportunities for performance improvement of the vaccination process was the suppliers, input, process, output, and customers (SIPOC) map (Table 3). This type of map allows a process to be delineated into its individual steps and can be used to clearly identify areas that can be considered problem foci.

A fishbone diagram (Figure 2) was used to identify variation sources in the process that would lead to failure to immunize a patient per the CMS guidelines. Through this analysis, we found that high-risk patients were not being properly and efficiently identified. We used a Pareto chart (Figure 3) to highlight the most important factors contributing to the defects in the process. We discovered that improving the process of identifying high-risk patients, documenting a patient's age, and ensuring completion of the adult assessment form would solve 100% of the defects in the vaccination process.

RESULTS

Solutions for the problems encountered and error proofing were analyzed using FMEA. We also documented the effect of the pilot solutions compared to the baseline data. The changes involved

Table 3. Value Stream Map—SIPOC

S	I	P	O	C
Nursing	Patient history, medical records, family members	Admission assessment	Is patient eligible for immunization?	Pharmacy
Pharmacy	Advanced treatment protocol	Pharmacy order if patient is eligible	Vaccine prepared	Pyxis (CareFusion, San Diego, CA)
Pyxis	Advanced treatment protocol	Vaccine dispensed	Verify if correct, vaccine received	Patient's nurse
Patient's nurse	Two patient identifiers	Vaccine administered	Patient vaccinated	Patient's nurse
Patient's nurse	Patient's chart	Immunization status documented	Chart updated	Quality department

SIPOC, suppliers, input, process, output, and customers.

input from the process owner/sponsor and had to be implemented in the admission assessment form and communicated to the nursing staff. The Xs (inputs in SIPOC) were the prompts on the adult admission assessment form in need of improvement. An alert was added to Cerner prompting for completion of the assessment prior to patient discharge. Nursing staff were educated on CMS standards and the changes in the assessment form.

We next looked at the FMEA (Table 4) to see what could go wrong at each step, why, and how it could affect performance. The hazard scores were calculated by multiplying the severity of the problem by its detectability and by the probability of it occurring. The actions to reduce failure mode are listed in the table and will be considered in the future.

The potential solutions involved the IT and the Clinical Informatics Resource committees updating the prompts on the current adult admission assessment form, particularly for high-risk patients. The meetings held between the residents and the IT committee focused on revising the form to reflect the current indications per CMS guidelines. The revisions to the adult assessment form fixed 80% of the issues identified in the FMEA. In addition, the recommendation to use the Michigan Care Improvement Registry (MCIR) on all units in the hospital and to report adult immunizations to MCIR is a go-forward project. The new adult assessment form (Figure 4) is also now a part of the Downtime Assessment Paper Toolkit. During EMR downtime, the paper forms will be used and immunization status can still be documented.

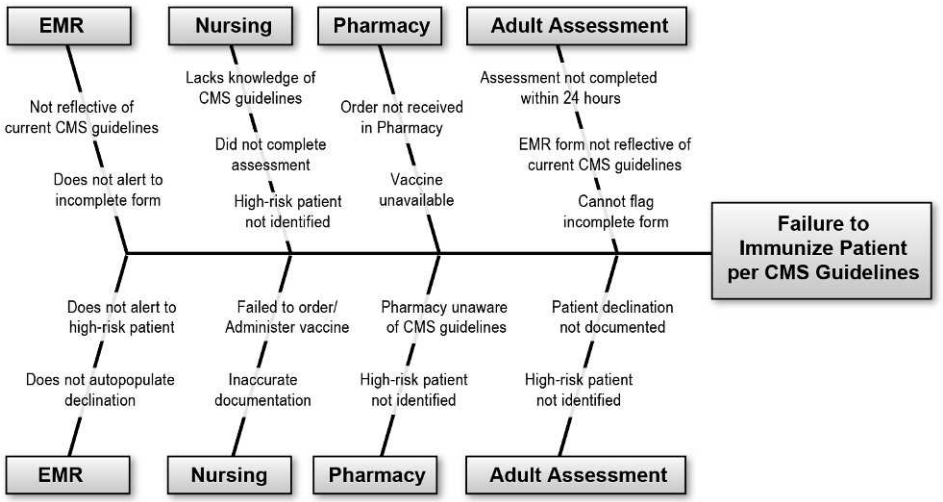

Figure 2. Fishbone diagram demonstrating potential error sources in key contributors to immunization process.
CMS, Centers for Medicare & Medicaid Services; EMR, electronic medical record.

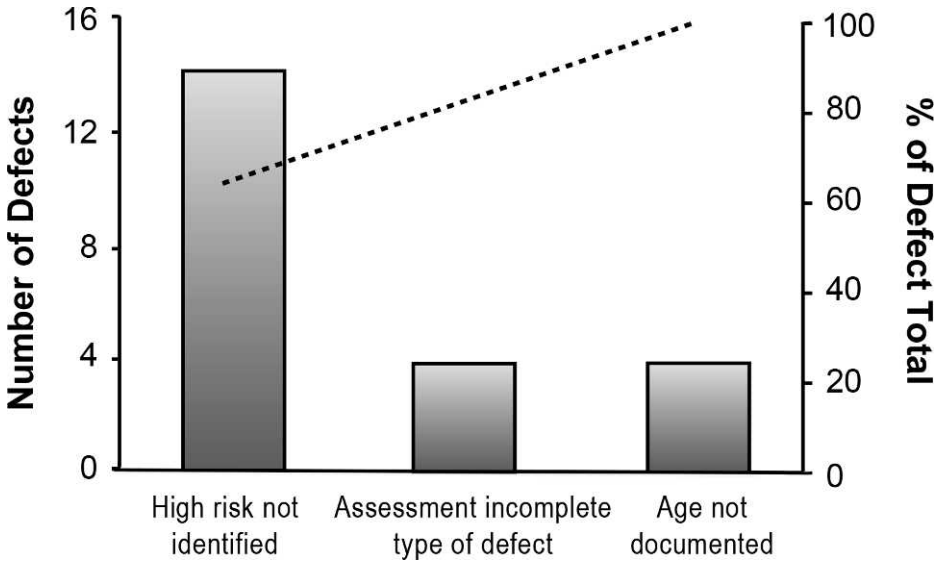

Figure 3. Pareto chart demonstrating that 3 key defects drive 100% of errors.

Strategies used to manage this change included regular interaction with the Clinical Informatics Team and the Cerner Super User group to discuss any trends that needed addressing (ie, any failure of the core measure). In addition, daily monitoring of core measures during implementation, consistently attending unit practice council meetings, and assisting with nursing unit education were deemed important to maintain the goal of 100% vaccination and documentation. The new process capability was calculated after the implementation of the solutions. The process to vaccinate high-risk patients against pneumonia operated at a Z score of 3.9 with a DPMO of 9,346 and a yield of 93.5% at the end of our intervention period. The new pneumonia vaccination process capability is shown

Table 4. Failure Mode Effect Analysis

Process	Failure Mode	Causes	Effects	Hazard Score	Actions to Reduce Failure Mode
Admission assessment	Incomplete, inaccurate	Poorly designed assessment form, no downtime procedure	Fail CMS measure, perpetuate inaccuracy	**80**	Improve assessment form, consider using MCIR
Pharmacy order	No order received, order does not follow patient, no EMR backup	Inaccurate, EMR failure, no downtime procedure	Fail CMS measure, perpetuate inaccuracy	**35**	Develop EMR backup procedure
Vaccine dispensed	Mislabeled, wrong patient, vaccine expired	Technical error, pharmacy error	Wrong vaccine given, delay in immunization	**30**	Develop medication safety process
Vaccine administered	Vaccine not administered, syringe failure	Staff distracted, patient discharged, manufacturer defect	Fail CMS measure, no vaccination coverage	**25**	Medication safety committee involvment
Vaccination charted	Incomplete, inaccurate	Poorly designed assessment form, no downtime procedure	Fail CMS measure, no vaccination coverage	**80**	Improve assessment form, consider using MCIR

CMS, Centers for Medicare & Medicaid Services; EMR, electronic medical record; MCIR, Michigan Care Improvement Registry.
Note: Hazard scores were calculated by multiplying the severity of the problem by its detectability and by the probability of it occurring.

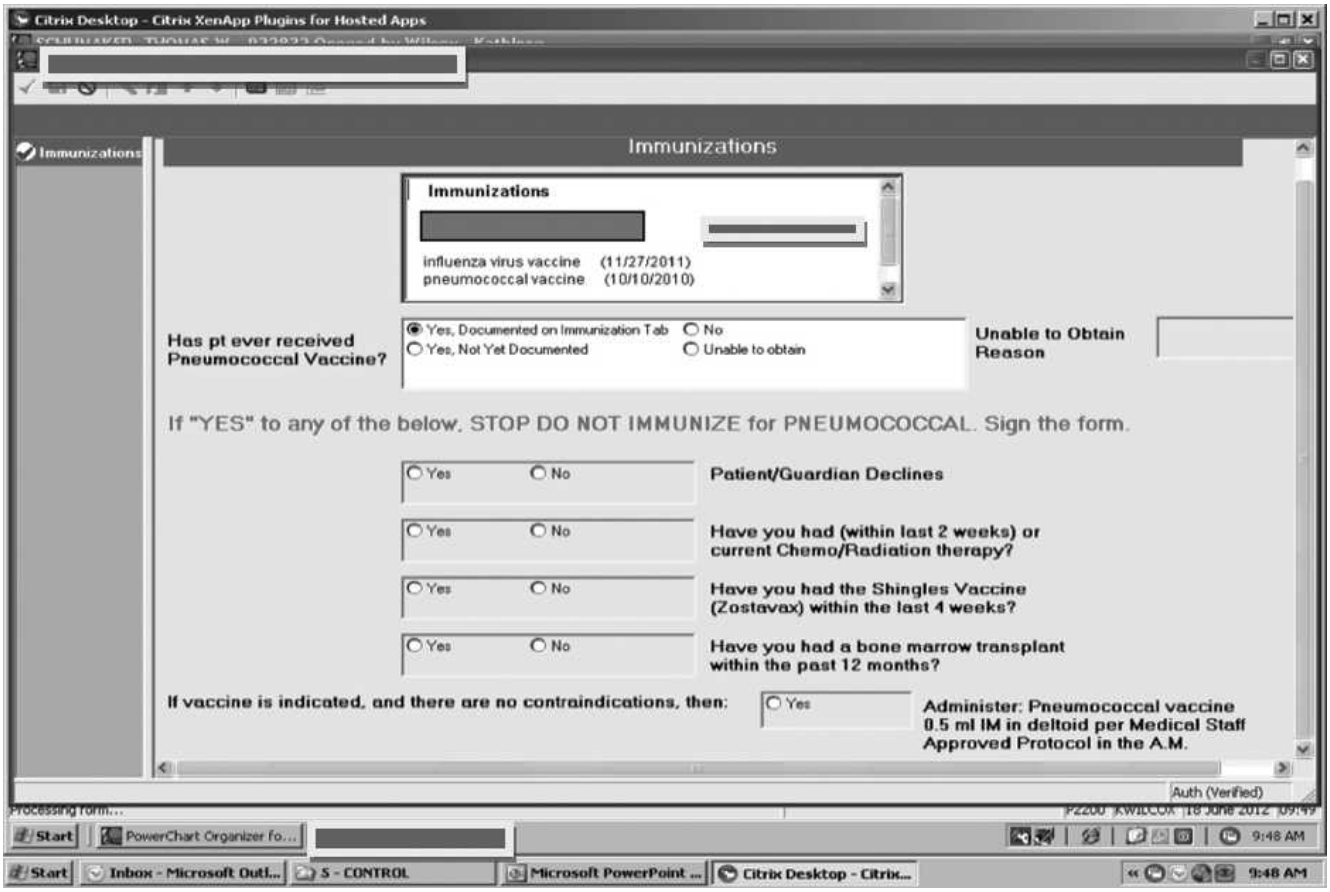

Figure 4. Snapshot of the new nursing assessment form for immunization in the electronic medical record.

in Table 5, and the new immunization compliance rates are graphed in Figure 5.

DISCUSSION

We demonstrated that aligning educational objectives with the hospital's strategic initiatives can lead to positive educational outcomes and more efficient care delivery through teamwork with faculty, residents, and hospital staff.

By using the Lean Six Sigma process toolset, we successfully identified the underlying problem for reaching maximal immunization rates and providing appropriate documentation in the hospital. The methods involved using the Lean Six Sigma process tools to assess Z scores, which gave us an idea as to how much work was needed to improve the process. During this phase, we realized that the original process was not addressing our high-risk population. We then put our process through the analysis phase and worked through using SIPOC. This activity helped identify the process steps involved, the problems encountered at each step, and the effect of the problem. Barriers to the process flow were addressed using FMEA. The final PI step was to compare data after implementing the new assessment form to the baseline data. The measures were calculated as part of the core measure abstraction process. This and similar projects can have far-reaching implications in terms of promoting patient health and improving the quality of care delivered by healthcare systems. The financial impact of this project will be more fully realized if global immunization measures are selected as part of future Blue Cross and Blue Shield pay-for-performance or value-based purchasing measures.

Table 5. Pneumonia Vaccination Process Capability After Solution Implementation

	Z score	DPMO	Yield
Overall	3.9	9,346	96.7%
Age 65+	6	0	100%
High Risk	3.9	9,346	93.5%

DPMO, defects/million opportunities.

The results of the QI projects were presented by the teams to the hospital administration and staff, other residents, and faculty at the first hospital-wide

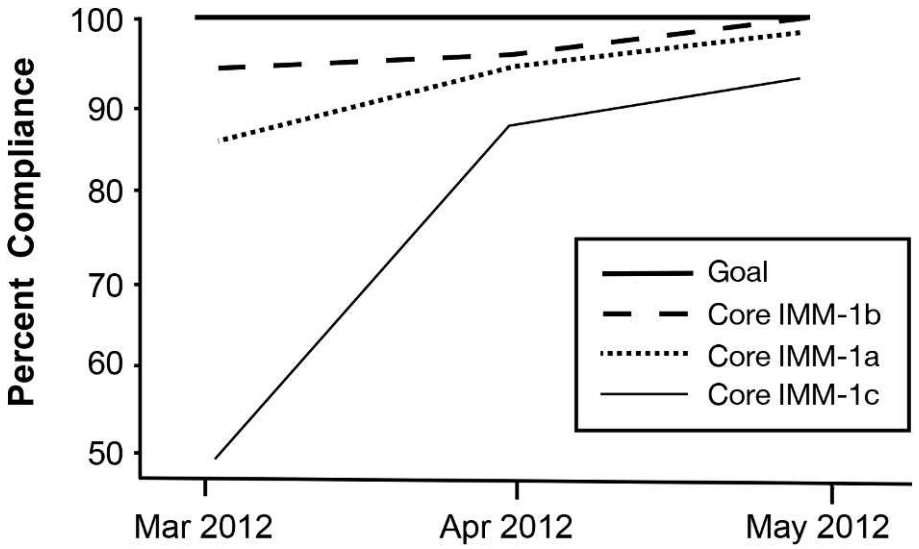

Figure 5. Postintervention data showing improvement in immunization core measure compliance rates.
Core IMM-1a – Pneumococcal Immunization (PPV23) – Overall Rate.
Core IMM-1b – Pneumococcal Immunization (PPV23) – Age 65 and Older.
Core IMM-1c – Pneumo Immunization (PPV23) – High-Risk Population (6-64 years).

Quality Improvement Day on June 20, 2012. More than 150 people attended. Residents engaged with and led interdisciplinary teams. All team members reported high satisfaction with the structured learning experience. They commented that didactic and experiential learning were powerfully synergistic, and the patient care improvements are motivating to the teams. The success of the initiative was grounded in the interdisciplinary teamwork.

The limitations were that our process solved only 80% of the issues identified in FMEA; this result speaks to the complex nature of PI. Our study encompassed a single end-user change during a single influenza season; it is unknown whether this short-term project will have a lasting effect on hospital flow. Lastly, our process was, by design, limited to the inpatient setting; implementing similar improvements in local primary care practices might have a more meaningful impact. Larger studies are needed to evaluate impact. Educational and organizational outcomes need to be tracked longitudinally.

In relation to the evidence, our findings were consistent with other literature on the subject. The American Health Quality Association[12] produces a fact sheet on QI projects designed to improve quality of care for seniors and lists various participatory organizations that have experienced similar success. Also, researchers at the University of Alberta, Edmonton, analyzed 106 studies—nearly 80% of which were performed in the United States—to map an effective way to increase immunization rates.[13] The researchers concluded that any of a variety of QI interventions could produce modest increases in vaccination rates, and they observed that 3—team change, patient outreach, and clinician reminders—are effective for improving rates of both influenza and pneumococcal vaccinations.

CONCLUSIONS

The immunization PI project was not only beneficial in terms of patient care but was also a positive learning experience, particularly for the residents. CHMC has undertaken QI projects in the past; however, this event was the first time residents were actively involved and participated in the QI and teamwork training. It was a new and exciting opportunity for residents to learn a new skill set that will be useful in their future endeavors in medicine. The project was challenging because the residents worked on improving a process that is not regularly taught as a part of medical training. Nevertheless, this type of experience can have a significant impact on the quality of care that these physicians deliver.

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