Improving the Hospital Discharge Process with Six Sigma Methods

ABSTRACT This article describes the application of a five-phase Six Sigma define, measure, analyze, improve, and control (DMAIC) approach to streamline patient discharge at a community hospital. Within the context of the five phases, the team applied statistical process control (SPC) charting, process mapping, Pareto charting, and cause-and-effect matrices to make decisions. The findings suggested that focusing on physician preparation for discharge order writing would have the greatest impact. A significant reduction in the average discharge time from 3.3 to 2.8 h was realized ($p = 0.06$) and missing chart data was reduced by 62%.

KEYWORDS cause and effect matrices, control charting, individuals charts, lean sigma, moving range, pareto charts

INTRODUCTION

Six Sigma continues to be of interest in the corporate world. Case studies to teach Six Sigma using hypothetical problems at universities are also important (e.g., see Johnson et al. 2006; Rasis et al. 2002a, 2002b). Yet, real-world case studies relevant to instruction are in surprisingly short supply (Allen 2010). In the field of health care, Six Sigma has been used to address numerous problems including decreasing length of stay, reducing medication errors, and improving the admissions process (Castle et al. 2005; Christianson et al. 2005). In general, Six Sigma is credited with an ability to manage and improve complicated processes. Even though patient discharge has been identified as one such complicated process (Watts and Gardner 2005), a review of the literature did not discover any hospital discharge projects utilizing the Six Sigma methodology. This article describes the application of Six Sigma to improve a patient discharge process at a community hospital.

The Joint Commission for the Accreditation of Health Care Organizations (JCAHO) requires hospitals to implement projects to improve their patient discharge processes. Yet, the rules are ambiguous about how to implement improvements. Several authors have studied the application of individual quality methods for data-driven systems improvement in health care. These methods have included failure mode and effects analysis (FMEA) and root cause analysis (Robinson et al. 2006). Other authors have argued that multi-method approaches are needed (Davies 2001). Six Sigma is one such
multimethod approach. It also has been defined as a data-driven method for process improvement (De Mast 2007; Linderman et al. 2003).

The setting of this discharge study was a 204-bed hospital in Alliance, Ohio, that is similar in many ways to the thousands of community hospitals across the United States. At the time of the project, the hospital was in a building such that critical care, medical-surgical, and emergency room facilities roughly corresponded to floors. The hospital had applied recommended practices for improving patient throughput with no significant improvements detected.

For purposes of this project, we defined the discharge process as all occurrences between the time a physician writes a discharge order and the time the associated bed is made available. At the time of this project, satisfaction surveys were not conducted with all patients. Nevertheless, of the few complaints provided by patients, problems with patient discharge were at the top. As a result, several projects were considered initially but the discharge one was selected because it was believed to most likely improve the patient experience.

**IMPLEMENTATION OF SIX SIGMA**

**Define Phase and the Project Charter**

The Six Sigma team consisted of a Six Sigma researcher/consultant, the chief of nursing, an advanced practice nurse, the head of case management, and an information technology engineer. The chief executive officer commissioned this team in April 2005. Although the Six Sigma protocol does not encourage the addition of team members during the analysis phase, three additional team members were added. These additions included another consultant who was a Six Sigma black belt, a nurse, and a nurse manager. An internal medicine physician and several nurses also provided valuable input including data from the pilot study of the proposed system. The team was chosen partly because the members had expressed the greatest interest in system improvement and partly to be representative of the main groups of the staff who would be affected by changes.

The team’s primary goal was to improve patient satisfaction with the discharge process, which was judged by the chief executive officer (CEO) to be a critical issue based upon the “patient-centered” hospital mission, past complaints, and historical patient satisfaction survey results. Another goal was to reduce omissions in the medical record of patients that might affect their quality of care.

At the beginning of the project, patient satisfaction surveys were suggested as the primary key output variables (KOVs) or project “Y.” Based upon a power calculation conducted during the define phase, it was judged that average rating on a five-level scale was insufficient because a larger sample size would be required than was possible given the number of patients affected by the project. Surrogate measures were selected, including the average time of discharge (from when the physician writes the discharge order until the patient was escorted from the floor) and fraction of records with specific types of omissions: therapy, medications, activity, referrals, follow-up appointments, diet, and other types.

The initial target unit was the hospital floor with the most patients discharged outside the hospital, with the initial target for project completion was 6 months. Extending the results to address hospital-wide discharges, including discharges to other parts of the hospital, was considered beyond the scope of the project and a possible subject of a follow-on project.

**Measure Phase**

The measure phase in the Six Sigma method involves documentation and evaluation of the system that exists prior to any changes that the team might suggest. As a first step, the team developed an approximate process map to clarify the scope of the project shown in Figure 1.

The next step was to develop a repeatable and reproducible measurement standard operating procedure (SOP) for discharge time. Therefore, the team developed a manual measurement protocol using a complete sample of 100 sequential (by time of discharge) patients’ medical records (paper charts) from the archives. The SOP involved finding the time the physician wrote the discharge order from handwritten orders, which usually included a time notation. In cases where no time notation was made by the physician, the time that the bedside nurse verified the order was used, which was always available. For the time that the patient left the hospital, times were typed into a system at the time the transportation service was
completed. To verify that the procedure was reproducible by a different person, two team members used the procedure on a convenience sample of five charts (an informal gauge R&R).

This measurement SOP provided 103 successive discharge times over approximately 3 months. The times were charted using the individuals moving range control chart method (Montgomery 2004) with the chart shown in Figure 2. The reason we chose individuals chart is that there was no basis for rational subgrouping, because of the irregular nature and small volume of patient discharges involved in our study subsystem. In Figure 2, we can see that there are four out-of-control signals on the initial chart. By inspection of the medical records, we found that all of these points correspond to overnight discharges. Overnight discharge was determined to be beyond the project scope because it related to rare events not of critical interest. Therefore, we removed these points and revised the chart limits. The revised individuals chart is shown in Figure 3, which includes the rest of the 99 discharge times and 47 times from the control phase.

Figure 3 shows that there still are two out-of-control signals. However, no assignable cause was found so these points were retained. This procedure established an average discharge time of the hospital of approximately 3.3 hours prior to any intervention for same-day discharges. The revised upper and lower control limits are 11.5 and 0.0 hours, respectively.

Also, we thoroughly investigated 30 of the charts to establish the benchmark fraction of incomplete charts. Figure 4 shows the fraction of cases that had at least a single nonconformity related to the various types of concerns described on the left. The error bars indicate a single sigma or “±” limits (not simultaneous intervals). The results shows that approximately a third of the charts were unclear in important ways that concerned the therapies those patients would need after they left the hospital.

Management at the hospital had been interested in measuring baseline customer satisfaction. However, the hospital did not have a satisfaction survey that was given to all patients at that time. The team handed out approximately 50 surveys to all patients leaving the floor. Because only 9 were returned, measuring significant differences in patient satisfaction was not possible.

### Analyze Phase

In the define phase, we identified the key output variables (KOVs). They were average discharge time and fraction of incomplete charts. The analyze
phase generally involves developing a list of key input variables (KIVs) or project “Xs” and clarifying how changes in these variables can improve the KOV values.

The team started by creating cost/time Pareto charts (Allen 2006) to study whether certain destinations or diagnosis codes were particularly important. The results in Figure 5 were derived from the team’s chart audits. In general, Pareto charts help in identifying which subsystems and associated KIVs should be focused on. In this case, the exercise confirmed the hypothesis of social workers that discharging to nursing homes takes the longest. However, the differences in the times between discharge to nursing home and discharge to home (the most popular destination) were not large enough to suggest that focusing on nursing home discharges could offer an easy way to drive down the overall average.

The orthopedic surgery discharges in the 200s of the diagnostic codes took much longer on average than other discharges. The obvious cause was found to be the mandated physical therapy in the afternoon. This therapy was being used partly to assess whether the patients were ready for discharge. Discussions with the therapists and the nursing staff suggested that the therapists were generally mindful that the patients in question were being discharged. The therapists were already scheduling these patients for first attention.

Though the scheduled nature of the therapy might offer an opportunity for improved coordination with the families who were coming to pick up patients, the team chose not to pursue improved coordination as an intervention. This decision was made because variability associated with discharge destinations and the results of the therapy discouraged possible attempts to change the somewhat informal system for communicating with families. As a result, the analysis of the Pareto charts in Figure 5 did not lead to any obvious or key input variables for immediate further study or recommendations for system change. As a result, the team used another analysis method designed to open up possibilities for system improvement. Figure 6 shows a cause-and-effect matrix related to discharge. The matrix was derived from conversations with an advanced practice nurse and staff familiar with the discharge.
In this exercise, the team brainstormed to compile a list of possible patient issues and rated their importance (1–10, with 10 being highest importance to the patient). The results are shown in the leftmost two columns. Next, the team brainstormed a list of possible system changes. The team then estimated the correlations between each of the patient issues and the proposed system change. If the team perceived the change as likely to affect that issue, a high correlation was assigned. For example, because disseminating the discharge summary information would almost certainly make all the relevant physicians in the hospital aware of the other physicians associated with patient treatment, a correlation of 10 was assigned. Conversely, if the team thought that a change would not affect an issue, low correlations were estimated. For example, the step of sending out instructions to the pharmacists, though important for other issues, would not affect the time the patient waits for discharge. Therefore, a correlation of 1 was assigned.

This version of cause-and-effect matrix generation was similar but not identical to the version in textbooks (e.g., see Allen 2006). The difference was that this team did not base customer ratings on direct testimony from patients but instead relied on the opinions of personnel familiar with the discharge process.

The factor rating numbers shown in the bottom row of Figure 6 are designed to prioritize the possible system changes based on importance to patients. They are derived from a summation of the products of correlations with importance ratings. In this case, the exercise concluded that creating a fast track similar to another hospital (Autman) and hiring a dedicated person or “discharge champion” would have the greatest effect on patient well-being. However, because both of these options involved incurring high expenses, other interventions were considered.

Preparing physicians to write their discharge orders using a preprinted form was then considered. The benefit to the system can be understood with reference to the simplified process flow diagram in Figure 7. Ambiguities in the discharge orders were causing nurses and patients to wait for clarification. Discharge orders were determined to be complicated, with many patients waiting too long for their discharge information.

**FIGURE 6** Cause-and-effect matrix summarizing team opinions and factor ratings.
being discharged with 20 or more medications and complicated instructions regarding activity, diet, and restrictions. Subsequent discussions with additional nursing staff provided converging evidence that pursuing improved physician preparation could save substantial time and frustration for all involved.

RESULTS

Improve Phase—Outcomes

In the improve phase, the results of the analyze phase are used to make tentative design change recommendations. These recommendations are then piloted, confirmed, and institutionalized in the control phase.

Prior to our intervention, physicians simply wrote their discharge orders on a blank physician’s order sheet in the patient’s medical record. Though the Alliance community hospital information technology system has the ability to generate up-to-date information about the patient drugs and therapies and deliver that information in a timely fashion throughout the hospital, physicians did not take advantage of this technology. Leveraging this strength, the team decided to enlist help from the information technology and nursing staff to design a computer-generated form to facilitate patient discharge. This printed form would then be inserted by case management into the medical record on the day prior to the expected discharge.

A sketch of the derived form used to prepare physicians for writing discharge orders is shown in Figure 8. Because the list of medications may be long, the form often requires two pages. The form is a tool that allows physicians to consider all medications when planning for discharge. This includes medications taken prior to the patient’s admission and those prescribed during the hospital stay. Check boxes give the physician the opportunity to indicate that a medication should be continued after discharge or discontinued. Similarly, physicians can modify or amend dietary orders, activity orders, and therapies described in the bottom sections.

Statistically significant evidence that the new system improved key output variables (KIVs) was not available until the control phase. However, during the implementation the immediate anecdotal feedback was positive.

Control Phase

The discharge worksheet form was introduced on the one unit of the hospital involved in the project. This required the information technology staff to work together with the nursing and case management staff to have the charts ready for the doctors. Yet once the report format was input into the information system, the cost was minimal. Typically, the nurses simply print out the form and put it into the medical record.

An audit of 27 charts belonging to patients discharged subsequent to the use of the form resulted in an average discharge time of 2.8 h. (There were 28 including one with an overnight stay.) This was completed in April 2006, roughly 1 year after the team charter. The 27 associated are charted on Figures 2 and 3. With 21 out of 27 observations below the previous average, the binomial distribution $p$-value is 0.00076, indicating a significant reduction. With 17 out of 27 below the previous median, the binomial distribution $p$-value is 0.06104. Therefore, the reduction in the average discharge time was statistically significant. Additionally, the team
achieved a dramatic reduction in missing entries in the charts as shown in Figure 4. Chart documentation completeness is important because it can potentially affect the quality of care given after the patient is released both at home and during subsequent visits to the hospital.

Reception of the form by nurses and physicians has been generally positive. Feedback from various stakeholders has caused the hospital to refine specific aspects of the discharge physician preparation form while adhering to the overall structure shown in Figure 8. Implementation of the form hospital-wide is currently being planned.

Overall, we feel that the application of the disciplined Six Sigma methodology has been beneficial in this case. The significant time reduction and improvements in chart completeness will improve the experiences of many patients. Moreover, previous consultants had attempted to improve patient discharge experiences through the application of recommended practices and failed to make any measurable impact. It seems that the systematic, data-driven Six Sigma approach used by this team is well suited for complicated processes involving many people and subsystems. Six Sigma seems to have helped the team to identify an appropriate substage in the process and make a small but important change; that is, preparing physicians to write their orders in a way that reduces ambiguity at the time of discharge.

DISCUSSION

The commitment of top management is critical to system improvement efforts because hospitals are under many competing pressures. Also, community hospitals like ours have limited resources to hire and retain process change leaders. Currently, our hospital has one part-time industrial engineering student. Problems with discharge persisted for many years and many similar problems exist today. Yet, it requires experience and leadership to identify subsystems that can be improved and complete their improvement.

In the discharge project, our team considered many possible changes, including some that involved the coordination of many personnel. We feel fortunate that we were able to identify a solution—that was small enough in scope as to have minimal side effects in terms of increased workloads for nurses.

Since the project completion, the community hospital moved to a new building. Also, the discharge form has gone through two subsequent iterations. It has now reached a mature form and is part of the protocols for all patient discharges. The nursing staff currently feels, however, that with the new pressure to improve medication reconciliation, efficiency gains have been lost. Yet, they also feel that the gains in chart quality and (likely) associated gains in care quality associated with the new form and process have continued. Also, accountability for medication errors for all types has increased.

CONCLUSIONS

In this article, we apply a DMAIC approach to streamline patient discharge at the hospital. Several tools are used including statistical process control (SPC) charting, process mapping, Pareto charting, and cause-and-effect matrices to analyze and solve the problem. We found that a significant reduction in the average discharge time from 3.3 to 2.8 h was realized ($p = 0.068$). This is based on the nonparametric Mann-Whitney one-sided test accounting for the fact that the times are not even approximately normally distributed. More importantly, missing chart data was reduced by 62%. When prescriptions of debatable relevance were not included, a 79% reduction in missing entries was realized.

Physicians and nurses were generally positive about the intervention. In particular, both physicians and nurses liked the reduction of phone calls from nurses to clarify information before discharging patients. The hospital had attempted to improve the discharge process for several years through the application of recommended practices for improving patient throughput with no significant differences detected. Success in this instance seems to be related to the data-driven Six Sigma approach. In the course of this project, a tool was developed for discharge planning and medication reconciliation upon discharge, which may be useful for other hospitals.

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**REFERENCES**


