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Quality Quandaries: Lean Nursing

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INTRODUCTION

Complaints with respect to the management of health care and health care delivery are huge. In combination with the drastic increases over the past decades in the cost of health care, we may say that health care is in serious trouble.

Fortunately, the quality profession can help to solve some of these problems. An important new application area for quality engineering concepts and methods is health care, where applications to processes are challenging. In this "Quality Quandaries" column we provide an example of the application of Lean Six Sigma in health care. The specific case study is about reducing the length of stay of patients with a total hip replacement. First, we provide a brief background for the case study. We then highlight some of the statistical aspects. After the major improvements were implemented, the team continued with Kaizen principles (cf. Imai 1986). This study is interesting because, unlike the common assumption, it shows that there is no trade-off between quality and cost; we can improve quality while at the same time reducing costs.

BACKGROUND

The Reinier de Graaf Healthcare Group in Delft, The Netherlands, is an 881-bed, medium-size teaching hospital employing a staff of 3,104. In 2009, the Reinier de Graaf Healthcare Group had 38,333 admissions, performed 29,332 outpatient treatments, and received 470,574 visits to its outpatient clinics, of which 164,985 were first contacts.

In 2008 the Reinier de Graaf Healthcare Group's management decided to initiate a Lean Six Sigma program. With the assistance from the Institute for Business and Industrial Statistics at the University of Amsterdam, Lean Six Sigma was kicked off with a one-day executive training for the board and directors and a first wave of Green Belt (GB) training. The GB training was provided in four separate blocks of two days, one month apart. Each GB was required to complete a project as an integral part of the training. The financial threshold for initiating a project was a projected minimum savings of $60,000. Each GB typically worked one or two days a week on his project. As part of the project management system, teams were carefully monitored and only allowed to proceed to the following phase of the Define, Measure, Analyze, and Control (DMAIC) sequence after presenting the projects' Champion (i.e., the coach of the GB) with interim reports providing evidence that the preceding phase had been completed. For a summary of the typical steps of a Lean Six Sigma project, see Figure 1.

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Teams were required to present their results in front of the class. The final presentation after the training served as the GBs' graduation exam.

The first wave was followed by additional GB training waves scheduled every 6 months. In September 2010 the fifth wave of GBs was started. In general, the Lean Six Sigma approach was well received. The GBs felt that the training and project management system supported them well. Importantly, the data-driven approach seemed helpful in establishing management support and in minimizing resistance to change. Of course, the curriculum was tailored to the specific needs in health care. Some tools and methods that were not so relevant in health care, like design of experiments and gage R&R, were skipped or not treated extensively.

Experiences from the previous waves of GB training in other hospitals indicated that many health care problems involve various forms of waste. Lean concepts were therefore more prominent in the revised Lean Six Sigma program. For example, we added materials on value stream maps and the eight standard forms of waste to the curriculum in the analysis phase; see, for example, Liker (2004). Further, the curriculum for the Improve Phase was expanded to include complexity reduction, cellular production, pull systems, line balancing, and the 5S-method to reduce inefficiencies due to clutter and poor organization; see, for example, George (2003).

In recent years, the Dutch Ministry of Welfare and Health had imposed severe budget cuts on hospitals. This necessitated a keen focus on cost reduction while maintaining or possibly improving quality. Potential projects were suggested by Champions, who were all department heads. The final project go-ahead was made by a steering committee consisting of board members and directors based on an evaluation of the projects strategic relevance.

Define	
Measure	1. Define the CTQs 2. Validate the measurement procedures
Analyse	3. Diagnose the current process 4. Identify potential influence factors
Improve	5. Establish the effect of influence factors 6. Design improvement actions
Control	7. Improve process control 8. Close the project

FIGURE 1 **Summary of the seps of the DMAIC cycle used in Lean Six Sigma (cf. De Mast et al. 2006).**

Over the last two years the Reinier de Graaf Healthcare Group carried out around 70 Lean Six Sigma projects. We now discuss one project focused on reducing the length of hospitalization of patients with a total hip replacement.

SHORTENING THE LENGTH OF STAY OF ORTHOPEDIC PATIENTS

At the Reinier de Graaf Healthcare Group, patients undergoing total hip surgery are primarily admitted to the Orthopedic Department. The patients differ in a number of ways, including age and sex. In this case study we exclude patients who entered the hospital via the Emergency Room. Hence, we only consider so-called elective patients. Because it was felt that the length of stay of these patients could be reduced, it was decided to put together a Lean Six Sigma team to evaluate the situation. Team members included the head of the nursing staff of the Orthopedic Department, an orthopedist, three senior nurses, a transfer nurse, and an employee from the admissions office. The managing director of the surgical wards assumed the role of Champion for the project.

Define Phase

During the define stage of the DMAIC cycle (see Figure 1), the team, in cooperation with the team's Champion, developed a charter statement. It stated that the primary objective was to discover factors influencing the length of stay of orthopedic patients undergoing a total hip surgery. In other words, the critical to quality (CTQ) metric was length of stay in the hospital for these patients. Due to space limitations we do not provide a full discussion of all the steps of this Lean Six Sigma project.

Measure Phase

After developing a detailed flowchart of the process from admission to discharge, the team created a cause-and-effect matrix, mapping all potential factors that might impact the length of stay for the specified category of orthopedic patients. Subsequently, the cause-and-effect matrix helped the team develop a list of factors that potentially could influence the length of stay. Table 1 provides a list and short description of the input variables. These variables were already being recorded by the hospital but needed to be assembled into a comprehensive spreadsheet for further analysis.

The months October through December 2008 were used as a baseline period. This period was considered long enough to provide a reasonable representative sample of the process. Fifty-six patients with a total hip surgery were included. The validity of the data was checked carefully by the team.

Analysis Phase

Data analysis usually starts with a comprehensive graphical investigation. Figure 2 is an example of a graph that is considered helpful in getting a comprehensive first overview of the data. It shows a control chart of the length of stay in days of patients with a total hip surgery. The order is the case number in time order as the patients were admitted. We notice a few

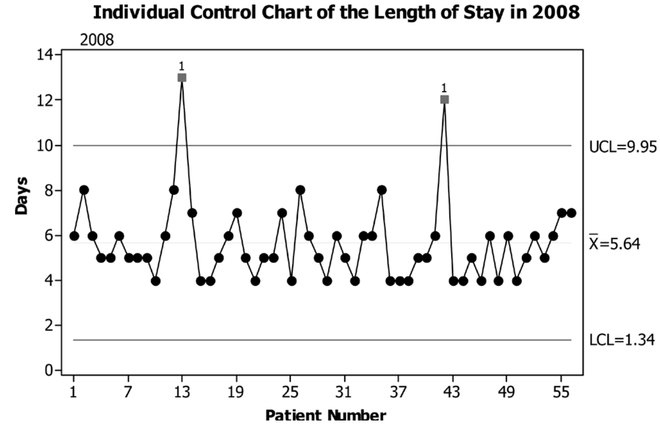

FIGURE 2 **Control chart of the length of stay in 2008.**

outliers, in particular observation 13 in Figure 2, representing a patient admitted for 13 days. After further scrutiny, it was found that this patient was a 68-year-old male with an ileus. The other outlier was an 86-year-old female with delirium. The minimum length of stay of 4 days was met for 28% of the patients.

Another useful tool for investigating whether there may be a potential causal relationship between certain (categorical) influencing factors and a continuously varying output variable such as the length of stay is the one-way analysis of variance (ANOVA). ANOVA is a simple but powerful tool for quickly screening a large number of categorical factors for a potential relationship. We have used ANOVA repeatedly, not only to check factors that we believe may make a difference to the length of stay but also to eliminate factors that do not. It turned out that there were significant differences between the specialists (ranging from an average length of stay of 5.0 days through 8.4 days); day of admission (increasing from Monday with an average length of stay of 5.0 days through Sunday with an average of 7.5 days); gender (males had an average length of stay of 5.2 days and females an average of 5.8 days); and discharge destination (to own home has an average of 5.0 days; to own home with assistance has an average of 6.3 days; and to another institution has an average of 6.8 days). There was no significant difference in length of stay by age (based on a regression analysis).

From the Lean Six Sigma team's discussion of the cause-and-effect matrix, another factor primarily suspected of influencing the length of stay was wound treatment. Until 2008 the patients were treated with an absorbent wound plaster. This has to be changed several times per day. Also the hygienic conditions

TABLE 1 **CTQ and Influencing Factors Collected for the Study and Short Descriptions**

Variable	Description
Patient number	A number assigned to the patient at admission
Main diagnosis	Main diagnosis of patients made at admission to hospital
Length of stay in days (CTQ)	Days for treatment from admission through discharge
Specialist name	Name of the specialist
Day of admission	Day of the week on which the patient was admitted
Age	Age of the patient
Gender	Gender of the patient
Day of discharge	Day of the week on which the patient was discharged
Year of registration	Year of admittance
Treatment of the wound code	Code describing the kind of plaster used: 1 = Zetuvit; 2 = Aquacel
Year and day of week of discharge	Year of discharge and day of the week
Destination code	Code describing the destination to where the patient was discharged: 0 = own home; 1 = assisted living; 2 = other institution (other hospital, nursing home, etc.)

were not very good (leakage of blood and wound fluid in the bed).

Improvement Phase

The Black Belt and her project team discussed the list of the vital influence factors. A meeting was organized with the orthopedists in which they discussed the best way to perform a total hip surgery. Data showed large differences between the doctors.

The differences in the lengths of stay with respect to admission day were also a subject of discussion. Differences occur because surgery cannot be scheduled every day due to limitations of the operating theater. The introduction of a joint care program in which a group of patients is operated on the same day was received positively. An extra advantage was that the group of patients rehabilitated together, which was a stimulus for their recovery. Gender was considered a noise factor, which could not be influenced.

With respect to the treatment of the wound, an experiment was set up to determine whether an alternative plaster would give better results. Further, a stricter protocol to discharge patients was introduced. Leaflets for the patients were scrutinized and adapted to reflect the new insights.

Control Phase

The Improve phase results in improvement actions that aim to change processes for the better. In the Control phase the quality control system is changed in such a way that the changes can be retained. Apart from this, sometimes the improvement comes from changing the way the process is managed. After changing the process and process quality control system, the results of the project are measured by doing a process capability analysis. Finally, the BB or GB is discharged.

The experiment with the alternative plaster was a great success. A three-layer Aquacel (hydrofiber) plaster, which was placed on the wound just after surgery, guaranteed sterility and consequently no leakage. Another benefit was that the plaster had to be replaced only after 5 days. Hence, the nursing staff could be reduced by 0.5 full-time equivalents.

An important Control phase deliverable is often the design of a dashboard that facilitates performance indicator monitoring and that serves management. In this case the Black Belt chooses to monitor the length of stay of the patient. It was to be expected that the average length of stay should be less than 5 days. The dashboard also includes the expected day of discharge. This forced medical and nursing staff to take measures if the discharge date was near. An out-of-control action plan was defined that prescribed the actions to undertake. The Black Belt documented the new working procedures and assigned new roles and responsibilities in the process, including the persons responsible for dashboard data collection. In Figure 3 a picture of the office with the dashboard on the wall is given.

In the period January through June 2009 the implementation was undertaken. During that period, patients were treated with both kinds of plasters (the original one, Zetuvit, and the alternative, Aquacel). In Figure 4 we see the results with respect to the length of stay for the two kinds of plaster.

In this period 171 patients underwent total hip surgeries, of whom 102 had the original plaster (Zetuvit) and 69 had the alternative one (Aquacel). Figure 4 clearly shows that the length of stay of patients with the Aquacel plaster is lower than patients with the Zetuvit plaster. The difference in average length of stay of both plasters was 0.5 days. Overall, the average length of stay over the first half of 2009 was equal to 5.1 days, which is about is about 0.5 days lower than in 2008. Forty-two percent of the patients stayed less than or equal to 4 days in the hospital, which also shows progress (in 2008 only 28% of the patients stayed 4 days).

The project closure consisted of a discharge form that was signed by the Champion and a controller on July 10, 2009. The financial benefits due to a reduction of personnel and additional admissions were around $110,000 annually.

FIGURE 3 Picture of the dashboard in use.

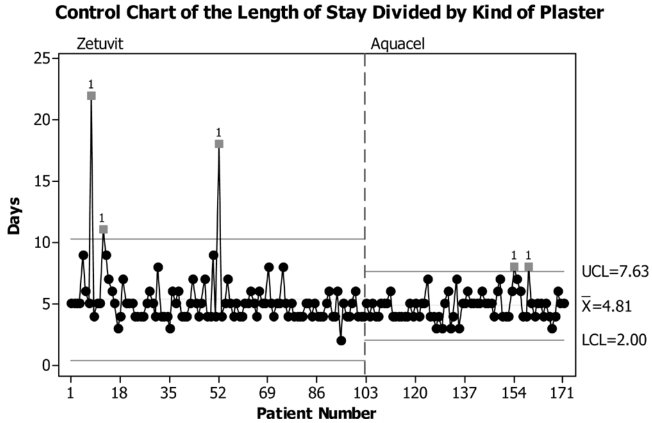

FIGURE 4 Influence of the kind of plaster on length of stay of patients.

Continuous Improvement (Kaizen)

Retaining the achieved improvements requires management and good organization; the danger that accomplishments deteriorate is real. Secondly, part of process improvement is a change in the process control system, especially if a once-and-for-all solution is not possible. Assuring quality and performance on the floor consists of three elements:

1. Clearly defining responsibilities.
2. Organizing self-control at the floor.
3. Standardizing responses to irregularities.

To define responsibilities for process control, the control pyramid of Juran (1989) is used as a template; see Figure 5. It should be adapted to the specific situation at hand. The control pyramid consists of four layers: top management, supervisors/process owners, the shop floor/employees, and automatic process controls. The bottom layer, consisting of automatic process controls, handles predictable, everyday problems. Examples of automatic process controls are mistake prevention, mistake proofing, automatic process adjustments, and electronic forms that automatically screen for erroneous input (for example, on the Internet). Organizing the process in such a way that predictable, everyday problems are handled as much as possible by automatons clears up time for employees to concentrate on other tasks.

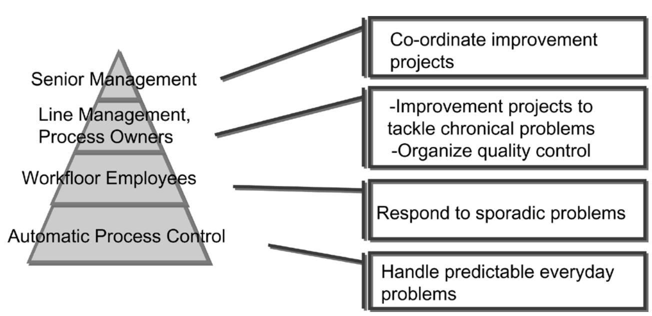

FIGURE 5 Control pyramid of Juran (1989).

The employees have the responsibility to tackle sporadic disturbances (“firefighting”). Ideally, the employees themselves are given the responsibility to control their processes: this is called *self-control*. It is based on the notion that in the current business environment it is not sufficient that employees just follow instructions. Exception handling is an increasingly larger part of the work of employees, and the need for swift responses leaves no time to report to managers and supervisors. In addition, self-control provides a sense of ownership, which is crucial to the motivation of employees. However, self-control is only possible if the process is “operator controllable.” Responsibility should always be coupled with the authority to intervene. Moreover, goals and how to achieve them should be clearly specified. A lack of authority or clarity about what is asked leads to confusion, stress, and frustration. The following are requirements for a process to be operator controllable.

1. Employees know what they are supposed to do. This means that there are clear and complete work procedures, CTQs and performance standards are specified, and adequate training is given to personnel.
2. The team gets feedback about how they are doing. This could be in the form of line management that assumes a coaching role or in the form of a dashboard or visual management system.
3. Employees have the means to influence performance. This includes having the authority to intervene and adjust the process and the availability of guidelines and sufficient knowledge to act effectively in the case of problems. But it also means that the process should be capable in the first place. Line management should stay responsible for processes that do not satisfy these three requirements.

The top two layers consist of supervisors and management. Their first responsibility is to organize process control well: ensure that everyday problems are automatically dealt with and enable the shop floor to deal effectively with sporadic problems. Thus, line management has a supportive and facilitating role. When management has organized process control well, they have time for their second responsibility: to do quality improvement. A well-organized process control system provides for an information system that gives information about chronic problems to line management. Signaling chronic problems and defining improvement projects to tackle them is the second responsibility of management.

After the discharge of the Black Belt project, the Lean Six Sigma team continued with improving the length of stay. The specialists had worked together to obtain a standard way to operate on patients who had to undergo a total hip surgery. Further improvements had to come from the care process. One of the improvement actions during the project was the introduction of visual management. It turned out that a bulletin board on the department attracted the attention of personnel (see Figure 3). As soon as the discharge date approached more focus was needed.

After some initial problems were overcome, the new plaster was applied to nearly all patients. It took nearly the whole year (2009) to obtain this result.

To stimulate involvement of the nursing staff, a quality game was introduced by the Black Belt. It consisted of daily activities that were part of the protocols. Every week each nurse received a card with an aspect from the standard protocol such as washing hands before entering the ward, medication check with two persons, checking sell-by dates of medication, disinfecting the scissors, updating medical records, and ensuring that no jewelry was worn during shifts. At the end of the day the team came together to discuss what had occurred. It stimulated to work according the protocols. This is important with respect to patient safety, patient satisfaction, and avoiding defects.

The results of the last 1.5 years are illustrated in Figure 6. It may be concluded that the length of stay is reduced to 4.6 days on the average, which means another 0.5-day reduction compared with the discharge date of the project in July 2009. Figure 6 also shows that the spread is substantially lower compared with the start of the project. In 2010, 10% of the patients stayed for only 3 days and 55% of the patients stayed for 4 days. Compared with the 28% of patients in 2008 who stayed for 4 days, this is a huge difference.

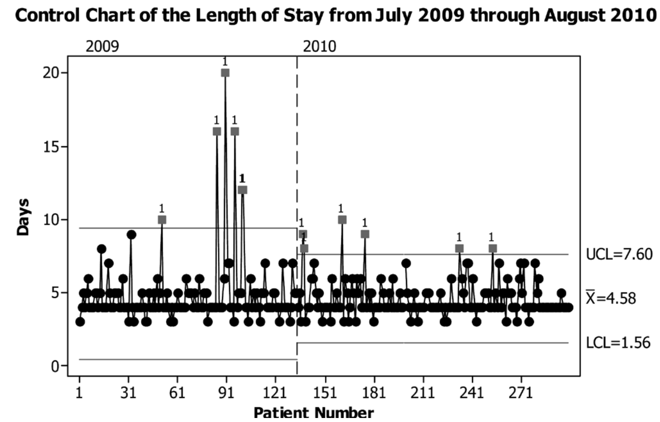

FIGURE 6 Length of stay of patients who underwent total hip surgery.

DISCUSSION AND CONCLUSION

After the changes, in-patient days were saved and more admissions were possible. As a rough estimate, if a bed in a hospital costs about $500 per day and the length of stay on average is reduced by one day for a patient volume of about 350 patients per year, the annual savings is approximately $175,000 per year. Moreover, any patient who can go home earlier is undoubtedly happier to do so and the hospital can treat more patients with 350 more bed days available per year. Additionally, 0.5 fte nursing staff was reduced because of the new plaster, which saved an extra $25,000 per year.

To arrest the escalating costs of health care while improving quality will require a wide variety of concerted initiatives with input from the political, economical, scientific, and managerial realms. Nevertheless, and regardless of what will be decided politically, we can immediately start to deploy quality management principles to health care. Although health care obviously differs from industry, a hospital is an operation just like any other service operation and, in some aspects, not unlike a manufacturing facility. Many of the same principles for the elimination of waste and defects, perhaps with some minor modifications, also apply to health care.

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