Quality in Trauma Care: Improving the Discharge Procedure of Patients by Means of Lean Six Sigma

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Background: The University Medical Center Groningen is a level I trauma center in the northern part of the Netherlands. Sixty-three percent of all the patients admitted at the Trauma Nursing Department (TND) are acute patients who are admitted directly after trauma. In 2006 and 2007, the University Medical Center Groningen was not always capable of admitting all trauma patients to the TND due to the relatively high-bed occupation. Therefore, the reduction of the average length of stay (LOS) formed the objective of the project described in this study.

Methods: We used the process-focused method of Lean Six Sigma to reduce hospital stay by improving the discharge procedure of patients in the care processes and eliminating waste and waiting time. We used the "Dutch Appropriateness Evaluation Protocol" to identify the possible causes of inappropriate hospital stay. The average LOS of trauma patients at the TND at the beginning of the project was 10.4 days.

Results: Thirty percent of the LOS was unnecessary. The main causes of the inappropriate hospital stay were delays in several areas. The implementation of the improvement plan reduced almost 50% of the inappropriate hospital stay, enabling the trauma center to admit almost all trauma patients to the TND. After the implementation of the improvements, the average LOS was 8.5 days.

Conclusion: Our study shows that Lean Six Sigma is an effective method to reduce inappropriate hospital stay, thereby improving the quality and financial efficiency of trauma care.

Key Words: trauma care, lean six sigma, inappropriate hospital stay.

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Healthcare and welfare expenses in the Netherlands amounted to €72.2 billion in 2006,[1] which is 13.7% of the gross domestic product, or €4,417 per capita. The cost of care increases every year and would still be higher if politics and insurance companies were not limiting the budget. Because ~45% of the healthcare budget is spent by hospitals, they must try to find acceptable strategies to reduce cost without loss of quality. At the same time, however, they will grow because of the ageing population, entailing a further increase in expected lifetime and a larger proportion of older people with multiple comorbid diseases. Because the healthcare cost per person increases exponentially from the age of 50,[2] cost reduction efforts are really necessary. At the same time, healthcare organizations are searching for ways to deliver higher quality of care (e.g., decrease in the number of defects and shorter length of stay [LOS]).

The LOS is often used as an outcome measurement in research. Managers and politicians have used it as a performance indicator of efficiency.[3,4] It is mostly applied as a financial indicator of costs, but can also be defined as a process, service or clinical indicator of the quality of care.[5] Factors influencing LOS include the injury/disease, the organization of care, the availability of hospital beds, and the chain of care in which patients are being transferred from the hospital to, for example, a nursing home.[6,7] In the last decade, many hospitals have chosen to organize disease-specific clinical pathways resulting in both cost reduction and a decrease in LOS for specific groups of patients.[8,9] This article describes an efficiency improvement project, using measurements of appropriate hospital stay (the Dutch version of the Appropriateness Evaluation Protocol [D-AEP]).[10] Reducing inappropriate hospital stay implies a decrease in LOS. Note that inappropriate hospital stay is not related to the complexity of the patients. The efficiency improvement project was carried out along the lines of the Lean Six Sigma (LSS) program, a relatively new methodology for reducing costs and improving the quality of healthcare. LSS is a widely applied program for company-wide quality improvement developed in industry but more recently also successfully applied in Healthcare[11,12] and Trauma care.[13] LSS is a process-focused strategy and methodology for business improvement and can be used to improve care processes, eliminate waste, reduce costs, and enhance patient satisfaction and safety.[14]

PATIENTS AND METHODS

The University Medical Center Groningen (UMCG) is the only level I trauma center in the northern part of the Netherlands with 10,000 employees and 1,339 beds, the hospital is the second largest in the Netherlands.

In 2007, the board introduced a strategic plan with focus on reducing costs, improving the quality of care, and facilitating the development of healthcare innovations. Based on the experiences of a few smaller hospitals in the Nether-

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lands[15] with LSS, the methodology was selected to realize these goals.

The Traumatology Department (30 beds) is one of five units of the surgical clinic at the UMCG. The surgical clinic is an autonomous subdivision, allowing a flexible admission of patients from the five units (with a total of 115 beds). Pediatric patients (younger than 18 years) were admitted to the pediatric clinic, and adult trauma patients with severe head, neck, and brain injuries were admitted to the clinic of neurosurgery. The aim of the LSS project was to reduce the mean LOS to create more admission capacity and reduce costs.

LSS is a combined approach of Lean Thinking and Six Sigma.[16] Lean Thinking[17] provides analysis tools and techniques with the aim of mapping out and removing inefficiencies (queue times, capacity bottlenecks, and quality defects). Six Sigma offers an organized, parallel organization structure to reduce variation in organizational processes by combining improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives.[18] The LSS project leaders are recruited from within the organization and trained as improvement specialists, to become Black Belts or Green Belts (GBs). LSS projects follow a rigid framework, called the five phases DMAIC roadmap[19] (Fig. 1): Define (D), Measure (M), Analyze (A), Improve (I), and Control (C).

This particular LSS project started in February 2008. A SIPOC (supplier-input-process-output-client) analysis[13,19] was the start, to give a broad outline of the process on a macro level, serving as the starting point of the process description on the micro level. The goal of the Measure phase is the translation of the problem into measurable indicators, called CTQs (Critical To Quality).[20,21] The CTQs of this project were LOS, bed occupation, and number of admissions. The targets were as follows:

An LOS as short as possible.
A bed occupation of 90% with 2 acute beds available on each day.
A maximum number of admissions.

First, we collected retrospective data from 2006 to 2007 of all the admissions to the Trauma Nursing Department (TND). The second set of data was collected from a prospective sample survey. During a 70 days period (February-April 2008), the following information was collected for all admitted trauma patients: day of (emergency) admission, diagnosis/kind of operation(s), day of discharge, and the bed occupation at 10:00 hour and 16:00 hour. The LOS measurements also included a value stream map[19] of the patients' process in which all separate steps from admission to discharge were measured to discover the factors that had a high impact on LOS. Reducing LOS was not the ultimate goal; we wanted to reduce any unnecessary (and potentially harmful) LOS. To identify the proportion of the inappropriate hospital stay, we used the D-AEP that is based on the original Appropriateness Evaluation Protocol (US-AEP). The US-AEP has already proven to be useful in the United States and other European care settings. The D-AEP was tested on different medical departments (Surgery, Neurosurgery, Internal medicine, and more) and proved to be valid ($\kappa = 0.76$) and reliable ($\kappa = 0.84$) to assess the (in)appropriateness of hospital stay.[10] Appropriate hospital stay refers to all inpatient stay during which continuous and active medical, nursing, or paramedical treatment is required, which cannot be provided through extramural care, day care, or outpatient care.[10] Table 1 shows a short description of the D-AEP. The GB (a Physician Assistant) and two specific well-trained nurses not directly involved in daily patient care measured the (in)appropriate hospital stay at the pre- and postintervention period.

The data from the prospective sample survey of 70 days (2008) provided us with information on daily bed occupation and LOS. The bed occupation at 10 AM (after discharge) shows the capability to admit emergency patients to the TND. During 1 week, we assessed each day whether the trauma patients stay at the TND was actually necessary. In another week, we followed all newly admitted trauma patients during their time in the hospital, assessing again the appropriateness of their stay. To avoid possible Hawthorne effects, the results were only communicated to the care providers 2 months after the measurements, during the "Improve" phase of the DMAIC roadmap.

The GB designed a process control system by creating a dashboard to make the performance (number of admitted

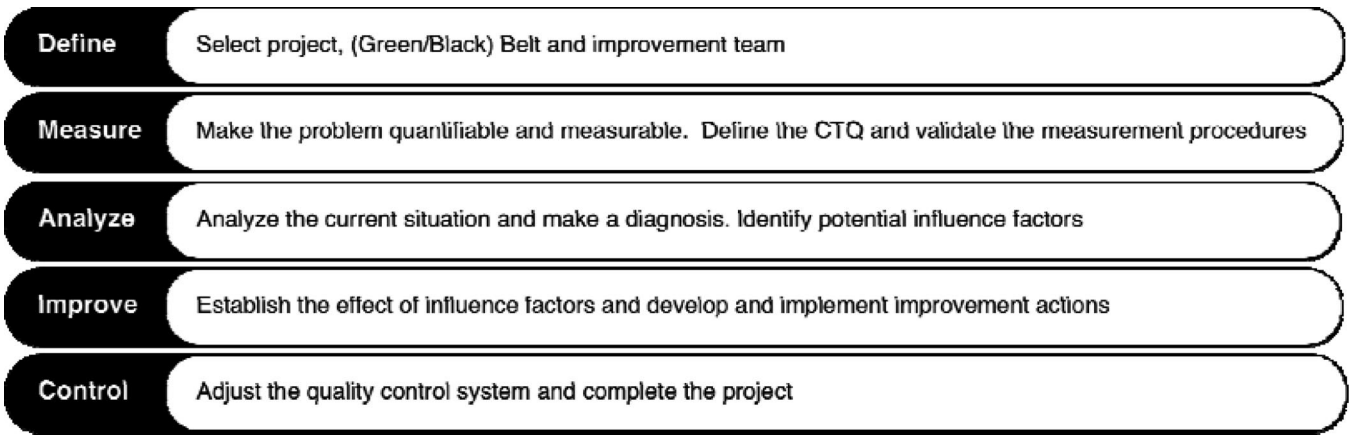

Figure 1. The five phases DMAIC roadmap.[19]

TABLE 1. Short Description of the D-AEP

Criteria for Appropriate Clinical Stay	Examples
Threatening situations, requiring clinical care	Spinal cord lesion, circulatory and/or respiratory disorders
Care, requiring clinical control or observation	Surgical procedure, wound, and drainage care
Monitoring	Close medical monitoring by a nurse
Infusion and/or medication	IV administration of fluids and/or nutrition
Nursing care	Isolation of the patient, endotracheal suction
Assessment of appropriate stay is not possible	Reasons, (to be specified)...
Reasons for Inappropriate Clinical Stay	**Examples**
Further clinical stay required	Delay in interventions for further treatment
No further clinical stay required	Delay due to discharge procedures
Inappropriate stay due to the patient or family	Lack of (persons for) informal care
Inappropriate stay due to care environment	Patient is waiting for transfer to other care facility

TABLE 2. Demographic Data of the Trauma Patients Admitted Before/After Intervention

	Preintervention, Oct 2007–July 2008	Postintervention, Aug 2008–May 2009	*p*
No. trauma patients	747	946	
ISS <16	674	888	
ISS ≥16	73	58	0.006
Gender (% male)	65.1	58.4	0.005
ISS ≥16	84.9%	77.6%	0.364
Age (yr)*	45.4 ± 19.9 (42)	46.8 ± 20.0 (45)	0.172
ISS ≥16	42 ± 18.2 (41)	41.9 ± 16.3 (41)	0.960
No. of re-admission for follow-up treatment	77	74	0.086
Acute admissions (%)	63.7	63.3	0.879
Mortality	5 (0.7%)	0	0.017
Discharge to (%)			
Home	78.5	81.5	0.141
Rehabilitation facility	16.6	14.8	0.313
Another hospital	3.7	3.1	0.585
Other	0.5	0.6	1.000

* Mean ± SD (median).

patients and the average LOS) transparent and visible. To examine LOS results, we compared the 10 months preintervention period (October 2007–July 2008) with the 10 months postintervention period (August 2008–May 2009). Table 2 describes the demographic data of trauma patients who were admitted to the TND in both periods.

The pre/post intervention groups are significantly different regarding injury severity score (ISS): 9.8% complex patients (ISS ≥16) before and 6.1% after the intervention. Patients with high ISS values have generally higher LOS.[22,23] Except for the smaller percentage of females and the lower mortality rate in the postintervention group, there are no other significant differences in demographic variables.

RESULTS

The performance (2006 and 2007) of the utilization of the TND was analyzed at the Define phase (Table 3). On average, there was always one available bed, but too often trauma patients could not be admitted to the TND. They were then admitted to one of the other surgical nursing departments, and some emergency patients even had to be sent to other hospitals.

The two measurements of (in)appropriate hospital stay gave almost identical results: ~30% of the hospital stay of trauma patients appeared to be inappropriate. The main influence factors of inappropriate hospital stay can be clustered into five groups. One group represents the patients waiting for a rehabilitation facility or nursing home (49% of the unnecessary LOS). The other groups include delays in discharge planning (18%), patients waiting for an operation (23%), patients waiting for a diagnostic result (4%), and other factors (6%). The high percentage of "patients waiting for an operation" could be explained by their admission one day before the operation to be absolutely sure that a bed is available.

The improvements (from August 2008) focused on the discharge planning and elimination of all waiting time of the care process because these variables could be influenced by the trauma personnel themselves. The most crucial improvement measure was the collective attention of doctors, nurses, and patients to the discharge. When a planned patient is admitted, the expected day of discharge and the expected need for care after discharge is given. Now, a rehabilitation facility, nursing home, or homecare can be organized in a timely manner. For emergency patients, the same information must be available within 24 hours after admission. The doctors have to communicate this information with the patient and write it down on the patient file. Planning is a

TABLE 3. Total Admissions, Patient-Days, Average LOS, Bed Capacity and Occupation of the TND

	Admissions			Patient-Days			Average LOS			Bed Capacity	Bed Occupation
	Trauma	Surgery	Other	Trauma	Surgery	Other	Trauma	Surgery	Other	Days	(%)
2006	956	131	27	9,874	588	37	10.3	4.5	1.4		
Total		1,114			10,499			9.4		10,950	95.9
2007	949	118	57	9,850	567	108	10.4	4.8	1.9		
Total		1,124			10,525			9.4		10,950	96.1

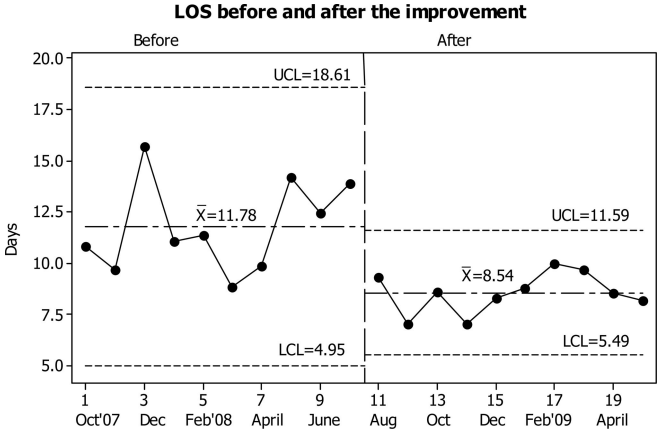

Figure 2. Reduction of the average LOS of trauma patients after intervention (August 2008).

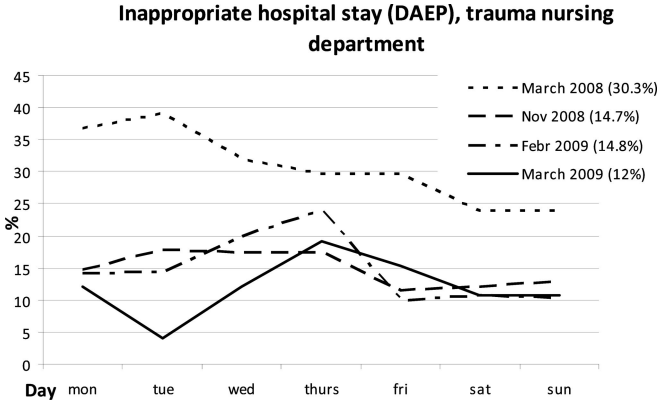

Figure 3. Measurements of inappropriate hospital stay in four different weeks.

structural part of the daily deliberations between trauma surgeons and assistant physicians. The average LOS of all patients (surgical and trauma) at the TND is 2.9 days shorter than before the intervention. The average LOS of trauma patients decreased from 11.8 to 8.5. The control chart[19] of Figure 2 shows the average LOS of the trauma patients from October 2007 onward.

The aim of the project was to reduce the inappropriate hospital stay with 50%. Figure 3 shows the inappropriate hospital stay in four different weeks.

The reduction of LOS enabled the hospital to admit more and almost all trauma patients to the TND. Most days (~80%), the TND haves at least two beds available for emergency patients, which is the way it should be in a level I trauma center. In the period September to November 2008, the average number of beds available for the admission of acute patients was 4.4. In 2007, we admitted 1,124 patients (949 trauma, 118 surgical, 57 others), whereas in 2008 this amount increased by 118 extra patients (10% more) (1,034 trauma, 144 surgical, 64 others). Compared with the same period in 2007 (January to August), in 2008, there were 33 less admissions, so the increase of admissions was achieved after the implementation.

Before the project, the other surgical nursing departments admitted on average 12 trauma patients per month, with an average LOS of 3.6 days. Now only 2.8 trauma patients per month are being admitted to other nursing departments (76% less), with an average LOS of 2.1 days. Based on the diagnosis of the problem, the project team decided to aim at reducing the inappropriate hospital stay with 50%. The average LOS at the TND would then be reduced to 8.2 days, gaining some 1,500 patient-days a year and four beds a day for other use. Previously, we showed that this target was more or less obtained, but the increasing LOS at the beginning of 2009 (Fig. 2) worried us. We therefore decided to measure inappropriate hospital stay again. Because these 1-week measurements showed no increase in the inappropriate hospital stay (Fig. 3), we concluded that the higher LOS could be attributed to more complex patients. This approach—using LOS to monitor the process and performing additional measurements of inappropriate hospital stay—forms part of the statistical process control system, which is used to detect and respond to irregularities in the process.[19] Measuring inappropriate hospital stay takes 5 to 10 minutes a day. The visual management of these parameters motivates the nurses, doctors, and management to continue to work according to these new standards.

DISCUSSION

The most important influence factor of inappropriate hospital stay was the delay in admission to a nursing home or a rehabilitation facility. The availability of other care facilities is an external factor of inappropriate hospital stay and can therefore not be controlled by the hospital. But, we can reduce the waiting time for such facilities by making a timely request. Our policy used to be to arrange a bed in a nursing home only after the operation. Now, we arrange a bed immediately after a patient's admission, and so we reduce the average LOS of patients with a hip fracture by more than 4 days. The average LOS of the postintervention population decreased with 3.2 days compared with the (10 months) preintervention population.

This LSS project has shown that it is possible to improve quality and reduce costs at the same time. Another result is the financial benefit for the hospital, based on 118 additional admissions, representing a value of €176,400. In 2007, the nursing departments' costs were almost the same as in 2008, as were the staffing costs. The total patient-specific costs (medical and nursing supplies, blood, and other patient-specific costs) increased by only €1,740. So, with a minimum of extra costs the UMCG realized 118 extra admissions to the TND.

In 2006, the D-AEP measurement showed that 30% of the hospitals stay at the TND was inappropriate. Two years later, in March 2008, it was still 30%. In fact ~30% of inappropriate hospital stay seems to be a common figure; measurements in other hospitals show similar results.[10,24] The positive effects of reducing the inappropriate hospital stay to the current level of 12% enabled us to integrate the new methods into the culture and organization of the TND.

There are several notable limitations to this study. The study was conducted in the specific context of a Dutch university medical center. Contextual factors such as the Dutch healthcare system may have influenced the results. This limits the external validity of the study. Øvretveit[25] argues the need for attention to intervention conditionality in quality improvement practice. The significant higher percentage (preintervention) of patients with an ISS ≥16 may have influenced the LOS and percentage of inappropriate hospital stay, because usually in June and July there are relatively more patients with an ISS ≥16. The number of patients admitted to a nursing home or rehabilitation facility is not significantly different in both periods, however. The delay in these admissions was the most important influence factor of inappropriate hospital stay. We measured process indicators regarding patient logistics, e.g., the average LOS, inappropriate hospital stay, bed occupation, the number of beds available and the number of admissions. We did not monitor patient satisfaction and patient outcomes. However, we expect that an increase in admissions and in beds available will have a substantial and positive influence on patient outcomes. We do know that the number of readmissions did not increase and that the mortality rate decreased. We do not know, however, whether effects exist on the long-term clinical and functional outcomes such as quality of life.

CONCLUSION

Our study shows that LSS provides an effective method to reduce LOS and inappropriate hospital stay of trauma patients, thereby improving process quality and reducing costs. The introduction of the organizational and conceptual framework of LSS, with specific roles for key players and a program aimed at reducing inappropriate stay appears to be an effective intervention. Within the UMCG, several other nursing departments have taken up the challenge to reduce LOS in a similar way.

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EDITORIAL COMMENT

In this era of pay for performance, consumerism, and an intense focus on patient safety, healthcare providers have looked to other industries for inspiration. For example, lessons learned in aviation have been adopted in the operating room and incorporated into team dynamics.[1] In this current work, Niemeijer et al.[2] look to the corporate world of error reduction to improve throughput in injured patients.

The major impetus for change of the authors was to decrease unnecessary length of stay to facilitate admission of appropriate patients to an overburdened trauma nursing unit. Implementation of the Lean Six Sigma toolkit resulted in an overall 2-day decrease in hospital length of stay. The majority of gains were achieved by earlier involvement of care coordination to expedite eventual hospital discharge.

The authors rightly acknowledge that other factors could have been responsible for the gains achieved—the most important being the significantly higher Injury Severity Score in the preintervention group. Furthermore, whether the improved efficiency will be sustained over time remains to be determined. Nonetheless, the group is to be congratulated for adopting a rigorous and comprehensive process to expedite throughput.

As healthcare reform will likely bring many new consumers to hospital beds as will the aging population of active patients who will suffer injury in greater number; it is incumbent on all trauma care providers to focus on efficiency as assiduously as we do safety. Perhaps, the most important lesson we can learn from this work is that the appropriate time to think about discharge is immediately upon admission. Using Lean Six Sigma is but one way to dissect the "assembly line" of a hospital stay to afford us the opportunity to correct "defects." This methodology has already been described as effective in understanding the causes for emergency department delays in injured patients and in improving safety in intensive care unit patients.[3,4]

Trauma providers should be cognizant that their healthcare organizations likely employ experts in Lean Six Sigma methodology—the so-called "black belts"—who can and should be called on to address safety and efficiency concerns.

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