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Impact of 5 Years of Lean Six Sigma in a University Medical Center

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Lean Six Sigma (LSS) is an originally industry-based methodology for cost reduction and quality improvement. In more recent years, LSS was introduced in health care as well. This article describes the experiences of the University Medical Center Groningen, the second largest hospital in the Netherlands, with LSS. It was introduced in 2007 to create the financial possibility to develop innovations. In this article, we describe how LSS was introduced, and how it developed in the following years. We zoom in at the traumatology department, where all main processes have been analyzed and improved. An evaluation after 5 years shows that LSS helped indeed reducing cost and improving quality. Moreover, it aided the transition of the organization from purely problem oriented to more process oriented, which in turn is helpful in eliminating waste and finding solutions for difficult problems. A major benefit of the program is that own employees are trained to become project leaders for improvement. Several people from the primary process were thus stimulated and equipped to become role models for continuous improvement.

Lean Six Sigma (LSS) is a methodology for cost reduction and quality improvement. The success was immense in industry, which is why in more recent years LSS was also used in services and health care.[1] This article describes the experiences of the University Medical Center Groningen (UMCG), the second largest hospital in the Netherlands, which dates back in 2007 when LSS was introduced. The aim of the hospital of implementing LSS was to improve quality and to reduce cost of its current activities, to create possibilities for innovations, such as the "Healthy Ageing" program (a large research program to examine the causes leading to age related diseases). Senior management of the UMCG decided to use the LSS methodology, because there were positive experiences from the hospital in Beverwijk, which in 2002 was the first Dutch hospital to adopt LSS.[2]

A major intervention in an organization, such as introducing LSS, requires top management commitment. The introduction therefore started with a half-day "champion training" for senior management, about basic knowledge of LSS and the specific role

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of managers/champions in the program. An external consultant was hired for training sessions to management and employees, and an external master black belt for support of the projects. Selected high-potential employees from all over the organization were trained to become an LSS project leader: a 14-day training for black belts (full-time project leaders) and an 8-day training for green belts (part-timers). These trainings explain the DMAIC (define, measure, analyze, improve, control) roadmap, with the corresponding tools, and the students are required to practice the new knowledge in a project. Projects were selected from all over the organization, ranging from length of stay (LOS) and nursing efficiency, to energy saving, computer maintenance, and registration. Many projects aimed at solving really hard problems, such as improving efficiency of the operation theatre or collective purchasing of implants.

The first experiences with the program were promising. Belts started enthusiastically, describing processes and determining relevant measurements: "Critical to Quality" parameters, or CTQs. Both elements were relative new to large parts of the organization. Process descriptions of patient treatments (critical pathways) existed, of course, but most management processes were just simply there. Many data were registered, but seldom according to generally accepted standards. As a consequence there used to be much confusion regarding measurements. Many key players collect their own data and their own version of reality, which is a major drawback for change. The value of an LSS project is that the context of a problem is clearly delineated and that valid, accurate, and precise measurements are collected to quantify the problem. The medical doctors in the UMCG appreciated this kind of diagnosis to managerial problems.

Most of the projects proceeded according to plan in the analysis and improvement phases. Improvement actions were designed and the calculated results were realized. But the progress of several projects ended when the actual interventions were to be done. Later on a few reasons were identified:

- Interventions were beyond the scope of the champion.
- Internal budgets and oblique financial structure made interventions financially unattractive.
- Implementation depended heavily on external capacity (especially information and communication technology capacity).

These reasons can be related to the specific organization of the UMCG: decentralized, divided into 10 sectors and managed by sector managing directors. Medical departments are part of a sector, but with their own budgets and direct relations to the management board. The financial system is very complicated, with more than 1000 sources of income (the ministries of health and education, the European Union, and insurance companies being the most important ones). Internal finance is likewise complicated and not transparent. It is difficult to calculate cost prices of activities. When the LSS program started, it was thought that the champion of a project was authorized to intervene in the whole organization. After all, the improvement actions were well grounded, based on scientific methods. But it turned out that this was a step too far: most managers did not allow interference at their departments from plans designed by others. The lesson was that for projects to be successful the scope should be limited to the organizational scope of the champion. And for large problems, with more than 1 manager (or decision maker) involved, concerted efforts had to be organized.

Notwithstanding some negative experiences with implementing improvements, management decided to continue using LSS as the method for efficiency and quality improvement. Many projects were successful in demonstrating that processes comprised wasteful activities. It became clear to management that these activities could be skipped without compromising quality of care, and at the same time saving money for the organization. Lean Six Sigma could indeed be used as a vehicle for judicious cost saving: see Wijma et al[3] for a project about nursing efficiency.

DEVELOPMENT OF LSS AT THE UMCG

During the first 2 years, the in-house LSS trainings were given twice a year by the external consultant.

Table 1

NUMBER OF PROJECTS, SEPTEMBER 2007 TO DECEMBER 2011

Primary Process of Patient Care	Frequency	Management and Hospital Organization	Frequency
Increase number of admissions	26	Reduce costs by reducing inventory	17
Improve capacity	19	Improve productivity of personnel	13
Improve productivity of nursing personnel	24	Increase revenue by improving registration	11
Improve productivity of medical personnel	10	Improve utilization of equipment by use of ICT	10
Reduce unnecessary use of diagnostic tests	5	Improve process of purchase and maintenance	9
Patient satisfaction	2	Improve utilization of outpatient clinic	7
Improve safety	4	Improve productivity of secretary personnel	6
Total	90	Total	73

Abbreviation: ICT, information and communication technology.

He trained 82 employees: 19 black belts and 63 green belts. As mentioned earlier, black belts are full-time LSS project leaders, usually staff members and green belts are temporarily assigned to LSS projects, usually 2 days per week, next to their normal work as manager, nurse, or medical doctor. Until 2011 there have been 163 official projects (Table 1) in nearly all parts of the organization, but with an emphasis on the primary process of patient treatment and care. The nursing efficiency and LOS of every nursing department has been analyzed. The categorization of Table 1 is based on 9 generic project definitions.[4]

The finance department calculated that the financial benefit of all projects amounted to approximately €15 million. Exact figures are hard to obtain, however, owing to the oblique financial structure.

Two years after the introduction of LSS, management decided to go along without external help. The master black belt was recruited and assigned the task of facilitating the LSS activities, including the training of new green belts. In the meantime, a group of coordinating black belts has arisen, not in a centrally organized group, but operating in their own sectors and departments. There have been stiff conversations about the organizational form for LSS, and the outcome was that a noncentral organization felt most comfortable. The nonmedical directors took upon them to solve all kind of tuning problems.

The experience with the LSS projects was that related problems in different sectors or departments were very similar, with often-similar solutions as well. With a process view in mind, and from a distance (the helicopter view), this is not at all surprising. Owing to the dominating culture of the hospital (as a result of employees moving from one department to another) one might expect comparable results in different departments, and related causes, as well as related solutions. For improvements to be implemented, however, it is really necessary for the employees involved to experience the problems themselves, and to design their own solutions. Projects were therefore "repeated" at different departments, wards, or clinics. It really helps, however, to have universally applicable measurements, such as "inappropriate hospital stay,"[5] which is valid for all hospitalized patients who are not in an intensive care unit. It seems a kind of waste-–doing projects "double"-–but it contributes to higher chances of implementing solutions. In this regard health care is really different from industry, in which improved processes may be obtained by new settings of a machine or other technical measures. Most improvements in health care require another way of working, new standards or protocols, and eventually new habits: a "culture change."

The Control phase of the DMAIC roadmap is concerned with preventing problems to recur. For a large part, this deals with the same matter of a culture change. Within the LSS framework (belt and champion in the driving seats) and its project-based

approach (projects lasting 5 months at most) a widespread culture change is hardly feasible. The Lean philosophy and tools are useful to obtain lasting results, in particular the elements of visual management, working as a team, and continuous improvement (kaizen). The end of an LSS project is ideally the beginning of a never-ending continuous improvement journey for the whole team.

Because several projects dealt with related problems, be it in different departments, the desirability of overall solutions and measures became clear. Two examples serve to illustrate the point.

- The projects on nursing efficiency demonstrated a need for clearly defined functions and general rules about staffing in relation to the number of patients and their needs. These matters can only be solved adequately in the form of guidelines and rules for the whole organization.
- Owing to the financial structure of the UMCG, the projects on LOS required central direction. Most projects analyzed that the ward needed fewer beds than available. Closing beds would bring only limited financial benefits, however, because staffing could not be reduced. A broader solution-—combining the reduced beds of several departments-—was needed for substantial financial results. This is clearly beyond the scope of department managers, so eventually senior management had to interfere to force the cooperation.

CONSOLIDATION OF LSS AT THE UMCG

When LSS was introduced in the UMCG, it was new and exotic, with the potential of being a hype. Five years later, LSS appears to be anything but a hype. The method is heard of in most parts of the organization, although for many employees LSS is still rather exotic. For management, LSS represents an obvious method to use for efficiency improvement. Indeed, within a current cost cutting program, LSS is explicitly used to analyze processes and to eliminate waste. More than 100 people were trained in the LSS methodology, constituting a pool of black belts and green belts, to be employed for projects and process analyses, although no more than 10 to 20 of them are at any given time doing LSS projects or related work. Several managers within this group play a special role in "spreading the word" and "walking the talk."

LSS projects are less scattered now than in the beginning. Initially, there were projects all over the organization, but the problem was to raise the results to a higher, organization-wide level. Now top management selects themes for improvement, and within a theme 1 or more LSS projects may be done. The organization also learned that LSS is not always the most suitable method, so alternatives are allowed-—use of LSS is less dogmatic than it was in the beginning. Scattered LSS projects still happen, however, allowing the UMCG to discover new themes.

Each half year there is an in-house training for new green belts, but the number of students is significantly smaller than in the beginning. To maintain the pool of belts, however, new employees must be trained to replace the dropouts. With a few guests from other hospitals in the neighborhood there are some 6 to 8 students per training. The outline of the training is equal to the green belt training of the external teacher, but tailored to the UMCG needs (less statistical analysis, more "Lean thinking") with UMCG cases only. With a new and separate workshop "Lean Thinking and Doing" all employees are targeted. Especially, coworkers of nursing departments, logistical departments, and laboratories are attracted to the workshop.

RESULTS OF PROCESS IMPROVEMENT AT THE DEPARTMENT OF TRAUMATOLOGY

The first LSS project at the surgery/traumatology department started in 2008. The goal was to reduce LOS, with percentage inappropriate hospital stay as driver for improvement.[6] After this project, the other main processes were analyzed and improved in following years.

After the interventions of the first project (August 2008) the average LOS decreased, and the number

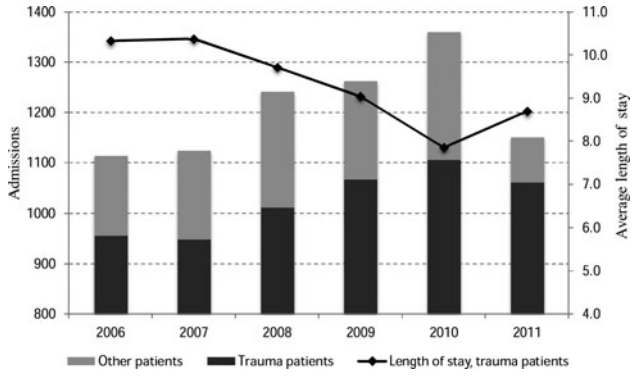

Figure 1. Admitted patients and average length of stay at the trauma ward.

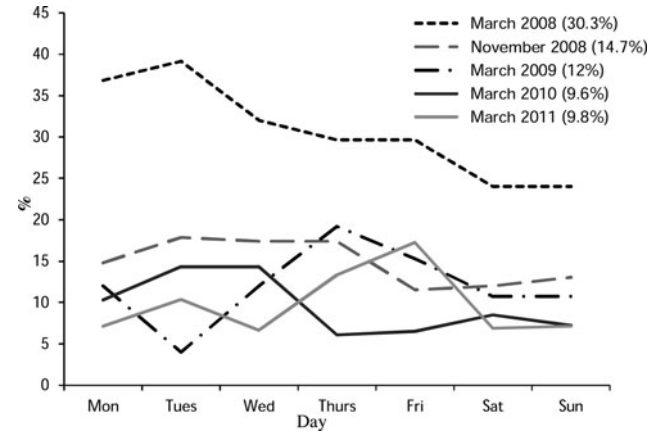

Figure 2. Some measurements of inappropriate hospital stay.

of patients grew. The results from the years 2006 to 2011 are shown in Figure 1.

In 2011, the number of patients decreased with 15%, mainly because of 60% less "other" nontrauma patients (who cannot [immediately] be admitted at the most suitable ward). In 2011, the effects of LOS reduction projects at the other surgical wards were felt. The capacities of these wards increased, and fewer beds of the traumatology ward were needed. The option to reduce the number of beds was not the fist aim of the LSS project on the trauma department. Trauma surgery is an emergency specialism. Therefore, the first aim of reducing the LOS was to create more flexibility on the trauma nursing department to accept all nonintensive care trauma patients from the emergency ward. So we reduced the number of patients who have been transmitted to other hospitals.

In 2011, the average LOS of trauma patients increased with more than 10%. The extra number of polytrauma patients (203 in 2011 vs 191 in 2010) may be responsible. Ultimately, the percentage inappropriate hospital stay, measured by using the Dutch version of Appropriateness Evaluation Protocol,[5] can tell whether the increase of LOS is acceptable. The measurement of inappropriate hospital stay is a very strong indicator of the efficiency of a department. Nowadays, this percentage is measured each day by one of the nurses of the traumatology nursing department. The average over the year 2011 was 10%, which is lower again than the 12% measured in 2009, 1 year after the interventions. Figure 2 displays measurements of inappropriate hospital stay during several weeks before and after the interventions of August 2008.

On the whole, the results regarding LOS are much better now than they were in 2006 and 2007, before the process was improved. The average LOS of trauma patients is now less than 9 days, and the production increased from 950 to (nearly) 1100. And most importantly for patients, the inappropriate hospital stay decreased from 30% to 10%.

The second LSS project also started in 2008 with the aim of reducing redundant diagnostic tests of trauma patients. Immediately after the improvements the average number of all diagnostic tests per treatment decreased significantly ($P = .001$) by 14.4%, despite the larger number of patients. At the (day) clinic the average number of tests per treatment decreased ($P = .000$) even more by 30.4%, with a reduction of costs per treatment with more than 10%, representing €52360 annual cost savings. The reduction of diagnostic tests is shown in the control chart of Figure 3.

For the patient, the most important achievement is that several redundant tests have been skipped. See Niemeijer et al[7] for a detailed description of this project.

The traumatology department hosted more projects to improve efficiency and reduce costs. In

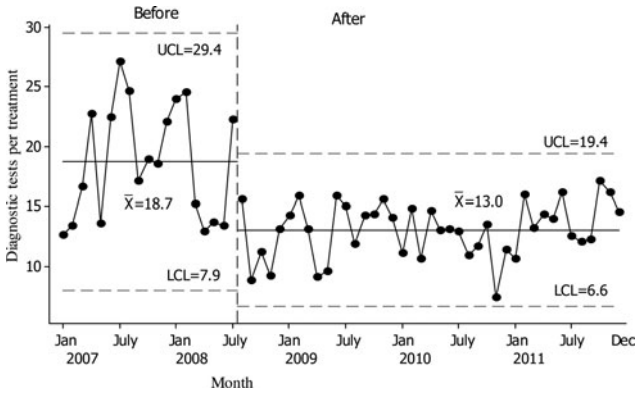

Figure 3. Average number of diagnostic tests per treatment before and after the interventions. LCL indicates lower control limits; UCL, upper control limits.

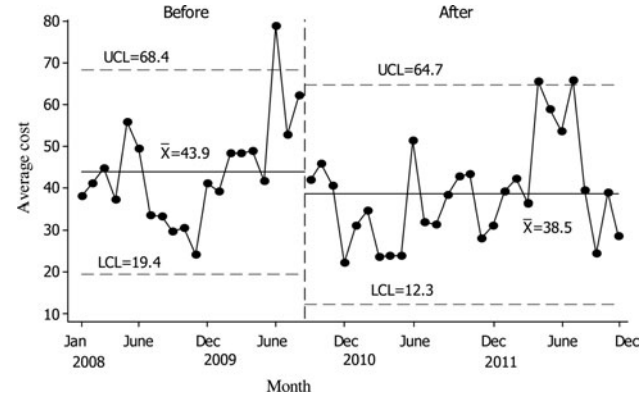

Figure 4. Monthly average cost per patient of patient related material (2008-2011). LCL indicates lower control limits; UCL, upper control limits.

the second half of 2008, an LSS project aimed at reducing the cost of implants. Surgeons used their own type of implants and instruments during surgery, out of habit or because they felt more comfortable with a specific type. After analysis of the data, the project team decided to standardize the full set of implants and reducing stock. This result could be achieved solely because of leadership of the senior management of the department. The financial benefits of the project can be seen in Table 2.

The reduction of costs in 2008 (compared with 2007) was achieved during the period from August to December. Before the interventions in August the costs actually rose.

An LSS project in 2009 aimed at reduction of material directly related to the patient at the trauma ward, such as dressings, sterilized gauzes, and injection syringes. The project measured the amount of wasted material, which was kind of a shock to many nurses. As a result, stricter procedures for ordering material were introduced. Moreover, a much cheaper contract could be signed with a single supplier of bandage material. The financial results of this project are shown in the control chart of Figure 4.

The average cost per patient before and after the intervention decreased from €44 to €39. This is an interesting success, considering the fact that in recent years more materials (eg, pain treatment for every patient) as well as more expensive materials are used.

The department of traumatology also used LSS as a tool for efficiency improvement of a clinical pathway for elderly patients with a hip fracture. The gain for the patients is an impressive reduction of LOS from 13.5 days (standard deviation, 10.2 days; n = 137) before the project to 8.8 days in 2011 (standard deviation, 8.2 days; n = 308). The gain for the department is that these patients can be treated with fewer costs. See Niemeijer et al[8] for a detailed description of this project.

Other projects related to the department are the efficiency of nursing staff (cf Wijma et al[3] for a related project). Within the surgical clinic, lack of personnel is now tried to solve with internal staff, instead of hired personnel. And finally, a project trying to improve the efficiency of the outpatient clinic can

Table 2

NUMBER OF PATIENTS, TREATMENTS, AND COST OF IMPLANTS (2007-2011)

Year	Number of Day and Inpatients	Number of Surgical Treatments	Cost of Implants per Patient, €
2007	1937	1643	198
2008	1949	1786	182
2009	2194	1948	168
2010	2276	1894	182
2011	2388	2053	193

be mentioned. With tools from the Lean toolkit, interventions have been done with an emphasis on reducing waiting times for patients.

CONCLUSION

This article focuses on the use and impact of LSS in health care. Several processes in the hospital and all main processes of the traumatology department have been analyzed and improved according to the framework of DMAIC. The cases of the traumatology department show that LSS can be applied to several types of processes. We may conclude that quality improvement for the patient and financial benefits for the organization are really 2 sides of the same coin. The cases also illustrate the value of the "mediation model for Six Sigma" of Schroeder et al[9] with leadership as a driver element, what should lead to strategic project selection and the use of improvement specialists and structured method.

Leadership engagement is a conditio sine qua non. Senior management was prepared to support the new and stricter procedures for surgeons and physicians. Without their support, not a single project would have succeeded. Senior management was also responsible for project selection, identifying processes with a need to be improved. Looking at processes with an eye for improvement needs special skills not normally present in health care employees. Therefore, every project was lead by an LSS green belt or black belt. The conscious choice to train employees as internal specialists to improve (care) processes in their own environment appears to be successful.

In the UMCG, LSS was introduced mainly because of a major cost reduction program. The notion was that LSS would be useful to bring this unique program to a successful end, and at the same time lay the foundation for future improvements in a financially healthy organization. Our claim is that these results were achieved, except for the "financially healthy" part. Much more severe cost reduction is needed now and in the near future, owing to the bad financial state of the Dutch government. The introduction of LSS, however, aided the transition of the organization from purely problem oriented to more process oriented, which in turn is helpful in eliminating waste and finding solutions for difficult problems. The organization is therefore well prepared to face the challenges of the near future.

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