Lean Six Sigma in a hospital

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Abstract: Hospitals today face major challenges. Patients demand quality of care to be improved continuously. Health insurance companies demand the lowest possible prices. Lean Six Sigma is a programme that can help healthcare providers to achieve these (seemingly) conflicting goals. Lean Six Sigma is an integration of Six Sigma and Lean Manufacturing, both quality improvement programmes originating from industry. Lean and Six Sigma are highly complementary. Six Sigma provides an integrated improvement approach that increases quality by reducing variation, defects, and costs. Lean adds tools that increases process throughput by eliminating waste. In healthcare faster means rapid access and no waiting times, while reducing defects means less complication. Increasing speed and reducing defects both lead to lower costs. Hence, Lean Six Sigma is an excellent tool to tackle present-day healthcare challenges.

Keywords: hospital; lean manufacturing; Lean Six Sigma; Six Sigma.

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1 Introduction

All over the world healthcare is facing serious quality problems while costs are exploding. The Institute of Medicine produced two reports demonstrating healthcare has serious safety and quality problems and is in need of fundamental change (IOM 1999, 2001). Care processes are poorly designed and characterised by unnecessary duplication of services, long waiting time and delay. Costs are exploding and waste is identified as an important contributor to the increase in healthcare expenditures. As a result, healthcare consistently does not succeed in meeting patient's needs.

In the Netherlands the government has introduced the healthcare market and reduced direct governmental interference in an attempt to reduce costs and enhance patient satisfaction. As a result hospitals find themselves in an environment that is becoming highly competitive. To attract the same number or preferably more patients, hospitals have to put customer satisfaction first. At the same time, due to competition, insurance companies are confronted with increasingly lower margins that subsequently lead to lower prices paid to the hospitals. Delivering more quality while revenues are going down is the major challenge in healthcare. In this article we demonstrate how implementing Six Sigma combined with Lean principles can help hospitals to enhance quality and to reduce costs. In the first place we will introduce Six Sigma, an improvement programme developed in industry. Then we describe the implementation and the results of Six Sigma in a hospital. Subsequently, we will introduce Lean Manufacturing and demonstrate why Six Sigma combined with Lean Manufacturing, better known as Lean Six Sigma, is such a powerful tool in healthcare. Finally, we give an example of a Lean Six Sigma project in the Emergency Room of a hospital.

2 Six Sigma

Six Sigma is a philosophy for company wide quality improvement. It was popularised by General Electric in the late Nineties. Several variants are current (Harry, 1997; Pyzdek, 2001; Breyfogle, 2003). The programme is characterised by its customer driven approach, by its emphasis on decision-making based on quantitative data and by its priority on saving money.

Six Sigma is deployed by carrying out improvement projects. Project selection is usually based on a translation of the company strategy to operational goals (Pyzdek, 2004). Furthermore, Six Sigma provides an elaborate organisational structure of project leaders and project owners. Six Sigma project leaders are called Black Belts (BBs) and Green Belts (GBs) and constitute a well-trained task force. Apart from GBs and BBs, management plays the role of project owner and are called Champions. Part of the Six Sigma programme is a twelve-step 'Breakthrough Cookbook', a problem-solving method 'specifically designed to lead a Six Sigma Black Belt to significant improvement within a defined process' (Harry, 1997). It tackles problems in five phases: Define (D), Measure (M), Analyse (A), Improve (I) and Control (C). In the Define phase a problem is selected and a cost-benefit analysis is carried out. Then, in the Measure phase the problem is translated into a Critical To Quality (CTQ) characteristic, and the current situation is measured. Identification of influence factors and causes that determine the CTQ's behaviour takes place in the Analyse phase. In the Improve phase, project leaders design and implement adjustments to the process to improve the performance of the CTQs. Finally, in the Control phase the process management and control system are adjusted. Each of the phases D, M, A, I and C encompasses itself several steps, which guide a project leader through the execution of an improvement project (De Koning and De Mast, 2006).

Weaknesses of Six Sigma lie in its complexity and its lack of standard solutions. In case of less advanced problems, problem-solving is not very efficient, if one has to go through a whole six month spanning Six Sigma project (George, 2003). Furthermore, Six Sigma does not use existing solutions to standard problems in these cases. Finally, the danger of sub-optimising a process, because of not taking into account the entire value chain, is ever present.

3 Six Sigma in a hospital

A brief overview of healthcare providers that have implemented Six Sigma is given by Van den Heuvel, Does and Verver (2005). Here we recall our experience in the Red Cross Hospital in Beverwijk, the Netherlands. The Red Cross Hospital is a 384-bed medium-sized general hospital. With an annual budget of 72 million Euros in 2004, the hospital admitted 12,669 patients, treated 11,064 in its day care facilities and performed 78,832 outdoor first contacts. A national 25-bed burn care centre is a part of the hospital. Six Sigma was introduced at the Red Cross Hospital with the purpose of enhancing continuous improvement (cf. Van den Heuvel, Does and Bisgaard, 2005). This was done after completing and complementary to the ISO 9001 quality management system, which was certified in 2000 in that hospital (Van den Heuvel et al., 2005). ISO and Six Sigma have proven to be highly complementary in other organisations (Warnack, 2003). The implementation of Six Sigma started with one-day introduction training for management and CEO. The first group of 15 Green Belts started their training in September 2002. Seven projects were initiated. To stimulate commitment, participants were allowed to choose the subject of their projects. The second group of Green Belts started in February 2003. As the number of projects increased the necessity for coordination and management of the Six Sigma programme became evident. We observed that Green Belts faced difficulties with closing their projects. A Master Black Belt was appointed to introduce a management control system to evaluate progress and to support Green Belts in finishing their projects. The Master Black Belt organised the necessary training programmes and ascertained that once Green Belts completed a project they initiated another project. In September 2004, the fifth group of Green Belts began with their projects. Co-workers showed more interest in following a Green Belt training. We started new groups of approximately 15 employees every 6 months. Participants emerge from various departments and disciplines within the organisation. We developed a special training programme for medical specialists. We also started training employees from partner organisations, such as home care and a nursing home, to initiate projects that improve cooperation, communication, and quality of care. We have been able to initiate Six Sigma projects in almost every unit and related to every discipline in our hospital (Van den Heuvel, Does and Verver, 2005). At the end of 2004 we had started 44 projects and 21 projects were completed. The total savings amount to 1.2 million Euros and these amounts are cumulative savings on an annual basis. At the beginning of 2004, the Red Cross Hospital anticipated serious financial problems. Management embraced the Six Sigma organisation to initiate an additional number of smaller 'quick win' projects instead of discharging personnel. This additional programme resulted in extra savings upto 1 million Euros. The Annual Report of 2004 consequently showed an, in its history, extraordinary net result of more than 2 million euros (Van den Heuvel et al., 2006). The introduction of Six Sigma in the hospital has stimulated a culture of awareness to find opportunities to improve healthcare delivery and also to take the responsibility to eliminate shortcomings. In the past, decisions were too often based on assumptions and feelings as well as inaccurate and incomplete information. By using Six Sigma, today co-workers take responsibility and provide management with solutions based on the facts and data.

4 Lean

The proliferation of Lean in the Western World started in 1990 with the publication of a seminal work on Lean Manufacturing entitled 'The Machine that Changed the World' (Womack, Jones and Roos, 1990). Lean Manufacturing is an outgrowth of the Toyota Production System (cf. Ohno, 1988; Shingo, 1989). Toyota and other Japanese companies invented a manufacturing paradigm that was superior to the century old mass fabrication paradigm of the West, which was based on employing economies of scale. The Japanese had broken with dogmas like:

- a strong separation of 'thinking' and 'doing' of the job is most effective
- defects are unavoidable by-products of production processes
- organisations should be designed as a hierarchical chain of command
- inventories are necessary evils, used to buffer fluctuations in production speed and customer demand.

The Japanese surpassed Western companies on several dimensions simultaneously, while these dimensions were traditionally seen as trade-offs, i.e. quality vs. cost and responsiveness vs. flexibility. Much of the practices of the Japanese companies are incorporated in the Lean approach. The primary focus of Lean is on reducing waste, synchronising flows and managing variability in (process) flows. It offers a framework for the analysis of processes within an organisation (Standard and Davis, 1999).

A core element of this framework is the distinction between value-adding and nonvalue-adding activities. The dividing line between the two is determined by the customer. Value-added activities are these that contribute to what the customer wants of the product or service and that they would be willing to pay for (see George, 2003). The primary analysis tool of Lean is the value stream map. A value stream map is a process flowchart, extended with information about speed, continuity of the flow, Work In Process (WIP) and so on. Moreover, it specifies which steps add value and which do not. It helps to identify bottlenecks and is used to focus the improvement activities. The value stream map stretches the entire value chain, providing a holistic picture of companies' processes.

Because Lean focuses on process throughput the Lead Time is an important variable. The Lead Time tells us how long any item of work will take to be completed. According to Little's Law (cf. Standard and Davis, 1999) the Lead Time equals the amount of work in process divided by the average completion rate:

$$\text{Lead Time} = \frac{\text{Amount of Work in Process}}{\text{Average Completion Rate}}$$

So according to this equation one can increase the process speed either by reducing the amount of work in process or by increasing the average completion rate. We will elaborate on Little's Law in the project related to the Emergency Room.

Furthermore, Lean offers a set of standard solutions to common organisational problems. Visual management, complexity reduction, 5S-method, cellular production, pull systems, line balancing, one piece flow, and single minute exchange of dies (SMED) are some of the more familiar ones. In the Lean literature the advantages of and principles behind these solutions are described in depth (Standard and Davis, 1999; George, 2003). Lean's strength lies in its offering a set of standard cures and its build-in customer focus. The Lean tools are all proven solutions to problems often encountered in practice.

However, it is unclear how to launch Lean effectively into an organisation. Roles and responsibilities of Lean key players are not specified clearly. Moreover, where to start value stream mapping is also a big question. Guidelines for quality assurance and control are missing within Lean. Finally, in complex cases one needs tailor-made solutions, not just copies from other companies.

5 Integration of Six Sigma and Lean: Lean Six Sigma

Lean and Six Sigma have complementary benefits. For an integration, Lean may use the management structures that Six Sigma offers: Six Sigma's project-by-project approach provides an effective embedding framework to apply Lean principles. Further, Lean lacks a method for diagnosis, and has only limited methods for analysis. It is rather one-sidedly focused on problems with the process throughput, which are solved with a set of standard solutions. Lean does not analyse the economic performance indicators of a process to establish where the main points of improvement are, but focuses on inefficiencies in the process flow, even if that is not where the main opportunities for improvement are. Six Sigma's DMAIC method offers a thorough roadmap for analysis and diagnosis, driven by powerful tools and techniques.

However, Six Sigma is a general problem-solving framework. Given the ubiquity of process inefficiencies, Six Sigma projects – especially the ones pursuing process efficiency improvement and speed – can benefit from the standard solutions that Lean offers. The key to a successful integration of Lean and Six Sigma is to regard Six Sigma's project management and its DMAIC roadmap as a general framework for problem solving and process improvement. But within this framework, Lean's standard solutions and mindset have found their place. Thus, one will find the value stream map as one of the tools used in DMAIC step 4 (*Establish the process capability*) and many of the standard solutions that Lean offers in DMAIC step 9 (*Design improvement actions*) and DMAIC step 10 (*Improve the quality control system*). In Figure 1 we illustrate the integration of the Lean and Six Sigma approach in the DMAIC structure.

In the book of De Mast, Does and De Koning (2006) details about these issues may be found. Several hospitals have started to work with Lean Six Sigma (George, 2003; Chalice, 2005; De Koning et al., 2006). In the last mentioned paper worked examples can be found. It concerns examples with respect to complexity reduction in hiring personnel, improving in an operating theatre starting times, and improving a maintenance system to manage mechanical breakdowns and irregularities. Savings obtained with these projects ranges from €57,000 to €229,000. Additional examples may be found in Van den Heuvel, Does and Verver (2005) and Van den Heuvel et al. (2006). Tools used in these projects were value stream map, complexity reduction, regression analysis, ANOVA, visual management system, control charts, mistake proofing, critical path analysis and several elementary statistical techniques.

6 An application of Lean Six Sigma in the Canisius Wilhelmina Hospital

The Canisius Wilhelmina Hospital is located in Nijmegen, the Netherlands, and has 650 beds and a budget of 145 million euros. At the beginning of 2005 the Canisius Wilhelmina Hospital started to implement Lean Six Sigma. This was done by the same team that was responsible for the implementation in the Red Cross Hospital. In 2005 two teams of 20 Green Belts were trained. This time the training also included the key principles of Lean. An exercise was added in which the participants could experience directly the powerful effects of Lean tools. In 2006, we started to train another team of Green Belts and we plan to start two more groups. Employees are very enthusiastic about the training especially, because they are given the means and tools to solve problems in their own department, which they faced for a long time. Since the Canisius Wilhelmina Hospital is twice as big as the Red Cross Hospital, we also trained more than 60 Yellow Belts to make more employees familiar with Lean Six Sigma and to support the Green Belts in their projects. Furthermore, we did an additional Lean training of one day for all the managing medical specialists and the directors. In April 2006, we did a large survey among employees to evaluate the organisational structure. A large number of flaws in our structure are mentioned by our employees. However, Lean Six Sigma was appreciated as a very useful instrument. In the next paragraph, we will demonstrate one project in our hospital that has been conducted in the Emergency Room. This project has not been completed yet, but it illustrates very well the power of Lean Six Sigma in a hospital.

Figure 1 The DMAIC approach for Lean Six Sigma

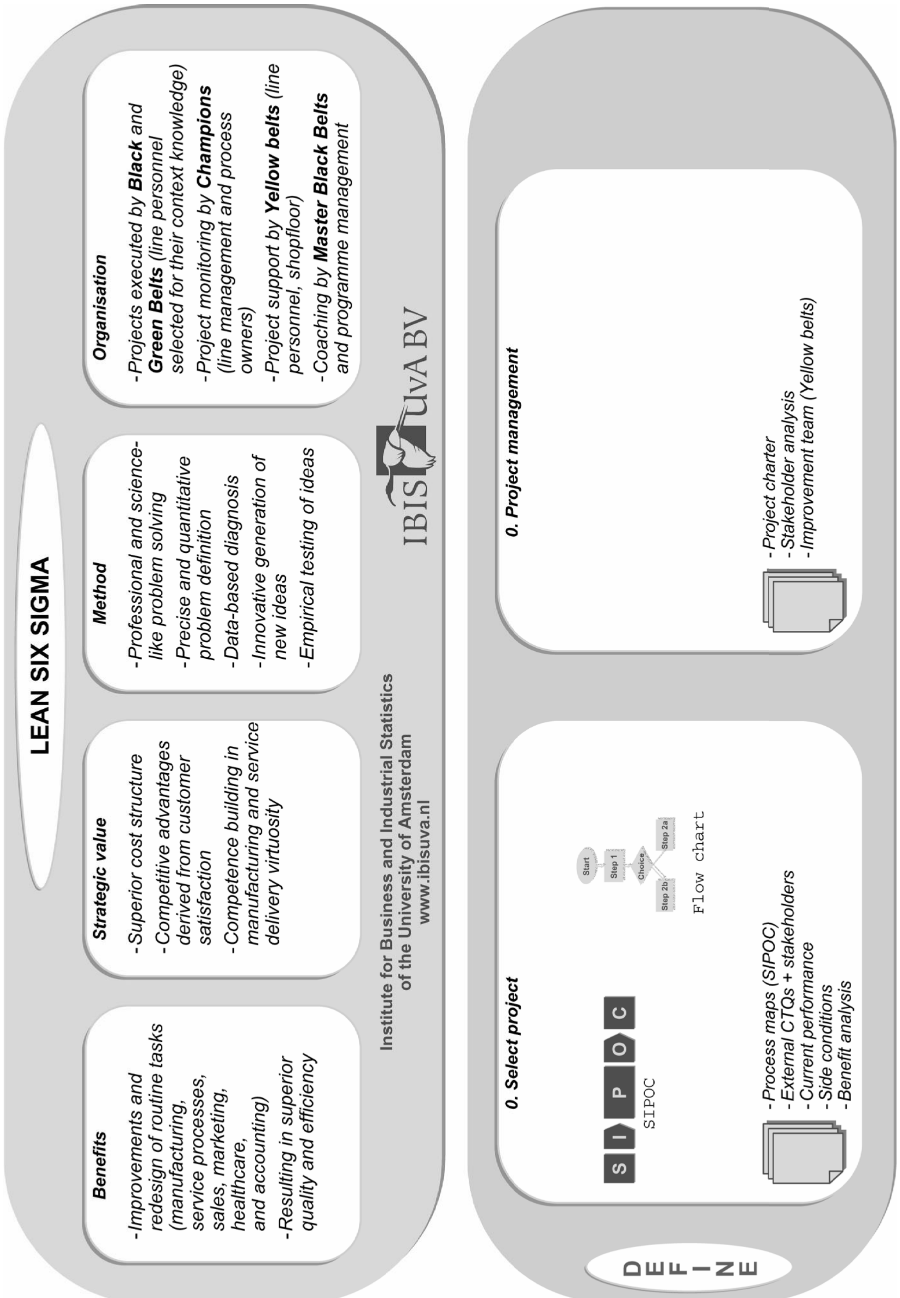


Figure 1 The DMAIC approach for Lean Six Sigma (continued)

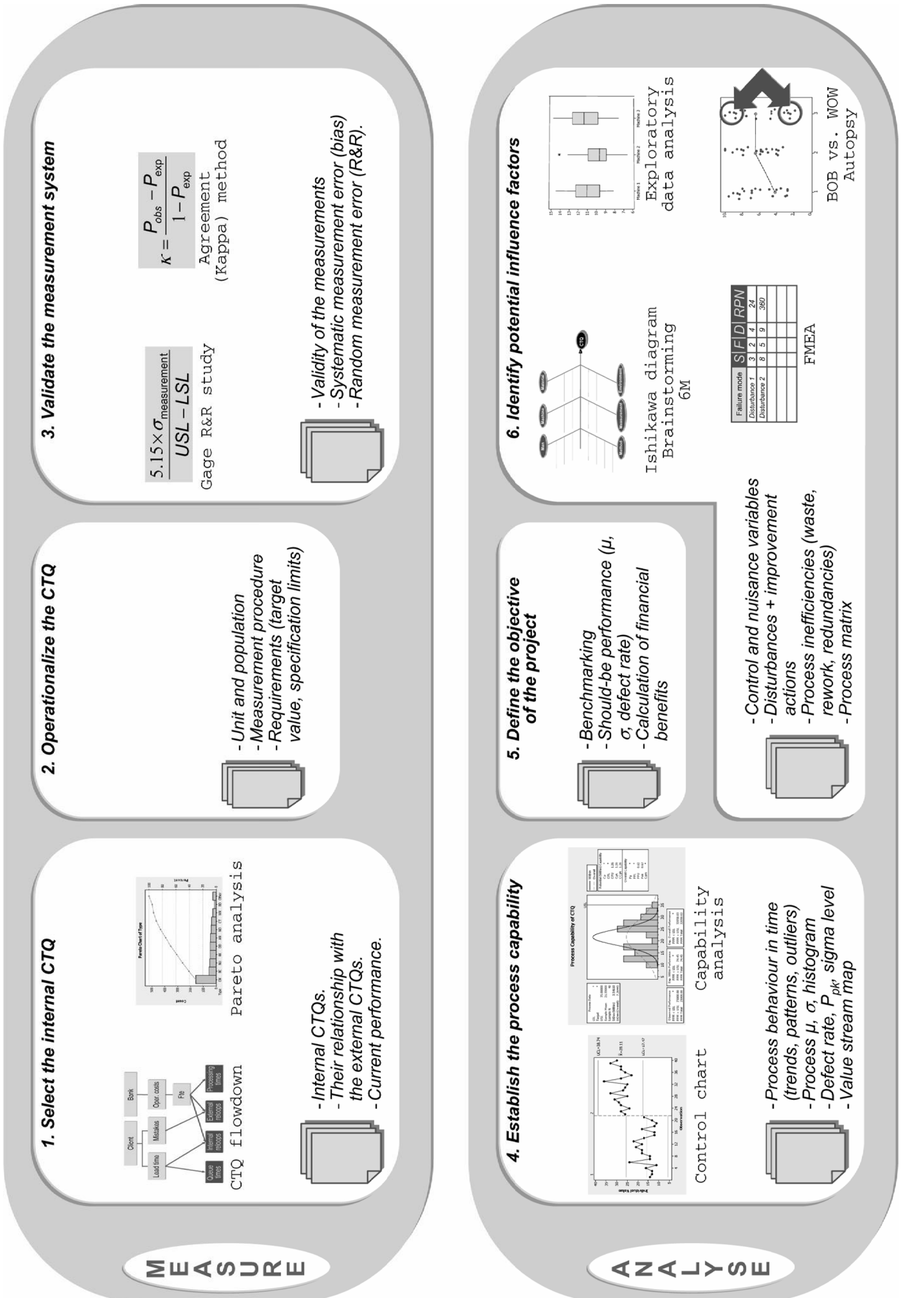
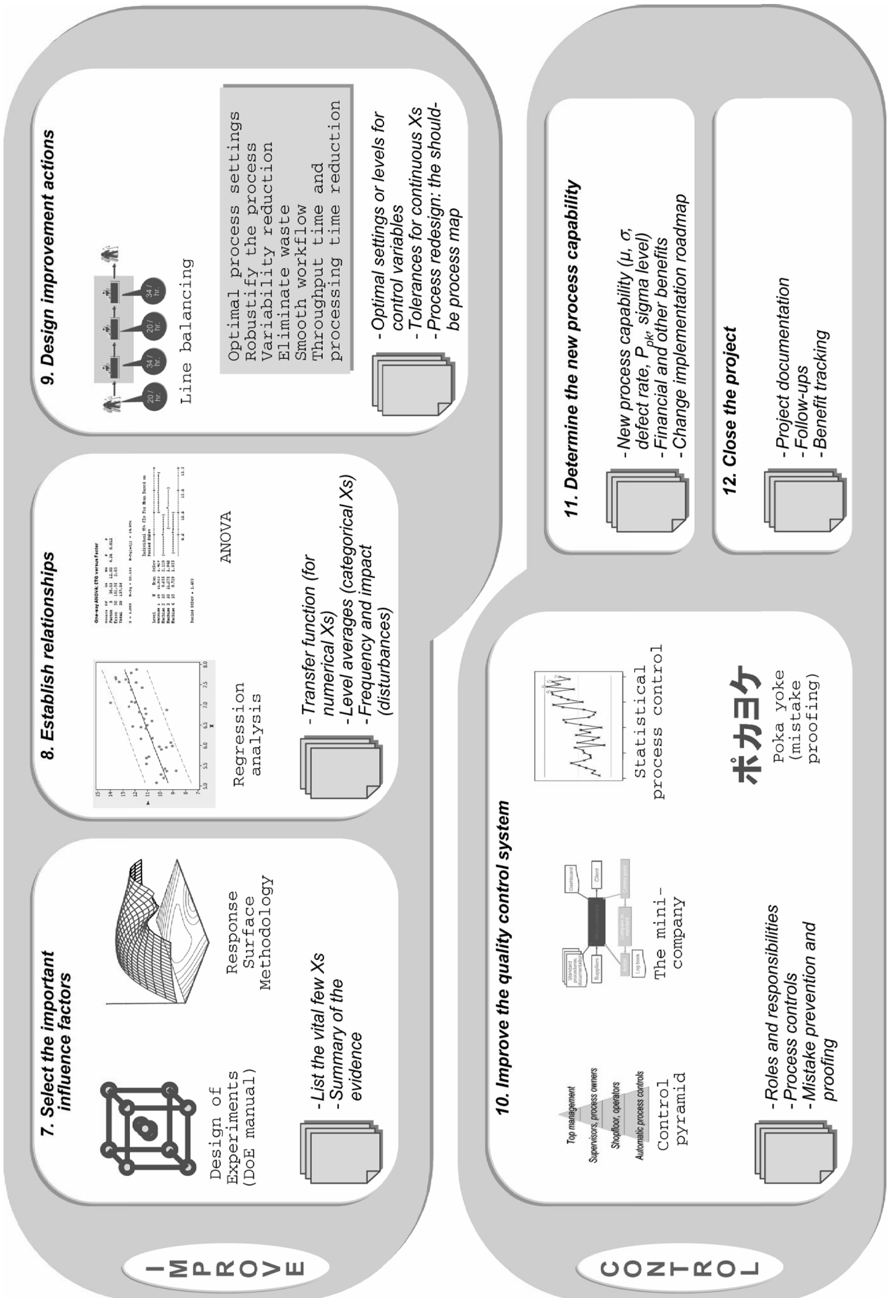


Figure 1 The DMAIC approach for Lean Six Sigma (continued)



7 An example: long waiting times and an over-crowded emergency room

The Emergency Room (ER) in the Canisius Wilhelmina Hospital faces three serious and persisting problems. In the first place, our patients complain about the duration of the entire treatment in the ER. In Lean terminology this time, as we have mentioned before, is called the Lead Time. Secondly, employees complain about the limited space in the ER. At peak hours all the treatment rooms were in use as well as the surgeries for doctors and nurses. Finally, employees experience a high workload, partly due to the fact that the ER is over-crowded on peak times. A number of plans have been developed to increase the number of treatments and surgeries. Due to the tight budgeting system, neither the physical space nor the financial means could be provided. The same holds for increasing the number of employees.

The ER is of high strategic importance, because a significant amount of our patients enters the hospital through this gate. We therefore decided to start a Lean Six Sigma project and chose the duration of the entire treatment in the ER as CTQ. Since the duration of the treatment course is identical with the concept of Lead Time, the Green Belt decided to put a number of Lean tools into action. Therefore, the primary goal of the project was to reduce the Lead Time. According to Little's Law, it is known that there are two ways to do that. In the first place, one can reduce the amount of work in process and secondly one can speed up the average completion rate.

Contrary to industry the reduction of the work amount in process looks counterproductive at first sight. It would mean that we prevent patients to enter the ER or to put them in the waiting room. Since the Lead Time starts from the moment a patient demands the service, there remains a reason to reduce the work in process. If we let more people wait before entering the treatment process, the lead time will decrease, because the actual care process accelerates: the same amount of personnel and equipment are engaged with fewer patients. Therefore, instead of pushing all patients into the ER treatment process one could seek for an optimum in the amount of patients in process. However, one needs also a kind of triage system, because acute patients should be treated in any case and despite the amounts of patients in process. Lead Time will go up but this is inevitable. We therefore implemented a triage system in our hospital.

Another way to reduce the number of patients in process is to see a number of patients on the outdoor department instead of in the ER. This looks self-evident but this option has only been considered after we introduced the concept of Lead Time. Physicians were just used to refer every non-scheduled patient to the ER, but we are going to diverse part of these patients to the outdoor department.

The rationale of reducing the amount of work in process may look a bit metaphysical; the positive effect of increasing the average completion rate on reducing the Lead Time is obvious. To increase the average completion rate we have looked at waiting times within the process, nonvalue-added activities and shortening the clinical pathway. We analysed the entire treatment process in the ER and looked at value- and nonvalue-added activities. We also measured the lead times of the sub-processes and the waiting times between the sub-processes. Most activities were executed after each other so we looked for opportunities (i.e. critical path analysis) to perform some activities, such as X-ray and Laboratory exams, parallel to others. New protocols will be developed that enable the nurses to initiate these exams. An example of nonvalue-added activities is the case that a patient had to be admitted but stayed in the ER to receive additional examinations. These examinations are nonvalue-added with respect to the emergency care process and can be performed equally well in the admitting department. We intend to develop protocols to arrange immediate transfer from the ER as soon as the acute care has been completed. The majority of the waiting times can be attributed to waiting for results from various examinations and waiting for (consulting) physicians. In addition to the critical path intervention we also asked the Laboratory and X-ray department to improve their lead times. The lead times for the treatment process of different physicians were measured and presented. Physicians were asked to increase their effort in the ER or at least increase the effort of house officers. Given the measurements and the necessity to increase service at the ER our physicians agreed to do this. At this moment the number of physicians that give priority to the ER has been increased. The first results are very promising: the average Lead Time has been decreased with 20%.

8 What can we learn from the experiences?

It is interesting to note that in industry the concept of process speed and Lead Time are related to costs containment and have to do with internal quality. The client is only interested in the end product. In healthcare Lead Time is perhaps one of the most important quality indicators from the perspective of our patients. Our customer, the patient, contrary to industry, is participating in the entire process. So the concept of Lead Time and the consequences of Little's Law offer major opportunities to enhance quality and, by nature, to reduce costs. Especially the concept of work in process or in our case patients in (healthcare) process requires additional attention. Nevertheless it provides insight in the dynamics of our ER and helped us to find ways to reduce the Lead Time. The concept of Lead Time appears to be even more challenging when we look at the other two problems; the shortage of rooms and the workload of our employees. When you increase the average completion time and in addition reduce the number of patients in process, the capacity (rooms, employees) that you require decreases. This is extremely relevant; we solved the most important problem of our patients (long waiting times) and in addition, we had two of our own, costly, problems solved as well. Our ER example shows why Lean can be extremely powerful in healthcare.

Waiting times and waste strongly affect the quality perception of our patients. Lean solves these problems. We already noticed in the Red Cross Hospital that Six Sigma by reducing defects also has a positive effect on quality as perceived by our patients (Van den Heuvel et al., 2006). Defects in healthcare are called complications. They do harm to our patients and cost vast amounts of money. So Six Sigma and Lean both increase quality and reduce costs. They do this by following different strategies and in this sense they are highly complementary. The combination is even more powerful because Six Sigma offers a complete quality improvement program and Lean tools can be integrated neatly within this.

The Lean Six Sigma approach has in the past predominantly been used to improve manufacturing processes. However, Lean Six Sigma is now increasingly also applied to a wide variety of non-manufacturing operations. This is an important development; there are potentially more benefits to be achieved in those areas than in traditional manufacturing where decades of good work have already paid off (cf. Does et al., 2002). The key to understand how Lean Six Sigma can be applied more broadly is to recognise that non-manufacturing operations are also processes; they process inputs from suppliers and provide output to customers. This is the reason that in both areas the same approach can be used. However, there are differences in which tools are used (e.g. Design of Experiments are not frequently applied in healthcare).

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