Lean Six Sigma in Healthcare

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Abstract: Healthcare, as with any other service operation, requires systematic innovation efforts to remain competitive, cost efficient, and up-to-date. This article outlines a methodology and presents examples to illustrate how principles of Lean Thinking and Six Sigma can be combined to provide an effective framework for producing systematic innovation efforts in healthcare. Controlling healthcare cost increases, improving quality, and providing better healthcare are some of the benefits of this approach.

Key Words
cost reduction
efficiency
innovation
quality improvement
service management

The cost of medical care is increasing at an alarming and unsustainable rate worldwide. Admittedly, a significant percentage of these cost increases can be attributed to an aging population and technological advances. These two factors, inevitable because of the technological and demographic developments of modern society, are largely beyond control. However, another significant source of healthcare cost increases can be broadly characterized as unnecessary operational inefficiency. Healthcare professionals have more control over this factor. Inefficiency can be measured and changes implemented to improve quality. These efforts provide more affordable and better healthcare for a large percentage of the population.

Some operational inefficiencies are associated with the direct medical service delivery process. Others are associated with the administrative, logistical, and operational side of the healthcare delivery system. Both areas can benefit from systematic process innovation activities.

It is not surprising that some object to the notion of industrialized healthcare delivery. However, industrialization is essentially a conversion of artisan methods to more efficient, cost-effective, streamlined systems for the delivery of products or services (Heskett, Sasser, & Schlesinger, 1997; Levitt, 1976). For example, the industrializing of shoe making made it possible for most citizens of modern industrialized societies to own more shoes of higher quality than royal families had a century ago.

During the past century, industry deployed a large arsenal of tools and innovation approaches to achieve high levels of operational efficiency. Economic history indicates that efficiencies in industry were obtained primarily as the cumulative effect of a large number of incremental improvements (Rosenberg, 1982). Lean Thinking and Six Sigma are two process-innovation approaches that are currently popular in industry (De Koning & De Mast, 2006; George, 2003; Robinson, 1990; Smith, 2003; Stalk & Hout, 1990). Both provide a systematic approach to facilitate incremental process innovations. Lean Thinking emerged within the Japanese automobile industry after World War II (Ohno, 1988) but can be traced back to the early days of the Ford Motor Company (Ford & Crowther, 1926). Similarly, Six Sigma, originally introduced by Motorola, is the culmination and synthesis of a series of century-long developments in quality improvement (QI) (Box & Bisgaard, 1987; Garvin, 1988; Snee, 2004) building on a number of other approaches, in particular, Juran's Trilogy (Juran, 1989). Lean Thinking and Six Sigma have gone through parallel developments in recent years. Both approaches are now also used widely in administration and service areas, although they were originally applied to the manufacturing environment (Snee & Hoerl, 2004). The latest development is a synthesis of these two approaches (Hoerl, 2004). This article explores their integration in the healthcare setting of a Dutch hospital.

Lean Thinking

The proliferation of Lean Thinking was facilitated by the publication of Womack, Jones, and Roos (1990). Lean, as it is often abbreviated, represents a fundamental break with

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Western manufacturing traditions. Stated somewhat simplistically, the traditional mass manufacturing concept of the West was based on the following assumptions:

- A separation of "thinking" from "doing" is most effective.
- Defects are unavoidable.
- Organizations should be designed as a hierarchical chain of command.
- Inventories are necessary evils used to buffer production from fluctuations in market demand.

Toyota and other Japanese companies developed Lean Thinking as an alternative paradigm. Lean is an integrated system of principles, practices, tools, and techniques focused on reducing waste, synchronizing work flows, and managing variability in production flows. An important distinction in Lean is between value- and non-value-added activities. Value-added activities contribute to what the customer wants from a product or service (George, 2003). Everything else is a non-value-added activity. The primary analytical tool in Lean is the value-stream map, an extended process flowchart with information about speed, continuity of flow, and work in progress. This tool highlights non-value-added steps and bottlenecks and is used to guide QI activities. The value-stream map provides a holistic picture of the entire value chain in an organization.

Lean offers a number of standard solutions to common organizational problems. Visual management, complexity reduction, 5S (a method for organizing the workplace: sort, straighten, scrub, standardize, sustain), cellular production, pull systems, line balancing, one-piece flow, and single-minute exchange of dies are some of the more familiar solutions (Shingo, 1989; Womack & Jones, 2003). The principles of Lean are described in detail in the literature (George, 2003; Standard & Davis, 1999).

Lean's strength lies in its set of standard solutions to common problems and its focus on the customer. Lean seeks to prevent suboptimization by its focus on the entire value chain. However, Lean is weak on organizational infrastructure, deployment plans, analytical tools, QI, and control.

Six Sigma

Six Sigma was originally a concept for company-wide QI introduced by Motorola in 1987. It was further developed by General Electric in the late 1990s (Breyfogle, 1999; De Koning & De Mast, 2006; Harry, 1997; Pyzdek, 2001). The program is characterized by its customer-driven approach, emphasis on decision making based on careful analysis of quantitative data, and a priority on cost reduction (Bisgaard & Freiesleben, 2004).

Six Sigma is deployed by carrying out improvement projects. Project selection is usually based on a translation of the company strategy into operational goals (Pyzdek, 2004). Six Sigma provides an organizational structure of project leaders and project owners. Project leaders are called Black Belts (BBs) and Green Belts (GBs). Members of upper management play the role of project owners, or Champions.

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Six Sigma's approach is similar to that of good medical practice used since the time of Hippocrates—relevant information is assembled followed by careful diagnosis. After a thorough diagnosis is completed, a treatment is proposed and implemented. Finally, checks are applied to see if the treatment was effective. To operationalize this problem-solving strategy, Six Sigma deploys five phases—*define, measure, analyze, improve,* and *control* (DMAIC)—that are rigorously followed whenever a problem, large or small, is approached. In the *define* phase, a charter is drafted that includes a cost-benefit analysis. If the cost-benefit analysis meets the company-established thresholds, the charter will be accepted, and the project will continue through the DMAIC process (i.e., the project becomes scheduled for solution and assigned to a team headed by a GB or BB reporting to a Champion). In the subsequent *measure* phase, baseline data are assembled, and the diagnosis is started in earnest. The problem is translated into quantifiable terms using critical-to-quality (CTQ) characteristics. The *analysis* phase continues the diagnosis and involves an identification of possible causal relationships between inputs and the CTQs. After the diagnosis is completed, the team proceeds to the *improve* phase and suggests a solution to the problem.

The GB or BB designs and implements process changes or adjustments to improve the performance of the CTQ. Finally, in the *control* phase, control systems are developed to ensure that improvements are maintained and the new improved process can be handed over to the day-to-day operations staff. Each of the five DMAIC phases involves detailed plans that help to guide project leaders through the execution of the QI project (De Koning & De Mast, 2006).

To secure a successful launch and deployment of Six Sigma, an organizational infrastructure is created. For example, a deployment plan for strategically relevant projects ensures an alignment of project goals with the long-term organizational objectives. Further, Six Sigma uses a stage-gate approach to project management whereby projects are monitored carefully by Champions and appropriate actions are taken if a project does not meet specified completion dates.

One perceived weakness of Six Sigma methods is its complexity. In the case of simple problems with obvious and easy-to-implement solutions, rigorous adherence to the Six Sigma problem-solving process may be considered "overkill" and inefficient (George, 2003). Furthermore, Six Sigma typically does not resort to standard solutions to common problems as does Lean. Finally, the danger of suboptimizing a process, while failing to take into account the entire value chain, is ever present. Nevertheless, Six Sigma offers a structured, analytic, and logically sound approach to problem solving, as well as a strong organizational framework for its deployment.

Synthesis of Lean Thinking and Six Sigma

Lean provides a total system approach but is short on details, organizational structures, and analytic tools for diagnosis. Six Sigma, on the other hand, offers fewer standard solutions but provides a general analytic framework for problem solving and an organizational infrastructure. The ideal solution is to combine the two approaches. Many practitioners have done so tacitly for quite some time. An integrated framework for Lean Six Sigma consists of the following elements:

- **a structured approach:** The deployment infrastructure is based on Six Sigma organizational mechanisms consisting of a task force deployment strategy using BBs, GBs, and Champions.
- **project-based deployment:** A project is a chronic problem scheduled for solution (Juran, 1989). Nonstandard problems are solved only project by project (Juran). Projects are classified as either "quick wins" (Lean) or "advanced" (Six Sigma). Lean projects apply best practices and focus on implementing standard solutions. Such projects typically involve speed, reduction of lead time, inventory, and processing time. Six Sigma projects apply to more general and complex problems and involve solid, data-based analytic methods and statistics, including QI and control methods. The problem-solving algorithm of DMAIC is always used, and projects are monitored after each phase is completed. Typical Six Sigma projects involve increasing quality, decreasing defects, reducing variation, and increasing yield but more generally involve systematic process innovation (Bisgaard & De Mast, 2005).
- **organizational competency development:** A dedicated workforce of Lean Six Sigma project leaders (Champions, GBs, and BBs) are trained in a curriculum that resembles that of Six Sigma with additional Lean components.
- **organizational anchoring of solutions:** To secure the implementation of solutions and guard against backsliding, tasks and responsibilities are clearly defined, procedures are standardized, and process controls are imposed as part of an improvement project.
- **linking strategy with project selection:** Strategic objectives are translated into performance indicators and tactical goals. These are then used as a basis for project selection and help secure an alignment of projects with the overall organizational strategy.

Lean Six Sigma Healthcare

Lean Six Sigma has recently also been applied in the healthcare sector. George (2003), for example, describes pioneering work on Lean Six Sigma at Stanford Hospital and Clinics. In this section our own experience with Lean Six Sigma at the Red Cross Hospital in the

Netherlands is discussed. Of course, as is often the case, elements of Lean Six Sigma were applied at the hospital years before the term itself was used (Van den Heuvel, Does, & Vermaat, 2004).

The Red Cross Hospital in Beverwijk is a 384-bed, medium-sized general hospital employing a staff of 966 with a yearly budget of €72.1 million. In addition to being a general healthcare provider, the Red Cross Hospital also houses a national burn care center with 25 beds that provides specialized services to all of the Netherlands. In 2004, the Red Cross Hospital had 12,669 admissions, performed 11,064 outpatient treatments, and received 198,591 visits to its outpatient units, of which 78,832 were first contacts.

The Red Cross Hospital began to use Six Sigma in 2002. However, the hospital management had already introduced a basic quality assurance system and obtained an International Organization for Standardization 9002 certification in 2000. Prior to the implementation of Six Sigma, management also deployed a number of teams to work on specific QI projects. At the time, management believed that these pre–Six Sigma projects worked well. Indeed, a number of the projects were completed with good results. However, over time, management discovered that an organizational framework and programs for project management, coordination, tracking, and support were necessary. Specifically, upper management identified the following problems:

- Projects were not necessarily of strategic relevance.
- Projects did not always have a significant business case.
- A systematic project-tracking system was missing.
- There was no uniform method for project management and control.
- Too many projects were not completed.

At the end of 2001, the hospital management was introduced to Six Sigma and found that this methodology provided solutions to many of these problems. The initial implementation of Six Sigma at the Red Cross Hospital is described in the literature (Van den Heuvel, Does, & Bisgaard, 2005; Van den Heuvel, Does, & Verver, in press). In addition to outlining Six Sigma's management framework and lessons learned relevant to healthcare, these articles also describe selected examples of projects. A sampling will provide an impression of the range of problems tackled:

- shortening the length of stay in chronic obstructive pulmonary disease patients
- reducing errors in invoices received from temporary agencies
- revising the terms of payment
- allowing parents to room in with their children
- reducing the number of patients requiring intravenous antibiotics
- shortening the preparation time of intravenous medication
- reducing the number of mistakes in invoices.

Indeed, some healthcare professionals think QI methods should address only defects, such as medication errors.

This list illustrates the important point that Six Sigma projects in healthcare typically include both medical and administrative problems. Indeed, some healthcare professionals think QI methods should address only defects, such as medication errors. Our experience is that significant gains can be made by widening the field of applications to all processes and all operational inefficiency and waste.

The list above also shows that several of the Six Sigma projects could just as well be characterized as Lean projects. For example, reducing the length of stay and shortening the preparation time for medication would be typical Lean objectives. On the other hand, the Lean approach would come up short in projects involving reducing errors in invoices received from temporary agencies, revising payment terms, and correcting the number of mistakes in invoices. The distinction between Lean and Six Sigma is artificial and often not helpful. An integration of the two approaches and a general focus on process innovation regardless of the origin of the tools and approaches would be more productive.

Introducing Six Sigma

Six Sigma was implemented in earnest at the Red Cross Hospital in September 2002 with the first wave of GB training. As is standard for Six Sigma, the training was provided in two separate periods of 3 days, 2 months apart. The GBs were required to complete a project in conjunction with their training. The financial threshold for initiating a project was an estimated minimum saving of €20,000. GBs typically worked 1 or 2 days a week on their projects. As part of the project-management system, teams were carefully monitored and allowed to proceed to the next phase of the DMAIC sequence only after presenting the Champion with a report providing evidence that the preceding phase had been completed. Teams were required to present their results twice in front of the entire class. The second presentation served as the GB graduation examination.

In addition to these complexity-reduction measures, a visual management system to signal mistakes was introduced.

The first wave was followed by additional GB training waves scheduled every 6 months thereafter. The Six Sigma approach was well received. The GBs believed the Six Sigma training and project-management system supported them well throughout the process of a project. The data-driven approach was regarded as helpful in establishing support of the teams during the implementation of the results. The data-based analysis and decision making seemed to minimize resistance to change.

After completing the training of the fourth group of GBs, it was decided that the training process needed revision. The experience from the previous waves of GB training indicated that many healthcare problems involved various forms of wasted time. It was decided to experiment with combining Lean with the DMAIC methodology. Materials on time-value maps, value-stream maps, and the six standard forms of waste were added to the curriculum in the *analysis* phase. Furthermore, 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. The total length of this revised training program was expanded to 8 days, divided into two periods of 3 days and an additional section of 2 days. The first Lean Six Sigma GB training program started in September 2004 with 18 participants distributed in teams of two or three GBs.

The Red Cross Hospital experience illustrates the key elements of the Lean Six Sigma approach. First, the hospital applied the organizational infrastructure typical of Six Sigma. Second, deployment of QI was project by project. Third, the Lean Six Sigma approach was based on developing organizational competency for innovation by training a dedicated force of Lean Six Sigma project leaders and GBs. Fourth, project selection had a strategic focus. In the present case the Dutch Ministry of Welfare and Health had imposed serious budget cuts on the Red Cross Hospital. This necessitated a strict focus on cost reductions while maintaining or possibly improving quality. Potential projects were suggested by Champions, all hospital department heads. The final word to proceed was given by the general manager, based on an evaluation of the project's strategic relevance.

Lean Six Sigma Project Cases

Complexity Reduction in Hiring Personnel

The Red Cross Hospital spends yearly more than €1 million on temporary personnel. Upper management suspected that the cost of hiring temporary personnel was unnecessarily high. A preliminary investigation indicated that errors on invoices was a problem resulting in significant non-value-added rework and unnecessary readministration. Thus, the project charter drafted by the GB and the project Champion stated that the objective of this project was to reduce the number of mistakes on invoices. The CTQ was the percentage of correct invoices received from the temporary agencies.

A baseline study performed in the *measure* phase showed that only 15% of the invoices were correct on first pass. The goal was set to improve the CTQ to 100%. If this ambitious goal was achieved, the financial saving was projected to be €36,000 per year. In the subsequent *analysis* phase, a number of influential factors and causes were identified. The most important were these:

- The signature of the department head was missing.
- A check on the hours worked was missing.
- Breaks were not registered.
- Mistakes occurred in the reported hours worked and time for travel.

- There was no check on the number of the temporary worker's years of experience.
- The hourly wage was incorrectly stated on the invoice.

Although a large number of mistakes were recorded, this initial analysis failed to unearth any single dominant type of mistake. However, further analysis showed that the errors were symptoms of a more significant problem. The root cause turned out to be that each of the temporary agencies used a different worksheet. Moreover, no single uniform standard for hiring and invoicing temporary workers was followed. Each department had its own forms and procedures. From a Lean perspective, having different worksheets for the same purpose is a non-value-added complexity that should be eliminated. This led to the following proposed improvements:

- A standardized worksheet was introduced.
- Requests for temporary personnel were centralized.
- The number of temporary agencies was reduced.
- A new administrative system for checking invoices was introduced.

In addition to these complexity-reduction measures, a visual management system to signal mistakes was introduced. A new procedure was introduced for hiring temporary personnel, requiring heads of departments to use a single standardized worksheet. This worksheet incorporated a "check invoice" feature designed to make it easy to compare invoices submitted by the temporary agency with internal documents, which made it easy to spot discrepancies. All of these incremental changes resulted in reduced rework and significant cost savings.

Reducing Operating Theater Starting Times

Operating theaters (OTs) are expensive and capacity-limiting facilities. Their optimal utilization is paramount to efficient hospital management. The general manager of the Red Cross Hospital suspected that the utilization of the OTs was far from optimal, so a GB team was assigned to increase the efficiency of the OTs. The GB team focused on the starting times of the OTs. The official starting time was 8 am. Baseline data collected in the *measure* phase showed that the average starting time was 8:35 am, which suggested a significant loss of capacity. As a realistic goal, it was decided to aim for an average starting time of 8:15 am.

During the *analysis* phase the GB team discovered several factors that affected the starting time:

- Patients had not been administered the prescribed medication.
- Patients were brought in late by the referring department.
- The OT had insufficient manpower.
- Specialists had to make rounds prior to performing procedures in the OT.
- Anesthesiologists and other specialists were late.

While diagnosing these problems, the GB team found that the underlying problem was a poorly defined process. This made planning difficult. Tools were needed to manage this operational process. Designing a new admissions process based on the following simple principles was the solution:

- Patients must be present at the OT facility no later than 7:35 am.
- Before arriving at the OT, patients must receive preoperative preparation.
- The referring department and the anesthesiologists must be informed about the planned OT treatment for the patient 1 day in advance of a procedure.

To control this new process, visual management was introduced. At the weekly staff meeting, a specially designed graph was reviewed, showing the OT start times for the previous week. The feedback from this control system was used to continually monitor the OT starting times and provide valuable input on how to improve processes even further.

Maintenance

The Red Cross Hospital has a system in place to manage mechanical breakdowns and irregularities. This system registers a problem and assigns a maintenance person a "blue coupon" with a description of the issue. After diagnosing the situation and solving the problem, the maintenance person reports that the problem has been solved. Although the system itself seemed efficient, the resolution of problems often took an excessive amount of time. A project team was chartered with the task of improving the process. The CTQs were the number of active, not yet resolved blue coupons and the lead time per blue coupon.

The first CTQ represents the overall cost in system downtime, whereas the second provides an indication of the quality of the service rendered. The following discussion will be limited to the first CTQ.

Analysis showed that the dominant problem was defective lights. It was further discovered that the maintenance department did not have standard operating procedures. Malfunctions were handled in an ad hoc fashion with no accounting for urgency or priority. A number of solutions were put into place to deal with this problem.

- **prevention:** Lights were turned off at night to extend the life of light bulbs.
- **standard operating procedure:** Guidelines were developed for dealing with breakdowns and failures.
- **work planning system:** Problems were divided into urgency categories.
- **performance monitoring and visual management:** Norms for fixing standard malfunctions were instituted and monitored.

The result of these simple systems changes was a significant decrease in the number of blue coupons. The related financial saving of this project was approximately €200,000.

These projects illustrate the benefits of combining Lean with Six Sigma. In all cases a thorough quantitative diagnosis was made before starting improvements. This is typical of Six Sigma. In all cases it was possible to use off-the-shelf solutions to solve the problems. The solutions were firmly anchored in the organizational infrastructure. Managers can keep track of the performance of CTQs using visual management systems and ensure that an organization does not revert to old habits and past performance standards. The gains are maintained.

Conclusions

Unless healthcare leaders deal with spiraling healthcare costs, a decreasing proportion of the citizens of industrialized societies will be able to afford high-quality healthcare. If healthcare services are inefficient, they cost more, and fewer can benefit from the technical advances of modern medicine. A persistence of traditional service practices will drain our economy. Continuous and relentless pursuits of innovations in the service delivery process are necessary. The industrialization of healthcare offers a viable alternative that can provide better economy, greater efficiency, and better service.

Industrializing healthcare does not mean that healthcare becomes less personal and that quality standards are compromised. For example, a modern car, objectively speaking, is far cheaper and of significantly higher quality than a handcrafted car manufactured 100 years ago. Prepackaged vacations typically offer better deals with higher levels of service than individually planned tours. Industrialization of services typically improves quality while making those services much more cost efficient.

The industrialization of healthcare service will require a large number of innovations, especially pertaining to the delivery of services. The popular perception is that innovation, like artistic expression, is the product of genius. However, in today's competitive economic environment, this process must not remain a mystery. Indeed, it need not be. Pianists and painters attend conservatories and art schools to receive intensive training in their profession. Innovation, like artistic performance, can be learned. The combination of Six Sigma and Lean—with their tools, road maps, and management processes—is essentially a carefully managed process for systematically scheduling and carrying out innovation projects that can be taught, learned, and performed with a high degree of success.

Lean and Six Sigma have strongly complementary strengths that are particularly useful for systematically developing healthcare service innovations. Synthesizing these approaches leads to an integrated program combining the best of both programs. Lean Six Sigma incorporates the organizational infrastructure and the thorough diagnosis and analysis tools of Six Sigma with Lean analysis tools and best-practice solutions for problems dealing with waste and unnecessary time consumption.

The application at the Red Cross Hospital provides an illustration of the significant benefits of the Lean Six Sigma approach. The management of the hospital adopted the Lean Six Sigma organizational infrastructure, developed organizational competencies, and instituted a process for selecting strategically aligned projects combined with rigorous project management. The net result was a process for institutionalized systematic innovation that consistently delivers the intended end results (Drucker, 1985). The adoption of similar programs will make possible the successful replication of the outstanding results obtained by the Red Cross Hospital in Beverwijk, the Netherlands.

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