

Review

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Effects of Lean Six Sigma application in healthcare services: a literature review

Abstract: The healthcare organization is the place where defects and mistakes cannot be tolerated. A simple mistake can cost a human life so defects or mistakes must be eliminated in healthcare service processes. A Lean Six Sigma (LSS) approach is the best option in a healthcare environment for dealing with a critical patient. The LSS methodology optimizes the average reduction of a desired process. The expected results can be reductions in several aspects of healthcare such as patient waiting time in emergency departments, lost charges for billing in patient financial services, delinquent medical records, diagnostic result turnaround times, accounts receivable days, patients' length of stay, or medication errors. This paper mainly discusses the effects of the LSS approach in different hospitals around the world according to the literature review. This review also discusses the relationship between LSS as well as their impacts on healthcare services based on literature review.

Keywords: healthcare; Lean Six Sigma; patient; quality service.

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Introduction

Healthcare is a service organization that has some unique characteristics. In the healthcare service, customers are the patients and are being cared for in addition to their family and friends. This can be confirmed since the result of the service affects the lives of all those involved. An error or mistake in this field can be devastating to individuals

and groups alike because lives and quality of life are at risk (1). Due to the potential risks, this area is highly regulated by government agencies to ensure quality standards. Nowadays healthcare organizations are complex dynamic systems that focus more on improving quality of care and meeting stringent guidelines. Therefore, re-examining the method of evaluating the service performance is becoming more important (1).

According to Heuvel (2), previous studies have found that healthcare has serious patient safety and quality problems and is in need of fundamental change. Healthcare processes are poorly designed and are characterized by unnecessary duplication of services as well as long waiting times and delays for the patients. Rising costs and generated wastes are identified as important contributors to the increase in healthcare expenditures. Due to these problems, the healthcare organization cannot be successful in fulfilling their patients' demands regarding the quality of service. To fulfill patients' expectations, the healthcare organizations must follow quality management practices such as Lean Six Sigma (LSS) methodology (2).

The LSS approach improves service quality and customer satisfaction by reducing the cost of operation and increasing business revenue. Healthcare organizations have embraced the LSS concept after it was fully developed, tested, and verified by many firms in the manufacturing sector such as Motorola, Allied Signal, Toyota, and General Electric (3). The application of LSS ensures the success of the healthcare center by reducing the number of defeats, such as patient waiting time, delivery of medical reports, unnecessary medical costs, and so on. It also helps the healthcare center achieve continuous improvements in the healthcare service by ensuring accurate results in a timely fashion. Providing accurate results to the healthcare providers enables them to diagnose and treat patients with a higher quality of care (4). In this paper, the authors discussed the history of Lean and Six Sigma, the relationship between the two, and their effects when applied in the healthcare service.

History of the Lean and Six Sigma

In the early 1950s, Taiichi Ohno introduced a concept of “lean production or lean thinking” to reduce muda (waste) from the production processing. The concept was first implemented by the Toyota Motor Corporation (hereafter referred to as Toyota) to reduce unnecessary waste in the production and improve the quality of activities in the plant (5). This concept was widely known as the Japanese Toyota Production System and later became known as “lean production” and “lean thinking” (6).

In 1947, Eiji Toyoda went to the US to learn how automobile cars were manufactured efficiently and effectively in the world’s largest plant. In the meantime, Ford’s Rough plant was producing 7000 cars per day, which was like a dream compared with Toyota’s 13-year production of 2685 cars (5). While Eiji was studying in the US, he wrote a letter back to the headquarters in Japan that he thought there were possibilities by which to improve the production system in manufacturing new Toyota cars. However, the application of Ford’s mass production system did not work in Japan due to the cultural and environmental differences (6).

They then realized that there was too much waste everywhere, i.e., waste in manpower, production, transportation, and facilities. They also realized that they were operating on limited human and material resources and that they were unable to adopt and implement the production system being used in the US at that time (6). Therefore, Ohno returned to Japan and motivated his employees to work together under the best performance operation concept, followed by the so-called “five S” activities. Ohno introduced another famous system to reduce waste, which he called just in time (JIT) or Kanban system. This helped the company identify how much waste was involved in the mass production system. The JIT system enabled the company to reduce waste in the following three ways:

- not requiring a large space, in which to house a large number of parts;
- only the needed quantity of parts was produced; and
- defects were immediately discovered to prevent many others from being produced (5).

By implementing the JIT system, the amount of waste generated was reduced. First of all, a large space was not necessary to keep a large number of parts. Second, only the needed quantity of parts was produced. Third, if defects were produced, these were immediately discovered, thus the system prevented a large number of defects from being manufactured by accident. However, this new system was not easy to implement, especially if the system

often produced defects. This meant that if just one small part of the whole production system failed, then the entire production system should be stopped. In fact, this point was precisely what Ohno thought about. He designed the system in such a way that every member of the entire production system focused on preventing potential problems and reducing waste (5). Nowadays, Toyota’s car manufacturing market shares have increased throughout the world. However, in the early 1950s, the US market rejected Toyota’s new brand, Crown, because of problems such as lack of security, lack of power, and its heavy weight, to name a few. Therefore, rather than follow the traditional quality assurance system, Toyota came up with a human-based system that involved their own people, ensuring continuous improvements and empowerment through education and training (5, 6).

After successfully implementing the lean approach, Toyota was able to increase the value of the car and reduce all other non-value added tasks. In 2004, Toyota beat Ford to become the world’s second largest automobile producer after General Electric Company (GE). By 2006, Toyota’s profits tremendously increased to US \$12 billion – nearly double GM’s highest annual earnings of \$6.9 billion in 1995. Meanwhile, GM lost \$3.4 billion and Ford lost \$12.7 billion in the quarter ending June 2006 (7).

Six Sigma was originally a concept for a company-wide quality improvement program, which was first introduced and implemented by Motorola in 1987. It has been extensively used within companies such as General Electric (GE), Allied Signal (former Honeywell), ABB, Texas Instruments, Caterpillar, Sony, Toshiba, City Bank, Bank of America, JP Morgan, and so on (8). In the healthcare system, a higher level of sigma means a higher level of performance. For instance, a 3 Sigma Process has a defect rate of 6.7% whereas a Six Sigma process has <4 defects (3.4 defects) per million opportunities. Defects in processes cause increase in costs due to scrap, rework, repair, re-test and so on (1).

Relationship between Lean and Six Sigma

According to Salah et al. (9), Six Sigma and Lean have a complementary relationship with each other. Nowadays, many companies are using a combination of both applications, which is called the LSS program. The LSS approach can be used to eliminate waste and variation through the DMAIC (Define, Measure, Analyze, Improve and Control) structure, in order to achieve customer satisfaction with

cost efficiency and quality performance. This application focuses more on continuous improvement (CI) processes, customer satisfaction, and better financial performance for the organizations using it.

The application tools used in Six Sigma and in Lean have some differences. In some cases, tools from either approach are better depending on the nature of the problem and opportunities being addressed. However, both have common tools by which to solve organizational problems (9). The examples of common tools are brainstorming, process mapping, standardization, and mistake-proofing (Table 1). According to Salah et al. (9), Six Sigma and Lean should not be used in parallel, although they can be used simultaneously. Previous studies have found that both methodologies applied in parallel to each other cannot be successful because they offer individual solutions in solving specific organizational problems (9). However, Mader (10) argued that a traditional Six Sigma application can be used in parallel with a Lean Kaizen event approach to decrease project duration. Snee (11) suggested that lean tools can be used in the first stage of an effective process improvement. In this stage, the main purpose of using Lean tools is to eliminate organizational waste and simplify the continuous improvement processes, before starting to tackle the more difficult problems through the optimization and process control steps. However, the author also mentioned that it is more effective to apply both applications simultaneously, when problems are occurring within the processes. Therefore, Six Sigma and Lean may not be applied in parallel but can be used simultaneously to achieve the desired benefits (11).

To successfully use Six Sigma and Lean, the organizations must develop a holistic improvement method, where Six Sigma and Lean mutually support each other. According to Salah et al. (9), Six Sigma and Lean can be integrated without contradicting their core principles. Nevertheless, there is no consensus on how the integration of Six Sigma and Lean should be done; at the same time, there is no widely accepted integrated methodology of the integrated LSS approach (12).

Effects of LSS on healthcare services

As mentioned before, Lean and Six Sigma have a complementary relationship with each other in improving the quality of services by reducing costs and wastes. According to Heuvel et al. (13), the Lean method uses a management structure based on the Six Sigma approach. The Six Sigma method provides an effective embedding framework according to the project-by-project approach of applying Lean principles. On the one hand, the Lean approach does not analyze the financial performance indicators of a process, and the main objective is to improve organizational performance by reducing unnecessary costs. On the other hand, the Six Sigma's DMAIC approach provides a roadmap by which to analyze and diagnose the organizational performance. This approach can specifically identify the problems/errors in the process and is driven by powerful tools and techniques. The Six Sigma method, however, is a general problem-solving framework that may suffer from process inefficiencies; for those who are after process efficiency improvement and speed, this drawback can be solved by the Lean approach (13). Thus, Lean and Six Sigma should be integrated to achieve high organizational performance through continuous improvement.

In the late 1990s, the Xerox Corporation first implemented the concept LSS to operate its supply chain management in the manufacturing processes. In the middle of 2002, the company's top management decided to integrate Lean and Six Sigma to increase quality production by reducing waste and costs. Since then, the company's performance quality gradually increased by adopting the LSS approach in its supply chain management process (14). Once the LSS method was successfully implemented by the Xerox Corporation, some healthcare organizations also began to adopt the LSS application to improve their quality performance towards patient satisfaction. According to Koning et al. (8), the LSS approach has strong

Table 1 Examples of Six Sigma and Lean common tools.

Some Six Sigma tools	Some Lean tools	Common tools of Six Sigma and Lean
Hypothesis testing	Kanban	Brainstorming
Control charts	Visual workplace	Process mapping
Regression	Single minute exchange of die	Standardization
Design of experiments	Single piece flow	Mistake-proofing
Measurement analysis	Layout planning	
Capability analysis		

Source: Salah et al. (9).

potential for developing healthcare service innovations by reducing costs and errors. They also mentioned that LSS minimizes organizational waste and unnecessary time consumption through its diagnosis and analysis tools.

In 2000, the management of Red Cross Hospital, Netherlands implemented the Quality Improvement (QI) approach to improve their quality performance in the healthcare services; however, they could not succeed due to some problems (8). These problems included the following:

- projects that were not strategically relevant;
- projects did not always have a significant business case;
- lack of a systematic project-tracking system;
- lack of uniform method for project management and control; and
- too many projects that were not completed (8)

At the end of 2001, the top management of Red Cross Hospital introduced the LSS methodology and solved these problems (15). At the beginning of the LSS program, the project champion identified some problems in the measure phase. These included the following:

- the signature of the department head was missing;
- monitoring of the hours worked was not done;
- breaks were not registered;
- there were errors in the reported hours worked and time for travel;
- there was no check on the number of the temporary worker's years of experience; and
- the hourly wage was incorrectly stated on the invoice.

Based on the LSS approach, the management was able to solve these problems and save €36,000 per year from unnecessary costs and waste (8). However, during the analysis phase of LSS, the Green Belt team discovered several issues that affected the starting time. These included the following:

- patients were not administered the prescribed medication;
- patients were brought in late by the referring department;
- the operation theater had insufficient manpower;
- specialists had to make rounds prior to performing procedures in the operation theater; and
- anesthesiologists and other specialists were late (8).

After identifying these problems, the LSS Green Belt team found that these problems were occurring due to the poorly defined process of the performance. To overcome

these, the management developed a new admissions process based on the following principles:

- patients must be present at the operation theater facility before 7:35 am;
- before arriving at the operation theater, patients must receive preoperative preparation; and
- the referring department and the anesthesiologists must be informed about the planned operation theatre treatment for the patient 1 day in advance of the procedure date (8)

The Green Belt team also identified other problems that led to excessive time spent in completing the target project within deadline. They discovered that the hospital maintenance department did not have standard operating procedures, and as such, malfunctions were handled in an ad hoc fashion with no accounting for urgency or priority (8). To solve these problems, they took some initiatives, such as turning the lights off at night to extend the life of light bulbs, dividing project problems into levels of urgency based on the importance of the task, and establishing and monitoring working performance for fixing standard malfunctions, as handled by the top management of Red Cross Hospital. Once the management succeeded in solving these problems, the Hospital was able to reduce the number of wastes and costs in the performance process. As a result, the hospital managed to save approximately €200,000 in 2004 just by implementing the LSS approach (8).

Following the success of the Red Cross Hospital, this was followed by the Canisius Wilhelmina Hospital, which also began to implement the LSS approach in improving quality performance in 2005. The Hospital is located in Nijmegen, Netherlands and has 650 beds for their patients. In this hospital, the LSS was implemented by the same experts who were responsible for implementation in the Red Cross Hospital (13). The experts trained two teams where 20 people were labeled "Green Belts." The training experts taught the teams about key principles of LSS to help them understand the powerful tools of the LSS approach (13).

In 2006, the Canisius Wilhelmina Hospital trained another team of Green Belts and the hospital began to form two more groups of Green Belt holders. This was due to the overwhelming response of the hospital employees after being given the tools of the LSS approach in solving healthcare-related problems they had in their departments for the longest time (13). The Canisius Wilhelmina Hospital is bigger than Red Cross Hospital. Thus, the hospital top management decided to train their employees to make more familiar with LSS application. The hospital trained

more than 60 Yellow Belts to support the Green Belts in the quality management projects. Moreover, the Hospital also held an additional Lean training for 1 day, which was meant to help the managing medical specialists and directors understand the principles of LSS application (13). In April 2006, the Hospital did a large-scale survey among the employees to examine the organizational structure and performance procedures; the management found that a large number of employees appreciated the LSS approach as a very useful instrument (13).

The Canisius Wilhelmina Hospital implemented the LSS method to overcome three serious problems related to the emergency room (ER). The first serious problem was patients; complaints regarding the duration of the entire treatment in the ER, which is called lead time.” The second serious problem was employees’ complaints regarding the limited space in the ER. During peak hours, all the treatment rooms were used by the doctors, nurses, and physicians for surgery purposes. The third serious problem was employees experiencing a high workload in the ER due to the over-crowding situation at peak hours (13).

To overcome these problems, the Canisius Wilhelmina Hospital management decided to implement a LSS project and selected the duration of the entire treatment in the ER as the target. Actually, the duration of the treatment course is a concept of lead time and the Green Belt team decided to reduce this by applying a number of LSS tools. This application helped the management reduce the amount of work in process and speed up the average completion rate of the project (13). By applying Lean tools, the Hospital management was able to prevent their patients from entering ER during the peak hours or placing them in the waiting room (13).

In addition, the hospital Green Belt team analyzed the entire treatment process in the ER and focused on value and non-value-added activities. They also measured the lead times of the treatment processes and waiting times during the treatment sub-processes (13). To reduce the lead time, the hospital management asked the doctors, nurses, and physicians to increase their effort in the ER. This agreement led to reduced treatment time in the ER (13). Moreover, the lead time was reduced to about 20% in the ER during the peak hours (13).

In 2008, one of the private hospitals in Taiwan “Hospital X (name is assumed)” began to implement LSS methodology to improve medical service quality by reducing mortality and medical costs (16). At the beginning of the LSS project, the team discovered that there were several problems that prevented Hospital X from providing medical services to the patients. These are as follows:

- patients who are always queuing;
- inexperienced physician in the ER;
- too much time waiting for the diagnosis;
- delay in receiving medicine;
- shortage of nurses in the ER
- overcrowding at the hospital corridor, and
- too many operation materials that are not necessary.

After implementing the LSS applications at Hospital X, it was observed that non-value-added time was reduced by 70.7%. It also improved the medical process and workforce efficiency to provide better service quality for the patients. Moreover, this approach helped Hospital X to save NT\$ 4.42 million (1 US\$=29.42 NT\$) per year from unnecessary costs and waste (16).

Discussion and conclusion

Day by day the healthcare market share gradually increases, making it essential for the healthcare organizations to provide high quality healthcare services to their patients so as to meet their expectation. When healthcare service quality improves, patient satisfaction also improves, leading to the healthcare organization achieving the highest level of patient retention and loyalty (17). To achieve these, a hospital must implement LSS methodology to achieve continuous improvement in the quality of services.

This is because the LSS methodology can ensure the success of the healthcare center through the continuous quality improvement in the service procedures. It helps the healthcare center establish a continuous improvement in the healthcare service, thus ensuring accurate results in a timely fashion. Providing accurate results to the healthcare providers enables them to diagnose and treat patients with a higher quality of care (4). The LSS methodologies can be executed in the following healthcare processes:

- increasing capacity in X-ray rooms;
- increasing surgical capacity;
- increasing productivity of healthcare personnel;
- increasing accuracy of laboratory results; and
- increasing accuracy of billing processes, thereby reducing the number of billing errors (1, 18, 19).

According to Taner et al. (1), LSS implementation clearly benefits the healthcare organizations in terms of better operational efficiency, cost-effectiveness, and higher process quality. Moreover, they also mentioned that LSS applications have a positive impact in clinical areas such

as infection control and medication delivery. The LSS applications could fail in the healthcare services due to the following reasons:

- lack of financial resources;
- lack of human resources;
- lack of time;
- lack of leadership;
- poor training;
- poor project selection; and
- internal resistance.

The authors also believed that the implementation of LSS can contribute to a better business strategy, through

which an organization can deliver truly high-class service to their patients. They mentioned that LSS methodology will continue to grow in the healthcare sectors for the next 5 years and beyond. For the successful implementation of this methodology, the healthcare organization must improve their workforce management by providing training as well as increasing team involvement, team commitment, and motivation.

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