Integrating Lean and Six Sigma Methodologies for Healthcare Quality Improvement

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Abstract— The aim of this study is to propose a new model called "Healthcare Lean Six Sigma System (HLS^3)" that integrates Lean and Six Sigma methodologies to improve healthcare quality. This new model bridges the service gaps between healthcare providers and patients and balances the requirements of healthcare managers, delivers and patients by taking the benefits of the Lean speed as well as Six Sigma high quality principle.

Keywords— healthcare quality improvement, Six Sigma, Lean production system

1. INTRODUCTION

Healthcare, as with any other service operation, requires continuous and systematic innovation efforts to remain competitive, cost efficient, up-to-date, and high quality of service i.e. a high quality of healthcare service. Define healthcare quality and its requirement is the first step for developing methodologies to improve healthcare service because it dramatically affects how healthcare process is designed and service is delivered. According to Institute for Health Care Research and Improvement (IHCRI) definition, healthcare quality includes six factors [1]:

- **S**afe - patients should not be harmed by the care that is intended to help them
- **T**imely - unnecessary waits and harmful delays should be reduced
- **E**ffective - care should be based on sound scientific knowledge
- **E**fficient - care shouldn't be wasteful
- **E**quitable - it shouldn't vary in quality because of patient characteristics
- **P**atient - care should be responsive to individual preferences, needs, and values (patient-centered)

Based on the IHCRI's healthcare quality definition, more efficient methodology that focuses on reducing the original healthcare process waste to achieve cost efficient and less waiting time, improving effective and efficient healthcare delivery to ensure patient safety, and assuring overall patient value and right is urgently needed for improving the quality of healthcare.

The aim of this paper is to propose a new model called "Healthcare Lean Six Sigma System (HLS^3)" that integrates *Lean Production Systems* and *Six Sigma* methodologies to improve healthcare quality based on the background and concepts mentioned above. This new model bridges the service gaps between healthcare providers and patients while at the same time balancing the requirements of healthcare managers, clinicians and patients by employing the principles of Lean speed and Six Sigma in improving healthcare delivery.

2. LITERATURE REVIEW

2.1. The Lean Methodology

Lean manufacturing processes, simply known as lean methodologies, can be defined as a group of methods that allow an organization to efficiently and effectively design workflow processes by eliminating mudas (or waste). Organizations do this by utilizing a set of tools (A3 reports, value stream maps, 5S…etc.) to identify and eliminate waste, while at the same time improving the quality of health care services and reducing the production time and costs associated with producing a good product or service.

Spear and Bowen [2], two pioneers in the development of Lean methodology, point out that "*the Toyota production system and the scientific method that underpins it was not imposed upon Toyota – it was not even chosen consciously. The system grew naturally out of the workings of the company* …" Therefore, few are able to fully articulate the methodology. However, the researchers concluded rules, not the specific

practices and tools that people observed during their plant visits, formed the essence of Toyota's production system. These rules guided the design, operation, improvement of everyday activities, connections, and pathways for every product and service. The researchers refer to this methodology as the DNA of the Toyota Production System.

Toyota uses this methodology to systematically guide problem-solvers through a rigorous process, document the key outcomes of that process, and promote improvements. This tool is used so pervasively that it forms a keystone in Toyota's world-famous continuous improvement program.

Outside of the auto production, the lean methodology has been successfully adopted to increase qualities in industries such as manufacturing, service and health care. For healthcare applications, Parish [3] reported that Lean methods, the pioneering techniques developed by car manufacturer Toyota to cut waste and increase productivity, are being adopted by the British National Health Service. Lean methodology aimed to remove activities that do not add value. Using Lean methods, Bolton Hospitals NHS Trust has saved almost 8 million Pound, in less than a year. Cole [4] described the collaboration between University Hospitals of Morecambe Bay National Health Service Trust and the Manufacturing Institute to incorporate Lean continuous improvement methods into the health systems in Great Britain. The key learning points from the experience are mentioned. According to the author, continuous improvement through the Lean methodology is more akin to preventive medicine than symptom management. Panning [5] discussed the management of Fairview Health Services' Southdale laboratory, Minnesota. Compared to its peers, Southdale was below par. Turnaround time was long and inconsistent. Southdale's authority consulted other well performing labs in the country and decided in favor of using a Lean methodology. By the end of their first Lean initiative over a 14-week period, they completed 91% of hemoglobin tests in less than 30 minutes (from collection to result). Before Lean, they just completed 40% of tests, and the cost per test dropped by 31%, from $9 to $6.24. Bush [6] also showed that in healthcare there is an opportunity to do more with less – if we can eliminate that waste. The Virginia Mason Medical Center has applied Lean to identify wastes in the Center. By redesigning processes and technology, the Virginia Mason Hyperbaric Oxygen Center reduced its workday by 50%, increased the number of patients per attendant by 100%, and eliminated waiting times for hyperbaric oxygen treatment. Emergency treatments no longer require cancellation of scheduled cases. Margin has increased by 330%.

Although the Lean methodology can be a powerful tool for promoting healthcare quality improvement, it is not a magic wand. Implementing the methodology requires conscious effort, and numerous obstacles must be overcome.

- Need to cooperate with other tools – In the Lean methodology, the A3 problem solving report is usually used as a tool that allows QI team members to identify specific activities that they can change to improve quality and reduce waste [7, 8]. However, it can't help them stand above and observe details of interruptions and delays in process. Other tools, such as Value Stream Mapping, House of Quality, and Six Sigma need to cooperate with it to make the process a reengineering success.
- Too simply the problem solving – The problem solving team is usually simply making the time or cost to do the problem solving, i.e., how many times or how much budget is needed to reduce errors and waste in the process is uncertain. In addition, it did not discover the most important (priority) element in satisfying QI requirements.
- No theoretical basis – Since there is no theoretical basis for constructing A3 reports, different QI team could construct different A3 report for identical problem situations, possibly producing a different implement plan. In addition, the statements for A3 report are arbitrary because they are based on subjective opinions. They are characterized as ambiguous and have multiplicity of meaning.

2.2. The Six Sigma Methodology

In statistical theory, Six Sigma is an ideal target value, and expressed as 6σ. This means that in any process or product we observe under a normal distribution, the probability of a specific attribute value shift from the mean would be a positive or negative six standard deviation shift or 0.002 parts per million (ppm).

Six Sigma uses two key methods [9]: DMAIC process (Define, Measure, Analyze, Improve,

Control) and DMADV process (Define, Measure, Analyze, Design, Verify). Both are inspired by Deming's Plan-Do-Check-Act Cycle. DMAIC is used to improve an existing business process. DMADV is used to create new product or process design

Various forms of Six Sigma have been used widely in many Fortune 500 companies. Motorola, General Electric, Sony, American Express, and Bechtel all use Six Sigma to improve quality and performance. The press has extensively documented the value of the methodology in manufacturing and transactional settings. More recently, published evidence suggests the methodologies have some utility in healthcare environments. For example, Chassin [10] discussed Mount Sinai Medical Centers experience adapting Six Sigma methodology to improve both patient care and Business processes. Hilton et al. [11] examined the relationship between Six-Sigma quality program and the performance of organizations in the health sector, drawing on data obtained from the Royal Victorian Eye Ear Hospital, East Melbourne, Victoria, Australia. Shukla et al. [12] reported the application of six sigma towards improving surgical outcomes. Dydyk et al. [13] described the Nebraska Medical Center's application of Six Sigma and Lean Quality Improvement methods. In this application of Six Sigma and quality improvement methods nursing staff found that the methodologies enhanced their ability to identify changes that could be implemented and sustained to accomplish their desired improvements in quality.

Six Sigma has made a huge impact upon industry as well as on healthcare. Currently, Six Sigma is widely employed as a strategy for achieving and sustaining operational and service excellence. However, there have also been various criticisms of Six Sigma. The main criticisms of Six Sigma are summarized as follows [11-14]:

- System interaction is sometimes not considered. As a result, several Six Sigma projects can go uncoordinated.
- It is based on arbitrary standards. While 3.4 defects per million opportunities might work well for certain products/processes, it might not operate optimally or cost-effectively for others.
- Processes are only improved independently.
- There is a lack of consideration for human factors – quality is the only focus.
- Significant infrastructure and investment is required.
- The process can over detail and complicate some tasks.

2.3. Comparison of Lean and Six Sigma

Lean and Six Sigma are both quality improvement methodologies. However, there are some philosophy contrasting aspects of the two approaches as follows [15-21]:

Lean provides the strategy and creates the environment for improving workflow. It focuses on eliminating non-value added waste in a process with the goal of reducing process cycle times, improving on-time delivery performance and reducing cost. Basically, Lean is a philosophy, not simply an exercise in eliminating waste.

Six Sigma, by contrast, is an effectiveness approach that uses mathematic techniques to understand, measure, and reduce process variation. Six Sigma starts with the question "How can we improve this process?" It does not ask: "Why does it exist at all? Six Sigma helps to quantify problems, facilitates evidence-based decisions (this prevents wasting time on anecdotal evidence), helps to understand and reduce variation, and identifies root causes of variation to find sustainable solutions. Furthermore, it quantifies the financial benefits and savings. This helps to focus organizational efforts in the areas that offer the most potential for quality improvement.

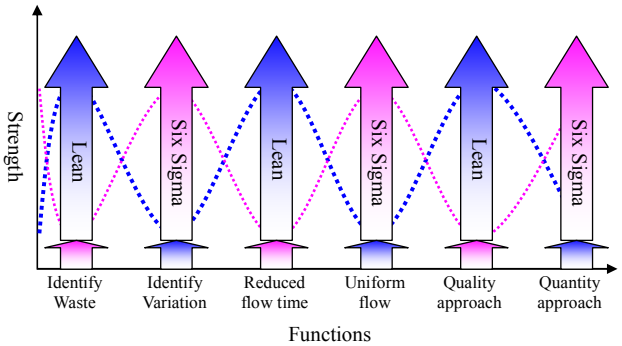

Figure 1: The strength comparison of Lean and Six Sigma

While Lean serves to eliminate waste, Six Sigma reduces process variability in striving for perfection. In other words, Lean is a quality oriented methodology while Six Sigma is a quantity oriented approach. A combination of both can provide the effective tools to solve

problems and create rapid transformational improvement at lower cost, high productivity, high quality, and can also provide a safer environment for patients and staff (see Figure 1).

3. THE HEALTH CARE LEAN SIX SIGMA SYSTEM (HLS^3)

The weaknesses in Lean or Six Sigma methodology have lead researchers to suggest that these two methodologies need to be integrated [14-21]. These models focus on either the healthcare provider's or the patient's requirements. This paper proposes that Six Sigma and Lean Production Systems for healthcare quality improvement (QI) called Healthcare Lean Six Sigma System (HLS^3) be integrated. HLS^3 differs from other previously published integration models in that it bridges the service gaps between healthcare providers and patients while at the same time balancing out the requirements of healthcare managers. HLS^3 delivers by capitalizing on the benefits of Lean speed as well as Six Sigma's principle of high quality.

Table 1: Key activities and tools of implementing the HLS^3

Stage	Activities	Tools
1. Identify	*Identify the QI goal by hearing the VOC:* • Select the QI team members • Define the QI performance indicators • Accomplish the project charter and job assignments	• Healthcare environment survey • Project charter • Annual police deployment • Structured/semi-structured interview • Questionnaire
2. Analyse	*Study and analyze the current status of targeted process* • Analyze the actual process and measure the baseline • Analyze the collected data to understand the present situation • Confirm the problem and critical-to-quality	• 5S • A3 report • Root Cause Analysis, RCA • Value Stream Maps, VSM • Motion and time study • Process capability analysis • Time Based Competition, TBC
3. Action	*Transform the VOC into countermeasures and implement them* • Draw up the improvement countermeasures • Implement the countermeasures to accelerate the service delivery • Confirm the results by performance indicators	• Analytic Hierarchy Process, AHP • Quality Function Deployment, QFD/ House of Quality, HOQ • Business Process Reengineering, BPR • Enterprise Resource Planning, ERP
4. Follow-up	*Develop follow-up plan and deploy the knowledge throughout the organization* • Continuous control the improvement level • Design the job value of employees in the healthcare delivery process • Knowledge diffusion and application	• Control chart • Check list • Error proofing • Education and training • Knowledge Management, KM

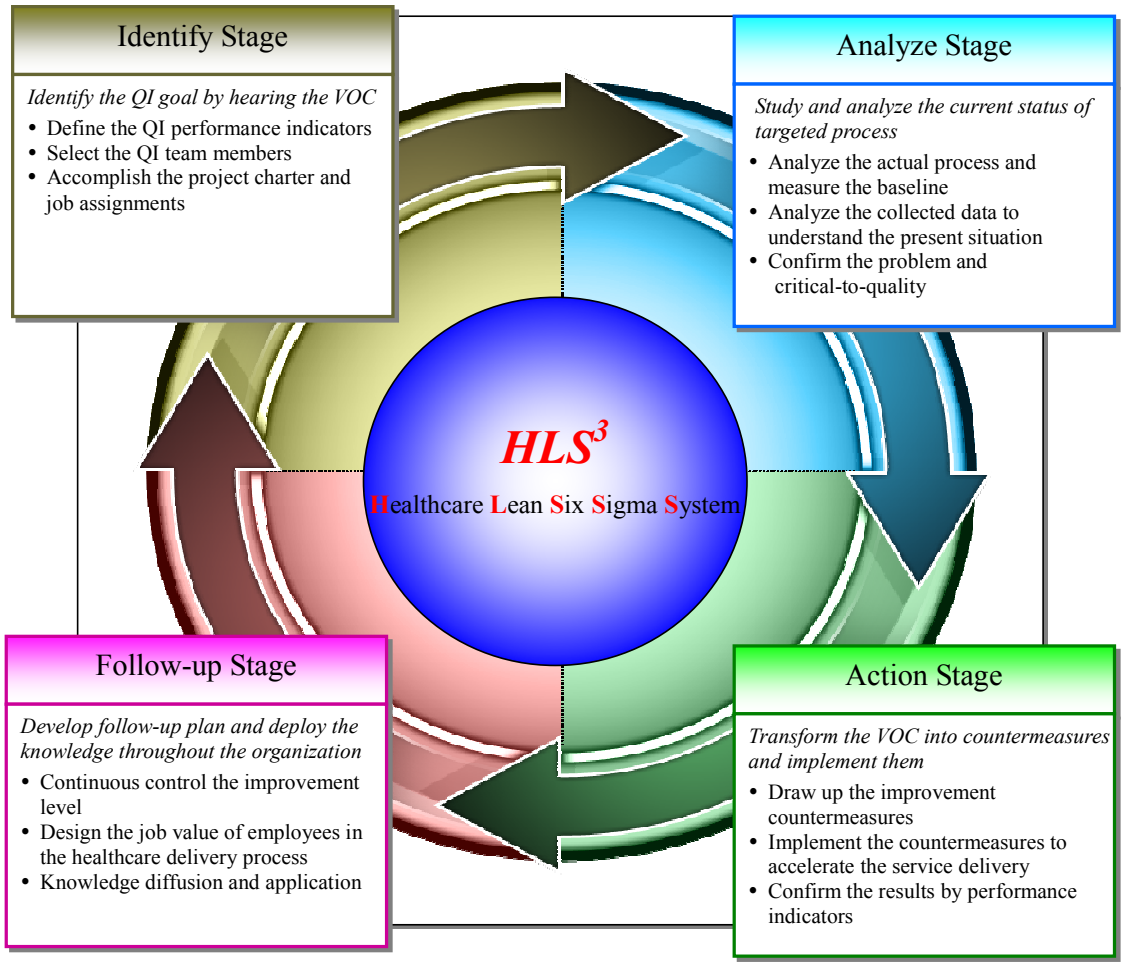

Figure 2: The HLS^3 health quality improvement model

In this model, the first stage of healthcare quality improvement is to identify the QI goal by hearing the Voice of Customer (VOC)-Patient. The QI identification and its scope must be clarified so as to serve the patients more efficiently and effectively by the improvement. In addition, the QI team has to well define healthcare quality indicators, and to explain the purpose as well as the use of each indicator. Most important of all, the performance indicators' definition and their evaluation methods must be agreed and confirmed by the people involved. So, this stage provides the QI team a well-defined scope of the problem they are faced.

The second stage of the integrated model is to analyze the current status of the targeted process. This involves collecting data to obtain the Voice of Customer (VOC) and Voice of Provider (VOP). The QI team can then identify the problem and begin to find out its root causes [22, 23].

After identifying and analyzing the current status of the targeted process, the third stage is to draw up problem solving countermeasures. First, the QI team generates information by identifying all the measurable characteristics of the healthcare delivery/service which they perceive are related to meeting the patient requirements. The VOP must be transformed to the countermeasures. Then, the QI team implements the countermeasures and confirms the results by using performance indicators.

The follow-up plan indicates when to measure and how to measure the improvements or results. Reasonable targets are established beforehand and the results of the new processes are measured against the specified targets or performance indicators to assess the magnitude of the improvement. Once the measurement is done, the QI team can view the resulting knowledge and experiences as the base of knowledge management (KM) and technology accumulation. Finally, the gained knowledge and experience must be diffused and deployed throughout the organization [15]. The LHS^3 operating model proposed by this paper is shown in Figure 2. The key activities and tools of implementing the LHS^3 are provided in Table 1

4. CONCLUSION

Healthcare, as with any other service operation, requires continuous and systematic innovation efforts in order to provide cost effective, timely and high quality services. This paper proposes a healthcare quality improvement model called "Healthcare Lean Six Sigma System (HLS^3)" that integrates Lean Production System and Six Sigma methodologies to improve healthcare quality. This new model bridges the service gaps between healthcare providers and patients and balances the requirements of healthcare managers, delivers and patients by taking the benefits of the Lean speed as well as Six Sigma high quality principles.

In a future paper we will provide an example of how the HLS^3 model is used in a real-world case study, and we are also in the process of publishing a paper comparing the Critical Success Factors (CSF) of implementing Lean Six Sigma to the practical everyday realities present in healthcare settings with the proposed model to verify the theoretical logic and feasibility of HLS^3. In summary this paper identifies and suggests that:

- Lean focuses on improving flow in value stream mapping and eliminating waste while Six Sigma focuses primarily on reducing variation. The main strength of our proposed new model is a combination of Lean and Six Sigma. Thus, it provides an over-arching improvement in philosophy and incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost.
- This new model bridges the service gaps between healthcare providers (value oriented) and patients (quality oriented) and balances the requirements of healthcare managers, delivers quality and for patients takes advantage of the benefits of Lean speed/value-maximum philosophy as well as Six Sigma's high quality/low variation principle.

The full benefits of the new model will be realized when applied at both strategic and operational levels, with universal application only at the strategic level. Application at the operational level results only in cost reductions, whereas application at the strategic level results in wider benefits for the organization [14].

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