



LEAN SIX SIGMA IN HEALTHCARE: SOME SOBERING THOUGHTS ON IMPLEMENTATION

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Received 16.05.2022.
Accepted 04.09.2022.
UDC – 332.155

Keywords:

Lean Management; Lean Six Sigma; Healthcare; Operational Efficiency; Profitability.

ABSTRACT

Lean Management and Six Sigma (LSS) concepts originated in manufacturing but later it was adopted by service industries including healthcare. This work explores several issues arising while implementing LSS in a healthcare organization by taking questionnaire-based feedbacks from all stakeholders' viz. distributors of pharmaceutical products, healthcare personnel and patients. LSS, though at present at a premature stage, has high potential for superior value creation and operational efficiency. The study reveals and emphasizes that LSS projects can yield significant benefits such as waste reduction, improvement in operational matters, minimizing errors in technical processes and identifying design of new processes.)

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1. INTRODUCTION

Extraordinary business environment often throws up unusual opportunities for organizations, opening new areas for exploration or revisiting so-far-unattended-to or deferred issues. Unsurprisingly, unexpected challenges usually accompany such occasions. For every organization, profit maximization, cost minimization, reduction of waste has always remained as challenges. Considerable help is on offer in Lean Manufacturing System to sustain oneself in competitive business environment (Sundara et al, 2014). It does not matter what type of organization it is: it may belong to production, operation, technology, and supply chain, legal, medical healthcare or whatever. This article reviews challenges, opportunities and the current situation for healthcare organizations while incorporating Lean Management (LM) principles in tandem with Six Sigma (SS) practices. There is a big expectation that Lean

environment would provide better service delivery, more satisfied patients, better patient flow through the system, and would keep medical staff more synchronized (Erceg et al 2020). LM coupled with SS i.e. Lean Six Sigma (LSS) may be a bouquet of promising and a powerful concept that is bound to improve organizations in the long run when implemented in true spirit.

That an extraordinary situation prevails now is obvious when the whole world is besieged by Corona virus. And as a result, healthcare industry has come under severe strain and many countries are forced to reassess, re-imagine, and rejig their Medicare system, formulating new strategies and policies to cope with disasters of this kind, now or later, and thereby future proof the society from any impending health threat. At this juncture, it is prudent to stop and take a hard look at quality issues to make the health delivery system affordable and accessible to everyone. A new architecture for delivering

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universal medical services has been envisioned with quality playing an integral part. The time to conceive radical solutions and operationalize hard decisions is now. In this context LM and Six Sigma practices hold a great promise, and it should seize the attention of health care providers and national governments. The present study therefore attempts to study the issues arising when a healthcare organization embarks upon implementing LSS. With right blend of Information Technology, LSS can be a great advantage for humanity, nay a blessing or boon, to counter current pandemic and prepare for future. This study critically analyzes LSS for providing comprehensive healthcare services by examining the whole service chain and embracing all the stakeholders.

2. LITERATURE SURVEY

Lean manufacturing is particularly important in every area of innovation, especially so in manufacturing sectors (Chahala and Narwalb, 2017). Continuous flow in Lean systems allows moving products through every step in the process instead of grouping in batches, which permits continuously streaming products to market. The purpose is to effectively utilize factors of production such as labour, time, space, inventory, and even movements of men, machine, and materials. Lean methodology basically tries to reduce waste in the processes, which finally results in improved processes, leading to value addition for customers (Muthukumaran et al. 2019). The lean principles deal with defining value from customers' perspectives and map value stream accordingly. Then, they allow one to create flow, establish pull and pursue perfection for eventually obtaining value addition by reducing production waste and optimizing use of resources.

The value can be determined from customers' perspective i.e., their willingness to pay for their actual/latent need that can be evaluated by customer's feedback through qualitative or quantitative techniques. Accordingly, activities are to be identified that purely add value namely, those that reduce or eliminate needless processes, and those that reduce cost of production and operation. Use of value stream mapping can visually highlight the benefits of a lean system by exposing the wastes in the value stream, and identifying opportunities for improvement (Djassemi, 2014). Accordingly, breaking down of production or service delivery steps shall be chalked out. Therefore, inventories pull-system should be established based on just-in-time standard. Over inventory/production/capacity is considered as one of the biggest wastes in lean management.

Lean thinking eventually looks for perfection and continuous improvement as part of the organizational culture, in which each employee endeavour to provide products and services based on customers' requirements. Lean thinking can be applied to enable a company to survive in today's competitive world and to maintain competitive edge (Karikalan et al 2019). Tracing their

history, the following paragraphs discuss Lean Management and Six Sigma in general, and a synthesis of these two paradigms as applied to healthcare industry. People think that healthcare is needed after at old age, which is not true, on the contrarily it starts from foetus stage.

2.1 Lean Management in healthcare

The evolution of Lean production systems is associated with Toyota Motor Company (TMC) dating back to 1918, whereas the term "Lean" or Lean Management (LM) or Lean Philosophy was adopted in 1990 with exploration of Toyota model. The linking of LM from manufacturing to healthcare was initially articulated by Joseph Juran who brought manufacturing and healthcare industry together. By 1950, Japanese auto industry production was one tenth of the USA car production; therefore, Toyota Motor Company (TMC) employee, Taiichi Ohno, who joined the company in 1943, came up with an observation that western production systems had two major faults: i.e., large batches resulted in large inventories and large production is preferred over customer preferences. Taiichi Ohno, also recognized seven wastes, namely (1) Wait Time (2) Overproduction (3) Over-Processing (4) Unnecessary Transportation (5) Excessive Movements or Motion (6) Inventory (7) Poor Quality and Defects. A conceptual framework of LSS was developed contemplating the integration of LP and Six Sigma, and providing a systemic and holistic approach (Nascimento, et al, 2019).

As the safety of patient and overall efficiency are more significant in healthcare rather than cost optimization, there was some delay in the implementation of LM in healthcare. According to Laursen et al (2003), the beginning of lean healthcare has been traced back to 2002, and their research shows that LM evolution has traversed through various stages of its life cycle, i.e. from auto industry to operation management to service management to hospital management. There are five basic principle an organization shall follow to implement lean and those are value, value stream, the flow, pull and observing Kaizen. Figure-1 shows the 80-year journey of LM:

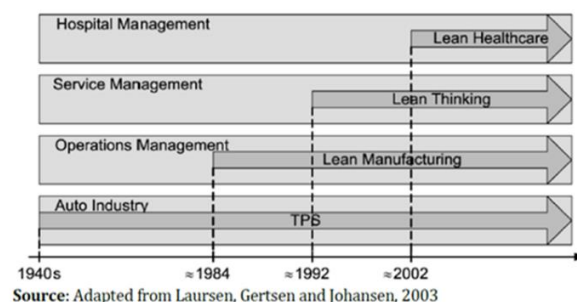


Figure 1. Evolution of Lean Management

LM calls for value creation through removal of waste, which is common in all industries whether healthcare or not, by addressing issues such as:

- a) **Overproduction** – in healthcare it can be equated with deployment of resources either men or machine more than the requirement.
- b) **Inventory**—large supply of medical inventory such as medical equipment for various departments e.g., cardiology, dental, gynecology, urology etc. Therefore, smaller, and more frequent shipments can minimize the cost,
- c) **Motion**— poorly designed working areas that entails more walking-around,
- d) **Transportation**—unnecessary movement of patients for treatment around hospital labs,
- e) **Over-processing**—duplication of tests, over-processing or extended hospital stays beyond medical necessity,
- f) **Defects**- wrong labeling of tests, partial patients' information on charts or even blood getting clotted before blood test,
- g) **Waiting**- unnecessary waiting line for testing samples,
- h) **Under-utilization**- lower utilization of employee's capacity and skills, their working hours, and lack of sharing of knowledge and creativity.

The primary logical tool for Lean is value-stream mapping, which endows with a holistic representation of the complete value chain in an organization. Its strength lies in keeping customer focus by setting standard solutions for common problems by sub-optimizing entire value chain. Lean Thinking and Six Sigma can be combined to provide an effective framework for producing systematic innovation efforts in healthcare (Koning et. al, 2006). The following sections discuss the application of Six Sigma in healthcare sectors.

2.2 Six Sigma in healthcare

The concept of Six Sigma came into being when Motorola started facing excessive pressures from foreign competition, from Japan through Quality Improvements drive in 1987. Bill Smith of Motorola advanced the concept of Six Sigma to catch up with competitors. Smith worked with Harry to come up with a four-stage problem-solving approach: measure, analyse, improve, control (MAIC); later, the word Design was added, and it became known as (DMAIC). This led Motorola to win the Malcolm Baldrige Award, and then Six Sigma philosophy became widely known. It supplements LM principles, which apply equally to issues like over-production, inventory, motion, transportation, over-processing, defects, waiting line, correct utilization of men, machines, and materials. According to Antony et al (2017), the integration of Lean and Six Sigma is important as Lean focuses on improving the flow of information and materials, whereas Six Sigma works to

improve value-adding. Six-Sigma performance-based statistics that equates to 3.4 defects per million opportunities.

Something like Six Sigma approach was practiced even during Hippocrates during the early periods dating back to 460 – 370 BC. It is a potent quality enhancement tool that could be used in healthcare industry to meet and exceed patients' expectation, to gain improved patients' satisfaction, productivity, profitability, and cash flow. It can be used in several situations such as triage operation where treatments of many patients or casualties are paramount. It can decrease time for patients stay in hospital, emergency room stay, scheduling time of discharge and other similar activities. Six Sigma adoptions in healthcare have many opportunities for development (Antony et al 2018). For example, it can be applied to treatment of patients and their support, nursing, hospitality, laboratory, radiology and even to supporting managerial services. However, Six Sigma approach is recent in healthcare sector. Six Sigma emphasizes not only useful practices of exploitation orientation, such as customer input, design for manufacturability or improvement and control of processes, but also to practices explorative in nature, such as discovery, novelty or innovation (Muñoz and Gutierrez, 2017).

There is no single, simple “royal road” to accomplish Six Sigma. The path is dotted with potential potholes and pitfalls. It is something like a multi-headed Hydra. A whole lot of issues are involved such as, leadership, client-driven approach, education and training, collaboration with partner and system linking. All these will support in developing organizational culture, performance management, business strategy, and company bottom line. The effective integration of LM and Six Sigma, along with a right mix of Information Technologies (IT) opens the door for a new wave of system integration, simulation, Internet of Thing (IoT), biotechnology and big data. The adoption of IoT with Industry 4.0 would mutually reinforce in collecting data in near real-time for integrated and enhanced value chain. Lean Six Sigma approach in global supply chain using Industry 4.0 and Industrial Internet of Things (IIoT) creates an ideal process flow that is highly optimized as well as perfect, and free from defects and wastage (Jayaram, 2016). It will enhance many processes and allow different processes to feed the results in real-time with the help of Big Data Analytics. IIoT will further pave the way for adoption of rapid DMAIC implementation.

2.3 Synthesis of Lean Management and Six Sigma Healthcare

Lean Thinking and Six Sigma can be combined to provide an effective framework for producing systematic innovation efforts in healthcare (Koning, et al 2006). The purpose of Lean is to establish a system with the aim of

eliminating all types of wastes by detecting any abnormality and stopping or discontinuing the processes where it was detected, instantaneous fixing of the irregularity, and further scrutinizing the root cause analysis. Successful lean implementation will generate better financial outcomes and lower cost (Burawat, 2019). LM could be applied in healthcare to minimize waste in every process, procedure, and task by involving all members continually endeavouring to recognize areas of waste and eliminate anything that does not add value for patients.

LSS has spread widely over the years and has found applications in many domains: manufacturing to service sectors, medical healthcare to communication industry, construction industry to assembly industry, and logistics industry to defence, as noted by Sreedharan and Raju (2016). And these authors suggested that health industry shall undertake change and advised to consider the experience of other industries to understand what has worked and what has not. However, as in any other industry, it would depend upon managerial processes that are followed in accordance with the logic and principles of LM. So, should it be for healthcare as well, though these principles were originally developed for production systems. Similarly, Six Sigma was primarily meant to eliminate defect in production and operation management. According to Schön et al (2010), employees participating in Six Sigma feel positive changes in many aspects of job satisfaction.

LSS not only reduces process defects and waste, but also offers a structural change in overall organizational culture. Albliwi et al. (2015) found the top ten benefits of LSS as: (1) increased profits and financial savings; (2) increased customer satisfaction; (3) reduced cost; (4) reduced cycle time; (5) improved key performance metrics; (6) reduced defects; (7) reduction in machine breakdown time; (8) reduced inventory; (9) improved quality; and (10) increased production capacity.

3. RESEARCH METHODOLOGIES

Research methodologies are developed based on literature survey. It was observed through critical analysis of earlier research and case studies on LSS in healthcare industry was limited. A few researchers (Albliwi, et al 2014; Daultani, et al 2015; Antony et al, 2018) have explored the most common factors that led to LSS failure in different industries, and after systematically analysing research published in academic journals or through case studies presented by Barnabè et al (2016) and Erceg et al (2020). None of them has found successful implementation of LSS in healthcare sector.

Moreover, the literature survey reveals that majority of researchers' use either quantitative or qualitative methods, or a mix of, each representing 76, 14 and 10 percent respectively (Cameron and Azorin, 2011). Only a limited empirical work exists on LSS in healthcare

industry, and a couple of case studies were accomplished by a few researchers. Therefore, it was decided that the present research employs qualitative methodology, in particular questionnaire-based approach, and observations by enlarging its scope and removing the limitations of earlier works to investigate the following aspects:

- 1) How LM, Six Sigma and LSS have evolved in healthcare services with time?
- 2) What are its applications, challenges, benefits, and critical success factors?
- 3) How Information Technology can be leveraged to play a significant role, including Industry 4.0?

Hence the present study is undertaken to evaluate the combined chains of healthcare services, by including upstream and downstream paths i.e. distributors of pharmaceutical and healthcare products, to personnel of clinics/hospitals to indoor and outdoor patients. In earlier research either clinical staff feedback was taken or in some case patients' input was considered. On the contrary, this research includes distributors and suppliers of pharmaceutical and healthcare products. Consequently, direct feedbacks were obtained from the whole gamut of stakeholders namely, medicine suppliers, healthcare employees and patients to extract and explore the opinions, thoughts, and feelings of the respondents on how LSS attributes notably affect healthcare sectors. The Table 1 shows that the main tasks carried out by staff and approximately average duration taken for each activity:

Table 1. Task accomplished by clinic staff.

SN	Description	Average duration in minutes	Performed by
1	Temperature recording	1.50	Nurse
2	Blood pressure	3.25	Doctor/ Nurse
3	Blood Collection	8.50	Nurse
4	Patient feedback and discussions	8.25	Doctor
5	X-ray	11.25	X-ray technician
6	Care	7.25	Nurse

It is a misguided belief that the sample size of quality research is not important, which is eventually a matter of judgment, based on required quality of information, individual experience and so on. On the contrary, researchers projected sample sizes depending upon type of research and its objectives and proposed that sample size should be sufficient in attaining saturation; however, beyond saturation point adding more participants would not affect the result. There are a variety of qualitative research methods such as Ethnography, Grounded theory and Phenomenological. LSS in healthcare is considered to belong to Phenomenology type of studies, which taps into the conscious experience, i.e. understanding from first person point of view. Researchers like Creswell (1998) recommended a sample size of 5 to 25 for Phenomenology studies, whereas Morse (1994) suggested

that at least six samples are essential for such studies. Samples collected from different segments are mentioned in Appendix 1.

Therefore, based on recommendations available in the literature, a sample of 30 respondents were considered, constituting an integrated chain of healthcare services i.e., distributor of pharmaceutical and healthcare products (pharmacist, medical representatives, storekeepers, sales engineers, and support staff), to healthcare workers (doctors, paramedics, supporting staff) to the patients (indoor and outdoor patients). According to Guetterman (2015), when considering sampling, researchers need to move beyond "how many?" to address the questions of "how?" and "why?". Accordingly, structured, and unstructured questions were formulated and directed at each segment. Patient feedback was taken after seeking their due permission, which was done randomly and instantly without any prior appointment.

3.1 Research Questions

The purpose and aim of this research is to bring to the fore the challenges and hurdles faced during implementation of LSS, and to delineate critical success factors that will bring about improvement in operational efficiency. According to Ansari et al (2016-1), service organizations shall put special emphasize on Service Quality (SQ) for achieving Critical Success Factors (CSFs), which would improve overall customer satisfaction, loyalty, improved revenue, and profitability. In line with the goals of this work, the following research questions (RQs) are posed, and the qualitative analysis is taken up to investigate them with a view to proposing a plan of action and remedial measures for accomplishing LSS practices in a healthcare establishment:

- RQ-1: How Lean Management attributes (Abolition of waste, Reduced cycle time, Value addition) could lead to LSS (Improved performance, customer experience, and bottom-line)?
- RQ-2: How Six-Sigma tools (Quality Improvement, Process Improvement and Overcoming defects) could lead to LSS (Improved performance, Customer experience, Perfection and Bottom-line)?
- RQ-3: How LSS (Improved performance, Customer experience, Perfection and Bottom-line)) could lead to Operational Efficiency (Responsiveness, Reliability, Productivity, Efficiency, Profitability)?
- RQ-4: How Operational Efficiency in turn reinforces implementation of LSS?

3.2 System Model and Hypothesis

A research model Figure 2 was developed based on the objectives and RQs; accordingly, a minimalist system model was worked out. This minimalist model schematically captures the underlying flow and interaction between the core entities responsible in implementation of LSS and investigates how the adoption of LM and Six-Sigma in private healthcare organizations facilitates achieving performance improvement, better customer experience, perfection, and bottom line. The model rightly takes into consideration the importance of IT. It should be noted that there exists a positive-feedback two-node loop, a kind of virtuous cycle, between Efficiency and LSS. The mediating role of LSS, the point of confluence of Lean with SS, primes the system to bring about overall operational efficiency, manifest in the improvement in Responsiveness, Reliability, Productivity, Efficiency and Profitability of healthcare system.

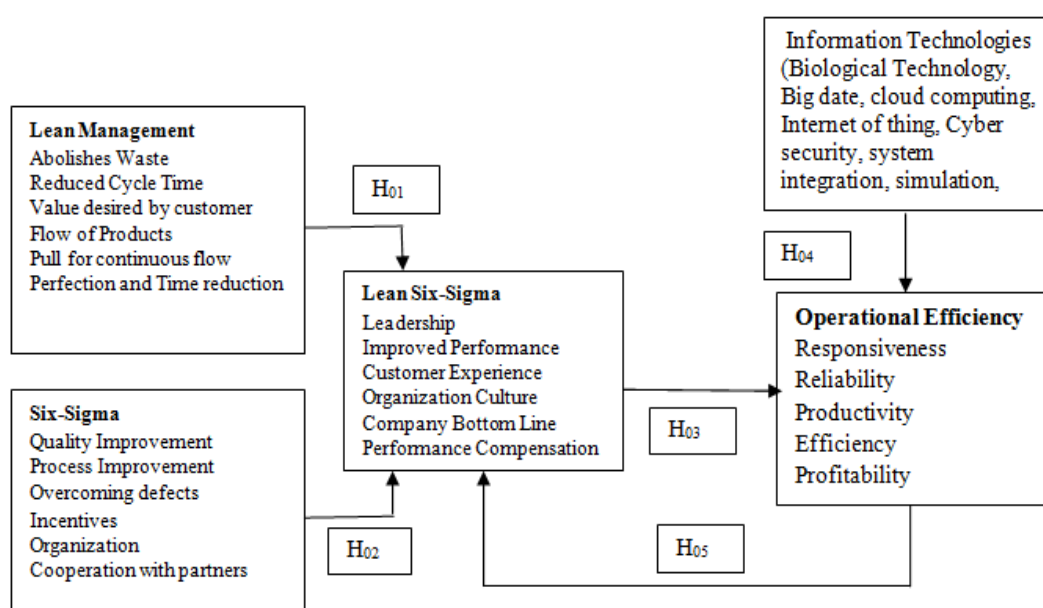


Figure 2. Research Model

Keeping in mind the prevailing experience existing in current literature (Daultani, et al, 2015; Barnabè, et al, 2016; Koning, et al, 2006; Erceg, et al 2020; and Antony, et al, 2018) and based on the RQ's mentioned above, these hypotheses were put forth for closer study and critical examination:

H₀₁ – Lean Management would smoothen the progress of LSS implementation.

H₀₂ – Six-Sigma tools would lead the way for LSS implementation.

H₀₃ – LSS would support operational efficiency of the organization.

H₀₄ – Information Technologies will improve operational efficiency.

H₀₅ – Improved operational efficiency will further consolidate and reinforce LSS traits.

The following sections verify the research model by validating these hypotheses, and present the findings, conclusions, and recommendations for future research.

4. ANALYSIS AND FINDINGS

The research model, as shown in Figure-2, melds two complementary philosophies of Lean Management and Six-Sigma, leading to LSS, to bring about significant improvement in the operational efficiency in healthcare systems. It is interesting to note that the model is “generic”, though the discussion below will be couched in the lexicon of healthcare industry. It is expected that healthcare institutions would greatly benefit from the combined use of Lean and Six Sigma, bundling the best of both worlds, so to speak (Barnabè, et al 2016).

Successful implementation of LSS is highly likely to improve processes, methodologies, and to lead to improved service quality. The paragraphs below explain how these hypotheses are validated through qualitative research methods of conducting one-on-one interviews, eliciting opinions through questionnaires, and holding brain-storming discussion with the stakeholders.

4.1 H₀₁ - Lean Management would smoothen the progress of LSS

Lean Management, though connoted “lean and mean”, comes packed full of powerful ideas. In healthcare it means minimization of waste in every treatment and nursing procedure. The removal of waste in any procedure should be recognized, appreciated, and acknowledged by every member. It shall be profoundly rooted in organization culture and shall be incorporated in supply chain. According to Bhamu and Sangwan (2010), one of the critical factors of implementation of LM is simultaneous adoption of leanness in supply chain. Implementing LM in healthcare organization can build employee focused approach that will improve employees' and patients' satisfaction and loyalty. The service organization should pursue employee loyalty in earnest, as loyal employees are likely to develop better relationship with customers (Ansari et al 2018). The right

blend of Lean and Six Sigma can generate synergy, which would improve employee performance, productivity, and profitability. Rathilall and Singh (2018) observed that there is an exceptionally low success rate of Lean and Six Sigma adoption as standalone systems, as they found it difficult to maintain the transition from theory to practice. Hence the need for a careful and judicious merger of LM and Six Sigma is important.

The aim of Six Sigma in healthcare is to minimize clinical errors, eliminate defects, and improve service delivery for eventually improving patients' satisfaction, whereas Lean Management strives for minimizing and eliminating all types of waste. Lean and Six Sigma began to grow significantly since the start of the new millennium; however, there are dilemmas and contemplation in merging or integration of Lean and Six Sigma (Muraliraj et al 2018). Lean is simple to understand by healthcare employees and patients, since it does not require understanding of advanced statistical technique, expensive statistical computing platform and training that are required for Six Sigma; therefore, it can be implemented in small incremental basis as part of constant journey in the direction of achieving value for the money. But this makes unconditional commitment of top management an absolute must for its success. According to Laureani et al (2013), Lean Six Sigma techniques yielded practical benefit to the hospital, and support from top management and regular communication with stakeholders were identified as key factors for its success. **Therefore, it is envisaged that Lean Management will support the progress of LSS.**

4.2 H₀₂ – Six-Sigma tools would show the way for LSS.

Lean embraces complete system approach with tiny details, whereas Six Sigma can assist with some standard solutions and present a universal analytic framework solution. Therefore, the best way of reconciling the two approaches is through a combination of them. The implementation of LSS is still in the early stages in many organizations (Albliwi, et al 2017). The deployment of a healthcare system based on Six Sigma has lately been widely discussed in the literature, and in a few cases, it has been implemented. The Lean Six Sigma techniques have yielded practical benefits to the hospital (Laureani, et al 2013). A highly efficient healthcare setup distinguishes itself by its constant insistence on continuous improvement in service quality to gain operational efficiency. A culture of continuous improvement is sine qua non for increasing production flexibility while reducing lead times (Lopes et al 2015).

Lean Management and Six Sigma, being orthogonal in philosophy and complementary in methodology, conveniently lend themselves to integration. The merger can be affected in multiple “shades” to suit the situation. They immensely help understand and assess clinical flow, treatment to patients and patients monitoring, tracking

medical inventory etc. All these invariably contribute to improving service quality, patient satisfaction and loyalty, and the positive word of mouth they carry around turns them into brand ambassadors. Service quality and employee satisfaction provide the major impetus for boosting customers loyalty, satisfaction, and their repurchase behavior and these attributes should be continually monitored assiduously for profitability (Ansari 2020). During the last two decades Lean Management and Six Sigma have moved far beyond the production line to the service industry and healthcare services have become part and parcel of it. The integration of lean and Six Sigma is important as lean focuses on improving the flow of information and materials between the steps in the processes and Six Sigma works to improve the value-adding transformations (Antony et al 2017). Though a few health service providers have implemented LSS in a willy-nilly fashion, by and large the healthcare industry has not taken to heart the importance and impact LSS promises. The respondents have uniformly voiced the opinion that the industry takes LSS seriously so that affordable health facilities can reach one and all. However, a perusal of the literature shows unfortunately that healthcare providers have not taken up LSS seriously

4.3 H₀₃ – LSS would support company operational efficiency.

Senior managers' commitment is essential before they embark upon the LM (Albliwi et al 2015). Lean Management is one of the most modern philosophies of minimizing waste that focuses on continuously improving performance of service companies. The nature and type of services may show wide variation in different service industry based on the service characteristics associated with respective service industry; however, due to universal service characteristics, all service industry can have common goal of customer satisfaction. Similarly, understanding how various healthcare services differ from each other, particularly SQ and patient satisfaction, is paramount in healthcare services than others. The healthcare service quality aspects (i.e., physical environment, customer-friendly ambience, responsiveness, communication, privacy, and safety) are positively related to patient loyalty, which is mediated through patient satisfaction (Fatima et al 2018).

Service perspectives, service factors and variables can be explicitly based on patient's needs. In healthcare industry every patient is unique, and service is to be tailored on a case-by-case basis. Generally, tailored service treatments require highly skilled staff and high capital investment, whereas standardized services or mass services incur low capital investment. Healthcare services pose unique challenges to lean implementation due to their inherent characteristics of service delivery (Daultani et al 2015). In healthcare, services can be categorized as mass service such as pharmacy, pathological test following standard procedure; conversely, radiology work, surgery or emergency care can be best seen as professional services,

where special attention by highly skilled experts and high capital-intensive equipment are necessary.

Therefore, in addition to capital investment, the healthcare providers should seriously consider skill development of staff for optimally utilizing resources for improved operational efficiency. According to Ansari et al (2016-1), service organizations shall put special emphasize on SQ for achieving critical success, which would improve overall customer satisfaction, customer loyalty, positive impact, sales from repurchase and firms' profitability. **Therefore, it is predicated that LSS can support operational efficiency.**

4.4 H₀₄ – LSS supported with Information Technology will improve operational efficiency.

The investment in IT has paid back reasonably in all industries, including healthcare, by way of increasing efficiency, productivity and bringing down cost. It facilitates people to expand their mental and intellectual horizon by doing more work in shorter time. The tools and techniques that IT enable an organization and its personnel to "whip up" their innovation spirit and "stir up" creativity. The unprecedented, earth-shaking developments in IT industry have immense potential to transform any staid, run-of-the-mill organization to a smart and bright one. Many companies have committed to adopting or supporting Industry 4.0 manifesto that promises a "brave new world" wherein smart technologies allow clients, suppliers and employees to become real-time contributors by reducing the need for continuous controls (Arcidiacono and Pieroni, 2018). The system can retrieve, collect, analyze and mine massive data through a mélange of technologies like IoT, wireless sensors, cloud, big data, Artificial Intelligence etc. for value creation. It can help in predicting, preventing, and resolving unexpected challenges ahead of time.

Industry 4.0 can support biotechnology for synthetic biology, genetic engineering techniques for making organisms by using DNA data, gene editing and so on. According to Arcidiacono et al (2017), the demand for patient-oriented and efficient health services leads to use of these technologies to improve hospital processes. The integration of LSS with IT in line with Industry 4.0 vision would bring about process improvement, reduction in waste and promoting standardization. It can bring enormous achievement in all type of industries including healthcare. LSS linked with Industry 4.0 could revitalize the existing somewhat cluttered or fragmented healthcare system by minimizing cost, improving productivity and profitability. In this virtual world, clinic and hospitals can learn to work together in a technology dominated world as envisaged in Industry 4.0 for overall improvement, promising the world with "Health for All" mantra. To make that a reality, a health care delivery system should be backed by relevant IT infrastructure in addition to being "nursed" by LSS. **Therefore, it is hypothesized**

that LSS supported with Information Technology will improve operational efficiency.

4.5 H₀₅ – Improved operational efficiency will further consolidate LSS traits.

Challenges in implementing Lean Management in healthcare revolve around issues like service value addition, patient satisfaction with respect to price paid. Evidence show that healthcare industry is falling behind in effectiveness, due to not being patient-focused and lacking in prompt service delivery. Such a dysfunctional system should be revamped or modernized so that patients are considered as most important purchaser of service; accordingly, it should be designed for service outcomes by using evidence-based tools such as avoiding customization and seeking ways to use nursing documentation for research that assist quality enhancement. Unsuccessful quality efforts in healthcare can be attributed to the strongly departmentalized, bureaucratic and hierarchical structure, professional autonomy, tensions between managers and professionals, and the difficulties involved in evaluating healthcare processes and outcomes (Mosadeghrad 2013).

The Lean Management should commence at macro and micro-levels with whole-hearted senior management support. Top management commitment is one of the most important requirements of any Lean implementation (Kumar et al, 2013). It is bound to have positive influence on employees for improved service value. The service value can be increased through healthcare employees' dedication, and commitment towards implementation of LSS. According to Ansari et al (2016-2), employees are valuable assets in a service industry, and growth of industry depends on employees' commitment. A comprehensive, holistic, and integrated approach for revitalization of entire system is what is needed rather than looking at a few pieces like improving a couple of small processes here and there, or improving a particular unit or department selected in an arbitrary manner. Such a haphazard approach is the very antithesis of scientific management, as espoused by Frederick Taylor!

The improved operational efficiency is expected to further consolidate LSS implementation efforts and contribute more thoroughly by reinforcing the features and traits of LSS. And by appropriately applying their tools and techniques one can bring together processes, methodology, people's mindset, and culture to the benefit of all. These elements shall strengthen LSS approach to bring about business improvement for ultimate improved operational efficiency. Lean tools and techniques adopted by management will have positive performance (Pereira et al 2019). Accordingly, managers at all levels shall reorganize each department workforce and motivate them, who will be the "foot soldiers" of the LSS implementation team. According to Burawat P (2019), successful lean managers need insight into and comprehension about lean concepts and associated issues,

and then venture into implementation by persuading their employees to get aboard with higher willingness and cooperation. **Accordingly, it is hypothesized that improved operational efficiency will further consolidate and reinforce LSS traits.**

5. DISCUSSION AND CONCLUSION

The research discusses Lean Six Sigma by evaluating an integrated chain of services in healthcare delivery encompassing all the stakeholders i.e. from distributor of pharmaceutical and healthcare products, to clinic setup, to indoor and outdoor patients. The study reveals that LSS projects can yield significant benefits such as reduction in waste, reduction in prescription lead time, lower cost for patients and proper upkeep of medical records, and myriad other similar benefits. As well as the immediate benefits on improved operational matters, a conscientious consideration on improving technical processes, improving skills and designing new processes will make for an influential blend and healthy mix, and more so when coupled with strong leadership support seen as an agent of change. There are some common factors for failure, chief among them being lack of top management commitment and involvement, in addition to lack of communication, lack of training and education, limited resources and others (Albliwi, et al 2014).

The implementation of LSS in healthcare is comparatively at a premature stage in contrast with manufacturing. The main barriers to implement lean manufacturing system are the lack of understanding about lean concepts and shop floor employees' attitude (Nordin, et al 2010). However, some of the healthcare providers intentionally or unintentionally, implemented some part of LSS with an aim of curtailing waste to minimize error as part of performance improvement. Such half-hearted, half-measure approach does not bring much good as noticed by Cory et al (2018). According to them, most transformations are focused on implementing one or two Lean tools that primarily target patient waiting times and there is minimal evidence about sustainability.

Daultani et al (2015) found that each healthcare service poses unique challenge to lean implementation due to their inherent characteristics of service delivery. LSS needs higher capital and more resources for its implementation and process improvement. There is limited research on LSS in healthcare organization and little help available for practicing managers to choose the right portfolio for setting up their hospitals and clinics. It was also found that LSS linked with Industry 4.0 can rejuvenate and revitalize healthcare system by providing economical service with the help of increased productivity and yet with improved bottom line. In this blended and virtual world, healthcare organizations can explore many ways to forge ahead and reap multiple benefits with LSS "riding piggyback" on Industry 4.0

However, the present research is expected to be of some value to a working manager who wants to implement LSS in his organization by bringing to his notice and alerting him to the critical issues to be faced, the barriers to be broken and pitfalls to be avoided while taking up a leading role in the LSS project. The effort is worthwhile, and the task though tough will be rewarding and fulfilling, if one is committed to bringing in improved quality, cost-effectiveness, value creation and definitive improvement in operational efficiency in an organization. Future research can be taken up using quantitative research using advanced statistical techniques such as Structural Equation Modeling (SEM) that will give a better, more accurate and fine-grained picture of implementation problems and ways of resolving them. A perceived limitation of this limited study is perhaps due to poor

understanding of Lean philosophy and Six Sigma concepts by the stakeholders. As a matter of fact, LSS is relatively new to healthcare industry, and it has still some way to go.

Acknowledgement: The author extends sincere thanks to all the employees for their feedback on questionnaire. Special thanks go to the friends and their family for assistance in collecting survey materials from end users. Of course, end users deserve most appreciation for their conscientious involvement in providing feedback by speaking their minds. Finally, author deems it a privilege to live in the Sultanate of Oman, which provided the right environment to conduct this study. Finally, I declare that there is no potential conflict of interest in the research and no support taken from a third party.

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APPENDIX:

Appendix 1. No. of samples from different segments

Distributor of pharmaceutical & healthcare products	No. of interviewees
Pharmacist	2
Medical representatives	2
Storekeepers	2
Sales engineer	2
Support staff	2
Total	10
Clinic setup	No. of interviewees
Doctors	4
Pharmacist	2
Paramedics	2
Supporting staff	2
Total	10
Indoor and outdoor patients	No. of interviewees
Indoor Patients	5
Outdoor Patients	5
Total	10

