Experience of Implementing Lean Thinking in an Indian Healthcare Institution

Abstract

Purpose: The purpose of this study is to document the experience and impact of implementing lean thinking (LT) in an Indian healthcare institution.

Design/methodology/approach: A detailed review of literature documenting the experience of implementing LT in healthcare institutions is carried out. Review revealed that there is a dearth of documentation on implementation of LT in Indian healthcare institutions. To address this gap, the experience of implementing LT in an Indian case hospital is documented by adopting a single case study research methodology.

Findings: Lean practices adopted by the Indian case hospital studied are documented. Performance measures before and after implementation of lean practices in the case hospital are compared. Based on this experience, a LT implementation framework is proposed for healthcare institutions.

Research limitations/implications: As the current study documents the experience of an Indian case hospital which is only at its initial stages of LT implementation, future study can longitudinally observe a healthcare institution implementing LT to assess its long-term impact. Future studies can also attempt to validate the proposed LT implementation framework in different healthcare institutions.

Practical implications: Review of lean principles, practices and performance measures discussed in the literature on implementing LT in healthcare institutions can act as a ready reckoner for practitioners. Framework proposed based on the experience of the case hospital studied is expected to guide healthcare practitioners in their lean journey.

Originality/value: This study is unique as it documents the experience of implementing LT in an Indian healthcare institution and proposes an LT implementation framework for future validation.

Keywords: lean thinking, process improvement, healthcare institution, hospital, case study, framework, India, developing economy.

Article Classification: Research paper

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1. Introduction

Accessibility and quality of health care services in India significantly varies across population primarily depending on the income and location. There exists a wide disparity between India and other countries across the world in terms of affordability and accessibility of health care. By comparing the health care expenditure of India with US, UK, and China for the years 2010 and 2011, it is clearly evident that for a heavily populated country like India, private expenditure on health is significantly higher than the general government expenditure on health. In particular, private expenditure contributed to nearly 70% of the total expenditure on health (2013 World Health Statistics). However, a diametrically opposite scenario prevails in a developed country such as the UK where nearly 80% of expenditure on health is funded by government and only 20% by private expenditure. In both China and USA, an equal proportion of expenditure on health is shared between private and government. In India, general government expenditure as a percentage of total expenditure on health was observed to increase by nearly 3% from 2010 to 2011, but the increase still remains insufficient for the increasing population and rising cost of living. The simultaneous increase in population and cost of living over the time period nullifies the net effect of increase in government funding for healthcare. Also, within urban and rural India, the quality and infrastructure available for providing health care services vary considerably. Unfortunately, according to the recent census, 70% of India's total population lives in rural India, which does not have access to quality health care (2011 Census of India). It is also to be noted that half of all residents in rural India live below the poverty line. As mentioned, even though attempts are made by the Indian Government to make health care accessible, still a wide gap is noticed between per capita government expenditure on health and per capita total expenditure on health. This gap makes quality healthcare an unaffordable luxurious good for major percentage of population in India. But, at the same time, India is internationally considered to be a preferred destination for availing high-quality health care at the lowest cost (Connell, 2006). Mochi et al. (2013) mentioned that India has adequate resources and potential to meet the demands of medical tourism when compared to other foreign countries. Fortis Healthcare Group from India reported in August 2013 that its international business (patients from other countries) has grown 20-25 percent a year over the past two years and it expects 28 percent growth in the current year (Mishra, 2013). Reasons for increasing medical tourism from foreign countries are attributed to the low-cost treatment and high-quality facilities (Gupta, 2008). Therefore, reducing the private health care expenditure would not only increase the affordability for Indian population but also will help in enhancing the competitive advantage and sustaining the existing demand for medical tourism.

On the other hand, literature revealed that several healthcare institutions in developed countries like USA (e.g. Virginia Mason Medical Center, Mayo Clinic, Thedacare Inc., Denver Health, etc.), UK (e.g. Bolton National Health Service (NHS) Foundation Trust, Royal Sussex County Hospital, etc.), Canada (e.g. Shouldice Hernia Centre, St. Joseph's Health Centre, etc.), and Australia (e.g. Flinders Medical Centre, Campbelltown Hospital, etc.) have adopted Lean Thinking (LT) for achieving low-cost high-quality health care delivery. But, it was observed from the review that the literature is in dearth of documentation related to implementation of LT in healthcare institutions belonging to developing countries, especially from the Indian context.

Thus, to achieve low-cost high-quality health care for Indian population and to sustain the rapid increase in medical tourism (i.e., to cater to the international population), application of LT in the Indian healthcare institution can be seen as one of the potential solutions. LT can help in improving the efficiency of existing operational processes in healthcare institutions which can ultimately reduce the cost of care delivered.

Considering the current situation of health care in India and the gap that exist in the current body of research, we attempt to address the following research questions (RQ) in this study:

> *RQ1. What is the current status of literature that deals with "LT implementation in healthcare institutions"? As an outcome from this review, we also expect to answer the following questions:*
> *RQ1a: What are the principles, practices, procedures, tools, techniques (in short, it will be called as "elements" from now on) of LT that are getting implemented in the health care institutions?*
> *RQ1b: What are the different performance measures utilised to report the benefits of LT?*
>
> *RQ2. Is there a standard procedure available in the literature to implement LT? If so, what procedure is being adopted by an Indian hospital while implementing LT and how does it help in improving its operational performance?*

To answer these research questions, authors have reviewed the literature on "LT implementation in healthcare institutions" and documented the experience of implementing LT in an Indian hospital.

2. Literature review

Literature review was carried out to support the claim that the literature on LT implementation lacked enough evidence from healthcare institutions in Indian context. Most of the studies reviewed have been reported in last one decade. This indicates the growing importance and relevance of LT in healthcare institutions. Review also captured the country in which study was conducted, name of the case hospital, problem targeted by the case hospital using LT, process in which LT was implemented, lean principles adopted, lean practices implemented, performance measures monitored and outcomes achieved (as shown in **Table 1** and **Table 2**).

"Insert Table 1 here"

"Insert Table 2 here"

Literature review revealed that only three published studies (Bhat et al., 2014; Díaz et al. 2012; Miller & Chalapati, 2015) have documented implementation of LT in an Indian healthcare institution to achieve process improvements. But, these studies differ from the current study in the following ways:

- Bhat et al. (2014) documents the experience of applying lean six sigma methodology whereas current study documents the experience of implementing only LT and not six sigma

- Díaz et al. (2012) explained the experience of applying LT to a single specialty hospital (eye care provider) whereas current study documents the experience of LT implementation in a multi-specialty hospital
- Miller & Chalapati (2015) is the study closest to the current study but it focuses on solving a specific problem of reducing outpatient waiting time using lean tools. This study claim to have developed a framework to analyze value streams for reducing waste, but it only documented the experience of the hospital in reducing the outpatient wait time. Study also fails to provide description on how to apply the framework in similar cases in future. Current study differs by documenting the experience of the following:
    - Implementing LT in the case hospital (especially the initial phases),
    - Solving different problems and reducing the wastes in the hospital using elements of LT tools, and
    - Proposes a structured framework for overall LT implementation with detailed description on the procedure to be followed

Along with these three studies, current study would add to the scarce literature on LT implementation experiences from Indian healthcare institutions.

Another common observation across all the studies reviewed was that the procedure for implementing LT in healthcare institutions varied from case to case. For instance, King et al. (2006) used process mapping tool to group patients together for minimizing complex queuing in the emergency department, whereas Jimmerson et al. (2005) have adapted Value Stream Maps (VSM) and problem-solving A3 report tools to improve patient or information flow issues across multiple departments. But, LT implementation in manufacturing sector was observed to adopt a standard procedure fitting with five tenets of lean proposed by Womack and Jones (2009).

In summary, the detailed literature review clearly revealed the following gaps and insights:

- Most of the hospitals in developed countries like USA, Europe, Australia, etc. have already adopted LT philosophy in healthcare and harvested significant benefits. Very few studies exist from the Indian context describing the procedure to understand, develop and implement LT in a healthcare institution.
- Almost all articles published confirm positive outcome after implementation of LT in healthcare and thereby supports the recommendation of LT for improving the operational efficiency of Indian hospitals.
- Procedure adopted for implementing LT was highly contextual and varies between different healthcare institutions. Review also showed that the lean practices and performance measures adopted by healthcare institutions varied depending on the issue/problem that is being addressed by implementing LT in that institution. Scope exists for proposing a standard framework in line with five tenets of lean which is widely adopted in manufacturing context.

Anchoring on to these gaps and insights identified in the review, this paper documents the LT implementation experience of a healthcare institution in India and proposes a standard framework for guiding healthcare institutions in LT implementation.

3. Case Study Methodology – A Multispecialty Hospital

Research questions stated in the beginning clearly shows that this study attempts to address "what" (what procedure is adopted by an Indian hospital) and "how" (how does it improve the

operational performance) questions on LT implementation in healthcare institutions without controlling for their behavioral events. According to Yin (2013), case study research methodology would be the most appropriate methodology for addressing such research questions. To understand the procedure adopted for implementing LT in a healthcare institution, a multispecialty case hospital located in southern part of India was selected. As prescribed by Eisenhardt (1989), Glaser and Strauss (1967), and Siggelkow (2007), case organization for this current study is not randomly sampled. It was selected based on how it would support in answering the research questions raised. Best-fit hospital for this study would possess the following characteristics:

i. Implementing process improvement initiatives based on the elements of LT
ii. Employees of the hospital including the physicians are open and involved in improving the processes of the hospital
iii. Top management is willing to share data and encourage the involvement of external researchers
iv. Data collection process is convenient for authors (convenience sampling)

A multi-speciality hospital with over twenty clinical departments and 256 employees (distribution of employees is given in **Table 3**) was chosen as a case hospital for this study as it possessed the above listed characteristics of the best-fit hospital. Case hospital chosen has continued to grow and stay competitive over past three decades by constantly adapting to the changing requirements of their customers. A key reason for hospital's competitiveness in the market is widely cited to be its top management commitment and employee involvement. These two characteristics enable the hospital to achieve efficient and effective processes that can deliver the best care to their patients. For instance, recently top management of the hospital with its HR team revised the induction training program for all the new joiners to introduce the fundamental aspects of process improvement such as 5S and housekeeping techniques. It also introduced staff incentive program for recognizing active participants, initiated free annual health check-up for employees, and installed integrated IT systems to actively involve the employees.

"Insert Table 3 here"

Motivated by the quantum of benefits harvested by several hospitals in developed countries after implementing LT, the case hospital was incrementally implementing process improvement initiatives using elements of LT. As the top management of the case hospital was also focusing on increasing its revenue through medical tourism by focussing on Gulf and African markets, it was expecting that implementing LT would help in achieving world class quality and standards.

In this study, we observed the events as it unfolded and monitored both the process and outcome in phases. As mentioned by Miles and Huberman (1994), following this procedure helped us in avoiding retrospection bias and the influence exerted by the data collector in the research context. The research project timeline is detailed in **Table 4**. The first author was present for all the events, and the second author was regularly consulted for any suggestions during the course of the research. Structured case study methodology discussed by Eisenhardt (1989) and Yin (2013) for data collection and data analysis (**Table 5**) was followed in this study.

"Insert Table 4 here"

"Insert Table 5 here"

4. LT Implementation in a Case Hospital – Data Collection & Analysis

Sources of data and evidence for answering the research questions were discussions with key employees, direct observations and hospital documents. These data sources provided targeted focus, contextual reality and stability advantages (Yin, 2013). Through triangulation of these multiple sources of evidence, converging lines of inquiry were developed as it is the primary evaluation criteria for case study research. Employees who played a key role in this process improvement initiative of the case hospital were identified using snowballing technique (composition of the team is shown in **Table 6**). Interactive discussion sessions were conducted with doctors, nurses, support staff, and patients to gather data on their initial experience of LT adoption. They had the complete knowledge of the hospital including its operational performance, the extent of wastes prevailing in different processes, applicability of different elements of LT, LT implementation plan, etc. Session reports were prepared after every visit to organize the data gathered. Iteration between fieldwork and data analysis was followed regularly as prescribed in the case study research process (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). The recursive cycling between these two tasks allowed to empirically ground the observations.

"Insert Table 6 here"

Problems were identified and analyzed through the lens of seven wastes of LT and suitable lean practices were proposed for tackling these problems. Easily implementable and affordable solutions with customer focus were given preference by the case hospital to create value to the patients. Performance measures capable of measuring and monitoring the improvements after implementing LT in the case hospital were also proposed. Some of the performance measures adopted in the case hospital to measure the improvements during pre and post implementation of LT were total lead time, average value added time, total waiting time of a patient, average turnaround time for reports, physical space usage, worker absenteeism, walking distances of staff, percentage of cases rescheduled due to late starts, and number of reports with errors. Two instances of implementing LT (as described in **Table 7**) in the case hospital to address problems in outpatient department and pharmacy department are presented in the following two paragraphs.

Outpatient department - Initially, scheduling process for the outdoor patient department was requiring the patients to travel to the hospital and check the availability of the doctor before making an appointment. Wastes that got generated in the process were external transportation of patients to hospital for seeking appointment, motion of patients within hospital for getting appointment, waiting before their appointment as well as before meeting the physician (inventory), and occurrence of over processing and defects on postponing patient appointments. To overcome these problems and remove the wastes identified, solutions were proposed based on LT practices such as process simplification, customer involvement, cycle time and lead time reduction and work in progress (WIP) reduction. The solution implemented enhanced patients to fix their appointment either by calling the hospital or using the hospital website where they had the option of selecting the timings and doctor of their choice. This solution reduced the wastes

significantly as the patient directly moved for consulting the specific physician in the selected time slot on entering the hospital. The performance measures used to assess the improvements after implementing the solution in the scheduling process of the outdoor patient department were waiting time at different nodes in the hospital, total lead time from entering and leaving the hospital, walking distance of patients, and percentage of cases rescheduled on a single day. Waiting time and lead time reduced from hours to minutes on the implementation of the solution proposed. Walking distance of the patients also reduced as they directly moved to the physician without traveling to multiple counters for fixing and finalizing the appointment which in turn was also found to improve the customer satisfaction. Percentage of cases rescheduled on a single day reduced considerably and were found to be nil on most of the days after implementing the solution.

Pharmacy department - Another solution, Integrated Pharmaceutical Information System (IHIS) based on lean practices such as electronic data interface, information sharing, supplier involvement and sole sourcing helped pharmacy department to leverage on special deals provided by the drug suppliers on bulk orders as consumption pattern of each drug was better predictable. The system also provided patients past purchases on inputting their enrollment number which helped in storing their medication history. The system also enabled supplier inventory monitoring by interfacing the information system with suppliers system which in turn reduced the instances of number of medicine stock outs in a month, lead time between order and delivery, number of instances of wrong billing, and number of emails transacted for order placement between supplier and pharmacy department. **Table 8** provides the comparison of the performance measures pre and post implementation of these two LT solutions discussed.

"Insert Table 7 here"

"Insert Table 8 here"

As observed in the literature review, performance measures used by the case hospital were highly contextualized and specific to the problem addressed. Significant improvements in performance measures post implementation of LT were observed. Thus, the experience of the case hospital clearly shows the potential of LT in reducing wastes in Indian healthcare system and thereby would help in progressing towards the objective of making it accessible and affordable. As current study is preliminary in nature, case hospital has to be studied in detail over a longer time period to quantify the improvements achieved and detail the issues faced. Even though the hospital started with its process improvement initiatives recently, it has followed a structured procedure to implement LT. In the subsequent section, we document this structured procedure as a lean implementation framework for healthcare institutions.

5. Framework for LT implementation in Healthcare Institutions

Yin (2013) while listing the advantages of case study inquiry methodology clearly mentions one of the key advantages to be the benefits of developing theoretical propositions to guide future data collection and analysis. Based on the detailed review of literature and experience of the case hospital, a 5-step framework (**Figure 1**) for LT implementation in healthcare institutions is proposed for future validation.

"Insert Figure 1 here"

Step 1: Form a dedicated LT implementation team

A lean sensei has to be recruited by the executive leadership for assisting the healthcare institution in its lean journey. Create positions and recruit qualified people with the assistance of lean sensei to form the core lean implementation team. In addition, identify key players from multiple departments of the healthcare institution to form a steering committee. The need for this step has also been widely indicated in literature by stating that the implementation of lean healthcare demands re-organisation of healthcare work by prominently reconfiguring the occupational boundaries and installing new forms of clinical leadership (Waring and Bishop, 2010; Aij et al., 2015; etc.). **Table 9** presents the LT implementation team that can be formed by the healthcare institution for assisting in their lean journey.

"Insert Table 9 here"

Step 2: Train and educate the frontline management team on LT

Before beginning the implementation of LT, all the employees including physicians, nurse, and staff, also known as the frontline management team, have to be trained on the concepts of LT by the dedicated LT implementation team. Training the frontline management team has been exhaustively mentioned in the literature using different terminologies such as employee training programs (Ben-Tovim et al., 2007), standardized training programme for all clinical assistants (Wood et al., 2008), training by counterparts to explain how protocols were designed (Shah et al., 2008), trained clinical staff (Smith et al. 2011), relevant training of staff (Radnor, 2011), etc. Hands-on experience through case examples and demonstration can be provided for different lean elements to experiment and understand their implementation in a controlled setting. The sequence of training can be followed as shown in **Figure 2**. Begin the training exercise with healthcare institution's top management and facilitate its transfer to different levels till the final frontline staff level. This procedure is also called as "*Leaders develop leaders*". Employees buy the need for implementing LT with much lesser resistance when trained and guided by their immediate superiors and employees of the same level. Therefore, proposed sequence of training can be expected to reduce the employee resistance and thereby increase the probability of success of the lean initiative.

"Insert Figure 2 here"

Step 3: Identify value streams & construct value stream mapping

Discuss with different stakeholders to identify the value streams of the healthcare institution. Matthias and Brown (2016) observed how some of the apparent contradictions in the requirements of the various stakeholders create operational and strategic tensions. Hence, it is highly recommended to discuss with different stakeholders before identifying the value stream. This discussion with different stakeholders also help in understanding the different types of value streams present and their contribution towards achieving the healthcare institution's mission. Lean implementation team can select a value stream by evaluating on different characteristics as discussed in Narayanamurthy and Gurumurthy (2014). After selecting a value stream, core lean implementation team along with the employees associated with the selected value stream can construct the value stream mapping (VSM). This step reveals various function areas, associated

processes, and interdependency between processes and function areas at the value stream level. Quantitative and qualitative data has to be included in detail at each process in the VSM to help in the lean waste assessment. As the case hospital was at its initial stages of LT implementation, process improvement team was still training its employees on the mapping of current and future value streams and hence is not presented in this study. For more details on the application of VSM, reviewed studies Jimmerson et al. (2005), Díaz et al. (2012), Bhat et al. (2014), Miller and Chalapati, (2015), Dogan and Unutulmaz (2016), etc. can be referred.

Step 4: Identify and eliminate waste to optimize flow

Almost all the studies presented in the literature review section have performed this step of identifying and eliminating waste to optimize flow and hence acts as the core objective of LT implementation. Few studies (e.g. Jimmerson et al., 2005; Huggins, 2010; etc.) have prominently focussed on only this aspect of eliminating waste and establishing flow. Impactful implementation of this step influences the executive leadership's decision on whether to continue with LT in future or not and therefore it is essential that the guidelines are diligently followed in implementing this step. From the data provided in VSM, different types of wastes that are prevailing at different processes have to be identified. Seven wastes proposed within lean manufacturing context have to be suitably adapted to the healthcare context as some of the wastes mentioned in manufacturing are not relevant to healthcare institutions. A modified set of six wastes identified in particular to this context are rework, motion, waiting, overprocessing, overproduction, and defects. The new waste introduced in this study namely 'rework' differs from the traditional waste 'defects'. Defects that can be rectified are categorized under reworks whereas those which cannot be rectified are categorized directly under defects. For example, incorrect reporting can be rectified by correcting the mistakes and changes can be notified to both the patients and physicians. Hence, this waste is categorized under rework. Lean tools and practices can be selected from the already existing comprehensive list depending on the waste to be eliminated. Lean practices listed in Table 2 can act as a comprehensive list for practitioners getting started with their LT journey. Through the implementation of the lean tools and practices, lean implementation team should target to optimize eight flows of healthcare - flow of patients, staff, families & visitors, information, medications, supplies, equipment, and process engineering. Once the solutions are proposed, future state VSM can be constructed.

Based on the literature review carried out and the experience of the case hospital, principles and practices assisting in implementing LT are documented as *Hospital of Lean* (similar to already existing *House of Lean* in manufacturing context) in **Figure 3**. *Hospital of Lean* provides the lean implementation team with the sequence in which LT has to be rolled out. LT implementation begins first with the components mentioned in foundation, followed by the pillars, and finally the roof. Healthcare institution during its initial stages of lean implementation has to focus on the first half of the foundation - people and teamwork. Committed leadership, employee involvement, training, team culture, and clear set of objectives are the enablers for building this part of the foundation. Gemba walks, frontline management systems (physician, nurse, and staff), and strategy deployment are the lean tools which helps in constructing the foundation. Second half of the foundation focuses on achieving stability and standardization to ensure that the work is done in the right way every time. Sustaining the improvement becomes very difficult in the absence of stable processes. Tools such as 5S and other housekeeping techniques can help in creating order and standardizing the work as well as the workplace. Going

ahead in its lean journey, the healthcare institution has to focus on building the pillars of just-in-time (JIT) and built-in quality. These two pillars can be rolled out in parallel or sequence depending on the resource availability with the healthcare institution. These pillars are focused to drive the optimization of healthcare service production (JIT pillar) and quality (built-in quality pillar) which is essential for ensuring cost-efficient and effective operations. Tools are listed in these two pillars in the sequence in which they have to be implemented. Tools that assist in achieving JIT (in the order of implementation) are A3 Thinking, VSM, one patient continuous flow, pull systems (patient demand triggers the processes in healthcare service production), and work smoothing (leveling/service production at a consistent rate). Tools that assist in achieving built-in quality pillar are five whys (asking "why" until the problem's root cause is found), employee suggestion schemes, visual management, poka-yoke and andon (designing a process that is mistake-proof). Strengthening these two pillars will provide scope for achieving the core of LT which is pursuing perfection, continuous improvement, and respect to humanity. On building these pillars, the healthcare institution can tap improvements in both patient and healthcare institution performance measures - clinical quality, experiential quality, employee engagement, cost effectiveness, and financial performance (listed above the pillars of "*Hospital of Lean*"). Improving on these metrics will help the healthcare institution in achieving its vision and mission statements which are focused to provide value to both its internal (employees) and external stakeholders (patients/customers). Future researchers are invited to further empirically validate and update the *Hospital of lean* in different healthcare institution contexts. Healthcare institutions implementing LT can use this as a handout as it lists the lean tools and their implementation priority.

"Insert Figure 3 here"

Step 5: Assess the improvement in performance measures & pursue perfection

Performance measures play a significant role in understanding the success of implementation of LT. Several studies in literature have relied on wide variety of performance measures to assess the impact of LT implementation (refer to Table 2 for the list of performance measures). Moreover, it helps in understanding the current situation and also provides the roadmap for continuous improvement based on the present or existing process performance measures. The benefits harvested can also be compared by evaluating the performance measures before and after the implementation of LT. Identification of performance metrics usually is left to the choice of implementers and completely depends on the nature of process studied and problem addressed. After comparing the benefits, all the processes (including the one to which LT was applied) need to be analyzed and one process needs to be selected again to repeat from step 3-5 to pursue perfection through furthering kaizen (continuous improvement).

Based on the level of LT implementation at a healthcare institution, it can be categorized into one of the five stages or buckets listed in **Figure 4**. Any healthcare institution on beginning with lean implementation has to achieve supportive management system which has focussed strategy deployment and accountability system. The absence of such a management system would not lead the healthcare institution towards successfully beginning its lean initiative. Hence, achieving better management system is the first stage or can also be called as a prerequisite for a healthcare institution implementing LT (Furman and Caplan, 2007). On achieving the requisite management system, the healthcare institution has to invest in its frontline management team to

build a learning environment with better problem-solving skills and least resistance (Kim et al., 2006). Employees with least resistance and motivation to engage in learning and implementing new lean practices to eliminate waste is an indication of successfully reaching the second stage of the lean journey. Post developing better management system and problem solvers, the healthcare institution has to put them into use to achieve efficient processes and value stream. Healthcare institutions can be categorized under 3rd stage if they have achieved least varying processes with built-in quality and least stress on employees. Healthcare institutions reach stage 4 on successfully achieving better results in key performance metrics such as clinical quality, experiential quality, engagement, and cost-effectiveness. On sustaining and improving the better results obtained, the healthcare institutions reach the final stage 5. Based on the evaluation of LT implementation experience of the case hospital, it can be categorized into stage 2 as it has trained its employees and provided a conducive environment to become better problem solvers. Initiatives have been taken by the case hospital to reach stage 3 with better processes and value stream.

"Insert Figure 4 here"

6. Conclusion

Current study has answered the research questions that were raised in the beginning. First research question was answered in detail by reviewing the literature on LT implementation in healthcare institutions and documenting the name and country of the healthcare institution studied, problem addressed, lean principles, practices and performance measures adopted, and results obtained. From the review, it was found that no detailed study exists from the Indian context describing the procedure to understand, develop and implement LT in healthcare. Current study addressed this gap by documenting the LT implementation experience of a case hospital in India. Comparison of performance measures showed that the implementation of LT has reduced the usage of hospital's resources including its employees and infrastructure and this was expected to reduce the cost that the hospital will incur in delivering healthcare to its patients. Positive outcome achieved through implementation of LT reveals the scope for LT in Indian healthcare institutions. Practices implemented by the case hospital and performance measures adopted by the case organization were also discussed. Based on the experience of the case hospital and review of literature, a five-step lean implementation framework is developed to assist healthcare institutions in structuring their lean journey. Step-by-step description and demonstration have been provided for guiding future implementers of LT in healthcare institutions. This answers the second research question.

LT, when implemented at the entire healthcare institution, can be expected to not only improve the responsiveness of the healthcare institution to the patient's requirements but also significantly reduce the cost incurred in delivering the care by removing the non-value adding tasks (Machado et al., 2014). Cost benefits harvested by the healthcare institution can be shared with the patients to derive a competitive advantage of providing quality treatment at low cost in the market. In a country like India which has wide income gap within and huge demand quality healthcare, it is an order-winner to implement process improvement strategies such as LT that can help in overcoming the constraints of receiving affordable care and ensure healthy development for all strata of people.

6.1 Research Implications

Current study summarizes more than forty papers on LT implementation in healthcare institutions in the literature review section. Review section tabulates the research questions answered, lean principles imbibed, lean practices deployed, and lean performance measures compared. This review can be used as a one point reference by future researchers in the area of LT implementation in healthcare institutions. In addition to the detailed review, this research is a valuable addition to the less explored domain of LT implementation in Indian healthcare institutions. This study on the experience of implementing LT in an Indian case hospital will reduce the dearth of documentation observed in literature. Finally, based on the review and also the experience of the case hospital, current study is unique in proposing a comprehensive framework with standard guidelines for implementing LT in healthcare institutions. This study contributes to the nascent literature of developing a framework for LT implementation in healthcare institutions with guidelines on employee training and classification based on the progress made in LT implementation (Narayanamurthy & Gurumurthy, 2016).

Results and implications of current research has its own limitations. Inferences made in the current study are based on the research carried out in a single case hospital and hence generalizability of the outcome is not claimed. Future studies can attempt to generalize the framework proposed as a result of single case study research in different healthcare contexts. In addition, the current study describes only the initial stages of LT implementation in an Indian hospital. Future study can assess the long-term impact of LT implementation by carrying out a longitudinal case study of a healthcare institution.

6.2 Practice Implications

Positive outcome on implementing LT is expected to motivate practitioners in Indian healthcare institutions to adopt such process improvement initiatives for improving the quality of care and deliver it at minimal cost. The proposed framework for implementing LT along with the Hospital of Lean (similar to House of Lean) structure is expected to assist practitioners in implementing LT in healthcare institutions. In addition, the last three steps of the proposed framework are in line with the 5 tenets of lean proposed by Womack and Jones (2009). Step 3 captures tenet 1, step 4 captures tenet 2 and tenet 3, and finally step 5 captures tenet 4 and tenet 5. Hence, these three steps are constructed cyclically as proposed by Womack and Jones (2009). The sequence of training the employees at different levels in the hospital discussed in this study can help the human resource manager and lean sensei during the lean journey. Finally, the five-stage classification of hospitals into buckets based on their position in the lean journey can assist them in conducting assessment and benchmarking.

Note

An initial version of this paper titled “Lean Thinking in Healthcare Sector: Experience from an Indian Hospital” was presented at the *25th Annual Conference of Production and Operations Management Society (POM 2014)*, 9-12 May 2014, Atlanta, USA.

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Experience of Implementing Lean Thinking in an Indian Healthcare Institution

Table 1 - Literature on LT implementation in healthcare institution

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
Jimmerson et al.	2005	USA	Intermountain Healthcare and Community Medical Center	Poorly specified activity and a complex pathway	Multiple processes
King et al.	2006	Australia	Flinders Medical Centre	To establish streams for patient flows in a teaching general hospital ED	Emergency department
Persoon et al.	2006	USA	Cerner Classic, Cerner, Kansas City, Missouri	To improve preanalytic processes using the Principles of Lean Production	Preanalytic processes
Towne	2006	USA	Virtua Health, Marlton, New Jersey	Streamline process, empower staff, and enhance care using lean	General processes
Kim et al.	2006	USA	University of Michigan Medical School	Improve the care of patients across various venues of hospitalization and flow toward discharge	Multiple processes
Weber	2006	USA	Virginia Mason Medical Center	Improve process efficiency	General processes
Ben-Tovim et al.	2007	Australia	Flinders Medical Centre	Redesigning of care	Multiple processes
Pham et al.	2007	USA	Virginia Mason Medical Center	Redesigning care delivery	Multiple processes
Balle and Regnier	2007	Paris	Nord 92 in Villeneuve-La-Garenne, Paris	Teaching lean thinking	Nursing
Kim et al.	2007	Michigan, USA	University of Michigan Medical School	Improve patient care access and reduce excess work	Multiple processes
Kollberg et al.	2007	Sweden	Not mentioned	Assessment of lean requirement was felt	Not mentioned
Nelson-Peterson and	2007	USA	Virginia Mason Medical Center	How to implement lean in health care to improve the service quality	Nursing

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
Leppa				by increased time for nurses to care for their patients?	
Kelly et al.	2007	Australia	Not mentioned	Improve flow through the emergency department for all groups of patients	Emergency department
Fillingham	2007	UK	Bolton hospitals, National Health Service (NHS) trust	Can techniques developed in manufacturing really work in hospitals? Could it possibly be that "lean" can save lives?	General processes
Furman and Caplan	2007	USA	Virginia Mason Medical Center	How to detect and fix every safety hazard (mistake) as soon as it occurs, using the Toyota Production System?	General processes
Esain et al.	2008	Not mentioned	NHS trust	How to effect change in public service organizations?	Multiple processes
Radnor and Walley	2008	UK and Sweden	Not mentioned	Do organizations regard lean merely as a set of tools and techniques without considering either the underlying conditions or lean as a philosophy?	General processes
Tsasis and Bruce-Barrett	2008	Canada	Sick kids, Toronto	How LT can be used to improve efficiency and cost containment?	Multiple processes
Wood et al.	2008	USA	Mayo Clinic, Rochester, Minnesota	How standardized care processes can be implemented in a large academic practice to improve quality and safety of patient care?	Outpatient service
Shah et al.	2008	USA	Abbott Northwestern Hospital in Minneapolis, Minnesota	How independent organizations achieve superior performance despite highly uncertain and variable customer demand? Why the organizations in the decentralized supply chain	ST elevation myocardial infarction (STEMI) heart attack

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
				coordinate their work?	
Dickson et al.	2009	USA	Not mentioned	Does a process improvement effort using lean principles improve emergency department care?	Emergency department
Castle and Harvey	2009	UK	National Health Service	What are the benefits of use of observational data over the traditional data collection methodologies while implementing LT?	Multiple processes
Toussaint	2009	USA	Theda Care, Wisconsin	How lessons from lean manufacturing can help to improve care and lower costs in healthcare?	Care delivery for heart attack and new-born delivery
Waring and Bishop	2010	UK	National Health Service	What are the different ways lean is translated into and impacts upon clinical practice?	Operating department processes
Grout and Toussaint	2010	USA	Theda Care Inc.	How Poka Yoke and Jidoka can be used to reduce the spiraling costs and medical errors?	Multiple processes
Huggins	2010	USA	Air Force Clinic	How the use of lean can improve a key process that supports battlefield medical fitness?	Medical Evaluation Board Process that supports battlefield medical fitness
Meyer	2010	USA	Denver Health	How to implement lean in healthcare for performance improvement?	Emergency department
Setijono et al.	2010	Sweden	Sahlgrenska Hospital, Gothenburg	How to find the “best” allocated number of surgeons and medicine doctors that reduce patients’ non-value-added time (NVAT) and total time in the system (TTS)?	Emergency department
van Vliet et al.	2010	Netherlands	Rotterdam Eye Hospital	What is the efficacy of the lean cataract pathway, that is, how many patients received care according to	Cataract pathway

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
				specifications of the lean pathway design? What is the efficiency of the lean cataract pathway, that is, did the implementation of the lean pathway decrease the number of hospital visits per patient and increase access to the pathway?	
Dahlgaard et al.	2011	Denmark	Not mentioned	How to develop a system for assessing and improving healthcare organizations?	General processes
de Souza and Pidd	2011	UK	NHS	What are the barriers in the implementation of lean and how to overcome them?	General processes
Gabow and Mehler	2011	USA	Denver Health	How to achieve quality and safety improvements using a multifaceted, structured approach?	Multiple processes
Papadopoulos et al.	2011	UK	NHS	How to articulate the dynamic nature of networks underpinning socio-technical change in the management process change initiatives?	Pathology department
Smith et al.	2011	USA	U.S. academic health system	Process improvement was required	Cystic fibrosis centers
Radnor	2011	England	1.Pottery General Hospital NHS Trust 2.Iron Hospital NHS Trust 3.Ring Mental Health Trust	How do organizations approach lean implementation? Do they focus only on tools of implementation and neglect organizational readiness?	*Pottery:* Short stay unit, Fracture clinic and Theaters, and Diagnostics *Iron:* Theatres, Outpatient discharge planning, Medical job planning tool, Pre-op assessment, Pathology, and Accident, emergency and the medical assessment unit

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
					Ring: Psychological therapy, Neuropsychiatry, and Pharmacy
Díaz et al.	2012	India	Aravind Eye Care	How principles of early triage and Lean practices can be applied to provide better healthcare operations?	Eye care
Morrow et al.	2012	UK	Not mentioned	How to tackle challenges associated with implementation of Lean innovations in Healthcare?	General processes
Toussaint and Berry	2013	USA	Bellevue Clinic, ThedaCare, and Christie Clinic in Champaign	Multiple problems in the healthcare process	Scheduling in radiology
Burgess and Radnor	2013	UK	Northern Lincolnshire and Goole Hospitals, NHS Foundation Trust	How lean is implemented in English hospitals?	General processes
Bhat et al.	2014	India	Health Information Department (HID) of a Medical College Hospital	How lean six sigma can be applied in the Indian health sector?	Registration process
Cook et al.	2014	USA	Mayo Clinic, Rochester, Minnesota	How to create a "focused factory" model within the practice's solution shop?	Cardiac department
Rees	2014	New Zealand, USA, UK, Australia	Virginia Mason Medical Centre, Seattle, USA. Royal Bolton Hospital, Bolton, UK. Flinders Hospital, Adelaide, Australia.	How organizational readiness affects the lean implementation?	Emergency department
Aij et al.	2015	Netherlands	VU University Medical Center	What are the effective lean leadership attributes that are essential for Lean transformation?	General processes

Authors	Year	Country	Case Hospital	Problem faced/Research Question	Process
da Silva et al.	2015	Brazil	Medical Centre of Campinas	Which are the management techniques in the healthcare sector?	Multiple processes
Miller and Chalapati	2015	India	Help Hospital	How lean tools can be applied to some unique issues of providing healthcare in a developing country where many patients face challenges not found in developed countries?	Outpatient service
Chiarini and Baccarani	2016	Italy	Not mentioned	How TPM and lean strategy can be applied to public hospitals?	General processes
Dogan and Unutulmaz	2016	Turkey	Not mentioned	How a healthcare organization can evaluate itself by using a pre-lean method, VSM, and use lean to become more efficient?	Physical therapy and rehabilitation department
Matthias and Brown	2016	UK	NHS	(1) Is there a structured, planned approach to service or operational delivery? (2) Where and how does behavioural and performance improvement feature as part of operations strategy planning? (3) Who is responsible for operationalising and achieving policy and performance objectives within hospitals? (4) Are the specifics of lean criteria set in place within the NHS and, if so, are they well known and understood at all levels?	General processes

Table 2 - Literature on LT principles, practices and performance measures in healthcare

Authors	Year	Principles	Practices	Performance Measures	Outcome
Jimmerson et al.	2005	Eliminate waste to establish flow	(1) VSM, (2) One-page problem-solving A3 report	(1)Turnaround time for reports, (2)Treatment delays (3)Number of labeling errors in laboratories	Complexity in implementation was found to be varying from one process to another
King et al.	2006	Waste reduction and flow establishment	(1) Process mapping with staff, (2) Identification of value streams, (3) Minimizing complex queuing in the ED	(1) Waiting time, (2) Overall time, (3) Average number of patients in the ED at any time, (4) Number of patients not waiting	Emergency department patient flows were redesigned with value streams
Persoon et al.	2006	Waste reduction and flow establishment	(1) Redesigning the process, (2) 1-piece flow to move blood samples through the accessioning, centrifugation, and aliquoting processes, (3) Process mapping	(1) Median preanalytic processing time (minutes), (2) Cycle time, (3)% of chemistry results in less than 1 hour	Significant improvement in chemistry test turnaround time was achieved without the addition of automation or other resources
Towne	2006	Waste reduction and create flow	(1) 5S (2) Flow (3) Put storage areas closer to where supplies are needed instead of having a centralized location (4) Label and color-code supplies to make them easier to find (5)VSM (6) Spaghetti map (7) JIT (8) Standardized pain management and other case carts	(1) Non-value adding activities time, (2) Time delay per central storage cart, (3) Time it took to fill an order, (4) Number of steps it took to stock an item	Lean has the capability to quickly streamline a particular process, empower staff members and ultimately, enhance the quality of care.
Kim et al.	2006	Waste reduction and to create flow	(1) VSM (2) Standardizing and mistake proofing the process of ordering, delivering and administering medications	(1) Number of medication errors, (2) Number of CT and MRI scans performed per day, (3) Waiting time, (3) Turnaround time for pathology reports, (4) Number of steps from medication order to treatment initiation, (5)	Hospital is an ideal setting for use of the lean production method, which could significantly affect how health care is delivered to patients. Successful implementation of lean requires cooperation of multiple operating units and

Authors	Year	Principles	Practices	Performance Measures	Outcome
				Time for unit clerks to process new physician orders, (6) Average time to line placement, (7) Number of peripherally inserted central catheters (PICC) referrals to interventional radiology	strong commitment from senior management.
Weber	2006	Waste reduction	(1)U-shaped cell (3)Standardized work sequencing for physicians (4) No-layoff policy	(1)Number of patients getting same-day appointments (2)Walking distances of staff (3) Defect rate	General process efficiency improved
Ben-Tovim et al.	2007	Improving the flow of patients and reducing the waste	(1) Work prioritization, (2) Production "cells" aligned with value streams, (3) "plan-do-study-act"-PDSA, (4) Employee training programs, (5) Visual management, (6) Load leveling	(1)Patients leaving with incomplete care (2)Overall time patients spent in the department (3)Numbers of patients attended by the department (4)Average length of stay	Decreased congestion, wasteful delays, and reduplication with improved staff morale, recruitment, and retention of medical and nursing staff
Pham et al.	2007	Waste reduction	(1) Volume reduction (2) Staff education and reorganization (3)VSM for different disorders (4) Documentation of treatment guidelines (5)Feedback on cost performance (6)Collaboration among purchasers	(1)Costs per episode of several medical subspecialty departments (2) Instances of medical errors or near-misses (3)Physical space usage (4)Worker absenteeism	VMMC increased affordability by maintaining the quality
Balle and Regnier	2007	Waste reduction and zero defects	(1)5S (2)Systematic audit (3)Zero out-of-date practice (4)Supermarket arrangement (5)Daily ward tour (6)Standardization (7)A3 report	(1)Lead times (2)Rate of error incidents per patient (3)Time took before responding to patient (4)Number of weekly delivery cycle	LT concepts were taught successfully
Kim et al.	2007	Waste reduction	(1)Value stream mapping (2)One piece flow (3)Standardization	(1)Number of process steps to begin treatment (2) Number of	Waiting time was reduced and value added activity was

Authors	Year	Principles	Practices	Performance Measures	Outcome
		and to create flow		visits to start therapy (3)Total lead time (4)Process cycle efficiency	improved
Kollberg et al.	2007	Establish flow	(1)Predicting periods of high demands (2)Moving staff from periods with low demand to high demand periods (3)Information visibility and transparency for everyone	(1)Waiting times and delays (2) Actual and expected times at 8 different points of patient entry and exit (3)Number of times and distance a patient is transported	Designed "the flow model" to measure changes towards LT in health care services by identifying key performance indicators.
Nelson-Peterson and Leppa	2007	Waste reduction and to create flow	(1)Andon (visual flags at patient room door indicating status of room and key indicators for patients), (2)Just-in-time (supply boxes with point of use supplies that are restocked as needed with kanban system), (3)Standard work, (4)One piece flow (sequencing of morning rounds to complete all aspects of work with 1 patient before moving onto next patient), (5)Cycle time (length of time needed to assess and document on one patient), (6)U-shaped cell (to minimize walk distance of patients)	(1)Space, (2)Inventory, (3)Staff walking distance, (4)Parts travel distance, (5)Lead time, (6)Work in process, (7)Standard work in process, (8)Productivity gains, (9)Environmental health and safety, (10)Setup reduction, (11)% of surveyed patients who felt their call light was not responded to in a prompt manner, who felt their concerns/complaints received a poor response, (12)% of time registered nurse and PCT spent in indirect non-value-added care	Application of Lean principles has created conditions empowering nurses to practice in accordance with their desire to care for others in a system where non-value-added work, or waste has been minimized
Kelly et al.	2007	Create flow	(1) Task analysis, (2) Process redesign	(1) Total episodes of ambulance bypass, (2) Waiting time (overall and by triage category), (3) Total ED time (overall and by triage category), (4) Proportion of	Used task analysis and lean thinking approaches to re-design processes of ED and improve its efficiency.

Authors	Year	Principles	Practices	Performance Measures	Outcome
				patients who left ED without treatment, (5) Staff satisfaction survey	
Fillingham	2007	Eliminate waste and establish flow	(1) 6S (2) Standard work procedures, (3) Segregating very sick and more stable patients in different wards, (4) One piece flow (Move away from batching, backlog and queues), (5) Pull systems (Create signals to Pull patients), (6) Reduce paperwork	(1) Length of stay for fractured hips, (2) Mortality rates, (3) Time taken to get patients into theatre with a fractured hip, (4) Reduction in floor space, (5) Sample processing time in the blood sciences area	Lean implementation in healthcare can improve productivity through lower infection rates, quicker recovery and shorter lengths of stay. Lean cannot be simply translated unthinkingly into a hospital but lessons can be adapted and developed so that it becomes owned by healthcare staff and focused towards the goal of improved patient care.
Furman and Caplan	2007	Establish pull	(1) Failure Mode and Effects Analysis, (2) Root cause analysis; (3) Patient safety alerts, (4) Web-based reporting system so that staff could report PSAs on the hospital intranet	(1) Number of PSAs reported by type of PSA, (2) Number of PSAs reported by role function, (3) Number of days elapsed from first report to resolution, (4) Number of staff and processes taken off-line, (5) Percentage of staff who are aware of the PSA policy, (6) Percentage of staff who feel comfortable in reporting errors, (7) Percentage of staff who believe that VMMC treats patient safety as a high priority	Lessons learned are (a) executive leadership is a prerequisite, (b) reporting should be easy with multiple methods, (c) claims management staffing will go down as patient safety alerts go up, and (d) be prepared to change the processes of care as the organization learns from the PSAs.
Esain et al.	2008	Identify	(1) VSM, (2) 5S	Not mentioned	Both planned and emergent

Authors	Year	Principles	Practices	Performance Measures	Outcome
		value and reduce waste			approaches to change will exist in an organization, particularly when dealing with large, hierarchical structures often associated with public services.
Radnor and Walley	2008	Identify value and reduce waste	(1) Kaizen, (2) 5S, (3) VSM, (4) Kanban, (5) Single piece flow, (6) 'Post-It Note' maps	(1) Flow time, (2) Manual time or touch time, (3) Number of steps, (4) Time taken for registration, (5) Staff turnover, (6) Customer acknowledgement time, (7) Time to first appointment, (8) Diagnostic wait	Lean approach introduced allowed a process-based view, a focus on value, the elimination of waste and employee-driven change
Tsasis and Bruce-Barrett	2008	Eliminate waste	(1) PDSA, (2) Referral and triage guidelines creation and wait time management, (3) Role clarification and re-alignment, (4) Improving patient flow and scheduling;	Not mentioned	By implementing LT and change theories throughout an organization, a culture will emerge that is not limited to one department, but rather is shared by all departments and members of the organization.
Wood et al.	2008	Create value and reduce waste	(1) Collaborative work between physicians and appropriately trained clinical assistants, (2) Standardized training programme for all clinical assistants	Medication list completeness for medication name, dosage, route of administration and dosing schedule	Health-care quality may be greatly enhanced by addressing the processes of care in a coordinated manner with teams of allied health professionals and physicians who work together to provide patient care.
Shah et al.	2008	Establish flow and achieve pull	(1) Treatment protocol is the same for all patients with STEMI diagnosis, (2) Posters/pocket reminder cards for protocol, (3) Protocol for conducting	Process cycle time	Successful process improvement in a decentralized supply chain hinges on the extent of shared goals, shared

Authors	Year	Principles	Practices	Performance Measures	Outcome
			tests (e.g., blood tests; ECG) at community hospital meet MHI's standards, so tests are not repeated, (4) Each group trained by MHI counterpart to explain how protocols were designed (e.g., MHI MDs train community hospital MDs), (5) Process is in motion before patient arrives, (6) Limited decision branches in process, (7) Patient movement minimized, (8) Aggregate community hospital data shared across all hospitals for benchmarking, (9) Continuously seek detailed input from front-line workers (community hospital nurse, transport personnel, etc.) for continuous improvement		knowledge, and mutual respect. Continued participation of all members in process improvement efforts may be contingent on achieving superior performance on the desired (shared) goal.
Dickson et al.	2009	Establish flow	(1) Value Stream Map (VSM), (2) Value analysis, (3) Process redesign, (4) Kaizen	(1) Length of stay, (2) Patient satisfaction, (3) % of patient who left without being seen by a physician, (4) Time from ordering to reading radiographs, (5) Patient visits per month, (6) Percent of patients ranking overall ED care as "very good", (7) Admissions per month.	Lean can improve patient care metrics and satisfaction but it depends on the degree of adherence to TPS principles and local culture of emergency care.
Castle and Harvey	2009	Eliminate waste	(1) Redesign of the workspace, (2) Gemba walk, (3) Closer working relationship between doctors and nursing staff, (4) 1:1 nurse to doctor ratio, (5) SPC	(1) Time to pack a set of instruments, (2) Waiting time, (3) Complaints about waiting time, (4) Length of time from arrival to assessment by a	Observational data collection methodology is advantageous while implementing LT as it allows instant root cause analysis, allows those

Authors	Year	Principles	Practices	Performance Measures	Outcome
				nurse	participating to feel involved in the change, and provides rapid feedback.
Toussaint	2009	Identify value and eliminate waste	(1) Kaizen,(2) Small cross-functional teams, (3) VSM, (4) Collaborative care, (5) Standard work, (6) PDSA, (7) Locked and Stocked medicine cabinets installed in each room (to give nurses extra time that could be spent at the bedside), (8) Electronic health records	(1) Defect free admission medication reconciliation, (2) Same day appointments in every office, (3) Preterm babies delivered, (4) Mortality rate, (5) Patients average time spent in hospital, (6) Costs for a coronary bypass, (7) "Door-to-balloon" time (the minutes between a heart attack patient's entering a hospital and receiving a lifesaving angioplasty, (8) Quality bundle compliance, (9) Patient satisfaction, (10) Case-mix-index, (11) Average cost per case	Improved care and reduced cost can be achieved through small cross-functional teams, collaborative care, patient's input, changing physician culture, and use of electronic health records
Waring and Bishop	2010	Creating value streams and reducing waste	(1) Process mapping, (2) 5S, (3) Kaizen, (4) PDCA cycle, (5) Waste audits, (6) Productive theatre programme, (7) Formalisation of task division within the theatre team, (8) Addition of numerous tasks and checklists, (9) Condensed handover between clinical domains along the pathway and the cutting of certain pre-operative checks that could be completed prior to the day of surgery	Not mentioned	Implementation of lean healthcare represent another stage in the re-organisation of healthcare work, which can be characterised as contributing to the three prominent lines of change within contemporary healthcare reform: the use of evidence-based guidelines, the reconfiguration of occupational boundaries and new forms of clinical leadership.

Authors	Year	Principles	Practices	Performance Measures	Outcome
Grout and Toussaint	2010	Eliminate waste	(1) Jidoka, (2) Poka-Yoke, (3) Standard word document, (4) Cross-functional team for patient care	(1) Waiting time, (2) Rate of admission and medication reconciliation defects, (3) Average duration of patient's stay, (4) Patient satisfaction, (5) Average cost per case	Financial and medical improvements can be achieved using Jidoka and Poka-Yoke.
Huggins	2010	Waste reduction and to create flow	(1) VSM, (2) Kaizen, (3) Standardized process that delivers a rapid Medical Evaluation Board (MEB) decision	(1) Flow time (time from identification of a boardable condition to patient notification of final disposition), (2) Touch time (time from identification of a boardable condition to patient notification of final disposition), (3) Value added touch time (time from identification of a boardable condition to patient notification of final disposition)	Lean can be used to increase productivity of people, increase critical equipment availability rates, improve response time and agility, and sustain safe and reliable operations.
Meyer	2010	Identify value and eliminate waste	(1) Rapid improvement events, (2) VSM, (3) Cross-functional teams (care provided by an attending physician paired with a nurse)	(1) % of patients who received prohylactic antibiotics within an hour before undergoing surgery, (2) Average length of stay, (3) Bed turnaround time, (4) Total collection from uninsured patients, (5) Wait time for lower acuity patients, (6) % of patients left-without being seen, (7) Ambulance diversions	Lean implementation helps in increasing the revenue, patient satisfaction, and staff satisfaction.

Authors	Year	Principles	Practices	Performance Measures	Outcome
Setijono et al.	2010	Eliminate waste and create flow	(1) Supply and demand matching, (2) VSM, (3) Design of Experiments	(1) Non-value-added time, (2) Total patients' time in the system	Simulation output indicates that the emergency ward may achieve considerable reduction in a patients' NVAT and total patients' time in the system by assigning three medicine doctors and three surgeons.
van Vliet et al.	2010	Eliminate waste and create flow	(1) Streamlining the care process, (2) Preassessments followed the initial ophthalmic examination as a one-stop visit, (3) Standardised surgical care plan, (4) Trained nurses interviewed patients using a protocol checklist during a telephone review	(1) Patient visits %, (2) Access to the cataract pathway %, (3) Ophthalmologist's time spent per patient, (4) Number of patients treated	Challenge for healthcare teams is not just to improve care delivery by using lean pathways as opposed to using traditional pathways, but also to strive for optimal performance by consistently measuring and meeting easy-to-follow specifications.
Dahlgaard et al.	2011	Identify value	(1) Root cause analysis, (2) Quality maps	Not mentioned	'4P Excellence Model' contains both intangible systemic factors and more logical tangible factors. Suggested system can be used for assessing the existing organisational culture and for identifying necessary improvement areas.
de Souza and Pidd	2011	Eliminate waste and create flow	(1) 5S, (2) Visual control and information boards, (3) Level scheduling	(1) % of files delivered first time on time to outpatients, (2) Average length of stay	Barriers to lean health care are perception, terminology, personal/professional skills of health care professionals, organizational momentum,

Authors	Year	Principles	Practices	Performance Measures	Outcome
					hierarchy and management roles, data collection and performance measurement, and resistance to change/scepticism
Gabow and Mehler	2011	Identify value	(1) Clearly outlined set of reasons for escalation and detailed processes for escalation, (2) Checklists, (3) Geographic clustering of similar patient types, (4) Computerized physician order entry with standard order sets, (5) Mandatory infectious disease consultation for certain common and serious infections, (6) Concurrent and timely feedback to a prescribing team when multiple antibiotics were used for the same patient, (7) Evidence-based risk assessment tool and a clinical practice guideline, (8) Providing aggregated point-of-care performance data by specific clinic site and specific clinician to make the data available for audit and feedback, (9) Uniformity in patient care processes (standard work)	(1) Cardiopulmonary arrest rate, (2) Number of patients who required transfer back to the intensive care unit within forty-eight hours after being moved to hospital floor units	Integrated system for care, employed medical staff, and strong health information technology infrastructure can be helpful in creation of a structured approach to patient safety and quality of care.
Papadopoulos et al.	2011	Identify value and eliminate waste	(1) Standard work introduced for labelling, centrifuging and booking in FIFO system, (2) Visual management to optimise specimen reception	Not mentioned	Highlights the role of orchestrating the views and agendas of the various actors in a network (actor-network) to create spaces and choice points that facilitate a shift from

Authors	Year	Principles	Practices	Performance Measures	Outcome
					entrenched routines to new process organisation.
Smith et al.	2011	Create value and reduce waste	(1) Voice of the customer, (2) Voice of the business, (3) Trained clinic staff, (4) Checklist to screen records during the weekly team meeting	(1) Lead time, (2) Baseline capability, (3) Service level and cost, (4)Staff turnover	Higher quality care and increased revenue potential were achieved.
Radnor	2011	Identify value and eliminate waste	(1) Rapid Improvement Events or a Kaizen event, (2) Effective monitoring of outcomes and impact, (3) Process mapping, (4) Demand-capacity matching, (5)Visible leadership, (6) Dedicated Lean project teams, (7) Dedicated Local Lean Experts based in local offices, (8) Central Lean Experts rotated over three-month periods between sites supported by external consultants, (9) Senior managers to 'Lead Lean', (10) Management commitment, (11) Relevant training of staff, (12) Communication of the changes, (13) Team working skills, (14) More clarity around staff accountability, and (15) Freeing the time of practitioner by using more administrative and clerical resources	Performance measures for seven wastes: (1) Reworks: Recording patient details in multiple places (2) Waiting: Patients being moved before beds are available, Excessive waiting for doctors and consultants, Variable discharge processes, Longer length of stay, Average turnaround time in pathology, Time taken to process important categories of blood, and Specimen processing turnaround time (3) Motion: Patients being moved from one ward to another, Staff walking, Lab space (4) Defects: Death rate for patients, Number of infections, Number of non-safety incidents (5) Resources: Direct savings, Manpower FTE reduction	There is a direct relationship between the approach taken, the conditions of readiness and the service improvement activity in the organization

Authors	Year	Principles	Practices	Performance Measures	Outcome
Díaz et al.	2012	Waste reduction and to create flow	(1) VSM, (2) Registration of recurring patients directly at speciality clinic, (3) Variability reduction (triage performed at the field, and at the beginning of process facilitate the classification of patients and capture data), (4) Process simplification, (5) Pokayoke (use of coloured saris and cards to identify patient sub-flows, use of simple brochures to prepare patients for process), (6) Transport and motion reduction (compact size of facilities and optimization evident in design of operating theatre reduces motion waste), (7) Inventory optimisation (vertical integration with maker of critical supplies used to reduce costs and assure availability of critical supplies), (8) Waiting (streamlined processes facilitate reduction of bottlenecks)	(1) Waiting time, (2) Cost of treatment, (3) Volume of patients	Main driver for Aravind's efficiency was found to be an embedded set of lean services practices facilitated by an early triage process
Morrow et al.	2012	Waste elimination	(1) Balancing work pressure/clinical demand, (2) Dedicated Productive Ward team skilled in change management, (3) Allowing staff to learn by doing, (4) Adapting and developing metrics to their priorities, (5) Focus on staff empowerment to encourage participation and innovation, (6) Effectiveness through recognition of value of identifying and implementing small step change, (7)	Not mentioned	To support implementation, policymakers should focus on expressing what can be gained locally using success stories and guidance from "early adopters".

Authors	Year	Principles	Practices	Performance Measures	Outcome
			Participating in Productive theatre development, (8) Regular and extensive communication with teams, (9) Standard written documents to share the best practices		
Toussaint and Berry	2013	Waste reduction	(1)Respect for front-line workers (2)Visual tracking and flexible regimentation (3)Internal communications and teamwork (4)A3 reports (5)Color-coded and numbered equipment supermarket shelving	(1) Total cost of care for inpatients (2) Waiting time (3) Call volume (4) Medication errors (5) Operating room turnover time (6) Mean nursing time spent on gathering equipment	Template for implementation of Lean management system
Burgess and Radnor	2013	Identifying value and waste reduction	(1) Kaizen, (2) Productive ward	(1) Turnaround Time, (2) Productivity, (3) Efficiency, (4) Errors	Three key findings: (1) Lean implementation continues to be popular in English hospital trusts, (2) Hospital trust managers are implementing lean in different ways ranging from a tentative exploration in the form of learning from others (hospitals and organisations in other sectors), through to a systemic approach aligned to strategy, and (3) English hospital managers increasingly enhance and elevate their lean implementation approaches in line with organisation-wide programmes and to the organisation's strategy.
Bhat et al.	2014	Identify	(1)VSM, (2)Kaizen, (3)5S audit sheet,	(1)Average waiting time,	Lean Six Sigma will help in

Authors	Year	Principles	Practices	Performance Measures	Outcome
		value, waste reduction, and create flow	(4)Brainstorming, (5)Fishbone diagram, (6)GEMBA method of validation, (7)Keeping the stationery closer to staff, using desk organizers, (8)Displaying the information needed by the registration staff about doctors availability, physician to be consulted for the most frequent disease, amount of registration fees for different registrations, (9)Ergonomic design, (10)Poka-Yoke in the registration counter, (11)Standardized procedure for registration and displaying the same.	(2)Queue length, (3)Scheduled utilization of staff for the process	gearing up the process by eliminating wastes while stabilizing the process, through elimination of root causes of the problem.
Cook et al.	2014	Establish flow	(1) Health IT systems to acquire and report data on care process events, (2) Identify focused-factory patients, (3) Support bed planning and staffing, and confirm patient's continued suitability for the care management strategy, (4) Streamlining of workflow, (5) Place decision making at the bedside, (6) Mapping the care process, (7) Segment the patient population, (8) Empower the non-physician providers at the bedside	(1) Resource use, (2) Length of stay, (3) Cost, (4) Cardiac surgery condition comparison before and after focussed factory introduction	A focused-factory model within a solution shop, by applying industrial engineering principles and health IT tools and changing the model of work, can be very effective in both improving quality and reducing cost.
Rees	2014	Waste reduction and flow creation	(1) Plan-Do Study-Act (PDSA), (2) 5S, (3) Visual work organisation method, (4) A3 problem solving, (5) Value stream mapping	(1) X-ray pathway (Hours), (2) Fast track low acuity stream(Hours), (3) Reduced non-urgent ED attendances, (4) Reduced Rework and checking, (5) Pharmaceutical	LT is a quality system that can be successfully applied to hospitals to realise waste reduction and improved patient flows. Key influencers were top leadership involvement and

Authors	Year	Principles	Practices	Performance Measures	Outcome
				savings, (6) Patient admission/transfer times(Hours), (7) Ward discharge times, (8) Admission times	visibility, an overarching programme of improvement governed by a stated strategy or policy, and the existence of some organisation capacity or team culture, all of which are components of organisational readiness.
Aij et al.	2015	Identifying value and waste reduction	(1) Gemba	Not mentioned	By not being afraid of going to the work floor to study hypotheses in practice, by showing themselves to be part of the team and able to empower others, and by combining willpower with modesty, leaders will learn not just how to best implement lean, but also how to become true leaders.
da Silva et al.	2015	Waste reduction and flow creation	(1) 5S, (2) Continuous flow, (3) Standardized work, (4) Kaizen, (5) VSM	(1) Lead time	Lean office principles helped users in having a clearer view of the real possibilities and, therefore, reduced their level of anxiety.
Miller and Chalapati	2015	Create flow	(1) VSM, (2) Root cause analysis, (3) Implement scheduling to manage in-flow of patients, (4) Addition of junior doctors to the outpatient process	(1) Average outpatient wait time, (2) Average outpatients seen per day, (3) Patients per standard wage, (4) Schedule accuracy, (5) Average patients staying overnight	Lean tools such as VSM and root cause analysis can lead to dramatic reductions in waste and improvements in productivity.

Authors	Year	Principles	Practices	Performance Measures	Outcome
Chiarini and Baccarani	2016	Identify value	(1) 5S, (2) Kanban, (3) Total Productive Maintenance (TPM), (4) Single-Minute-Exchange of Die (SMED),(5) VSM, (6) A3 problem solving	(1) Patient satisfaction, (2) Lead time, (3) Waiting list time, (4) Errors (complaints, infections, errors in treatment and diagnostics), (5) Inventory reduction, (6) Average cost of a patient's treatment, (7) Average cost of inpatient management, (8) Cost of medical and surgical supplies, (9) Cost of capitalized or fixed assets, (10) Cost of repairs and maintenance on equipment and buildings	Deployment path for implementing TQM-Lean strategy starts with a strong commitment and involvement of top and senior managers and an external political endorsement. Strategic objectives are connected first of all to patient satisfaction and then to cost and time reduction.
Dogan and Unutulmaz	2016	Identify value and eliminate waste	(1) VSM	(1) Patient length of stay, (2) Non value added time per patient spent in the processes, (3) Transfer times, (4) Cumulative non-value added times	Healthcare organizations can benefit from Lean principles by evaluating its current state and understanding its potential for improvement
Matthias and Brown	2016	Identify value, reduce waste, and establish flow	(1) Service Improvement Teams/ Transformation Team, (2) Deliver 'more for less', (3) Teams are held accountable for outcomes through a series of monthly meetings to monitor performance against the plan	(1) Patient flow time, (2) Surgical day-care capacity, (3) Medical day-care capacity	Lean has to be seen as part of wider operations strategy. Moreover, this operations strategy needs to be seen as Lean's main driver. Lean capabilities need to be seen as the outcome - and not the driver - of operations strategy.

Table 3 - Distribution of employees in the case hospital

Role	Number
Doctors	31
Administration	8
Nursing	90
Housekeeping	25
Pharmacy	10
Front office and billing	8
Laboratory	17
Medical record keeping	13
Maintenance	8
Others	46
Total	256

Table 4 - Timeline of research study

Month & year	Event
October 2014	In collaboration with a doctor who joined our institute for pursuing master's program in business administration, the case hospital was approached to seek permission for studying how the LT initiatives were implemented. He recited anecdotal evidences on the case hospital's LT initiatives and how they differentiated from other competing hospitals in the market.
November 2014	After two initial visits and several email transactions with details on the objective of this research and expected outcomes, permission was given by the managing director of the case hospital to conduct our research. First author of this study was introduced by the managing director to the operations head of the hospital for assisting in taking forward the project.
December 2014	Operations head after briefly mentioning about their LT initiatives introduced the first author to their quality and accreditation manager. With the help of this team, all the major departments and associated LT initiatives were studied.
January 2015	Employees from different departments of the hospital, who were involved in the LT initiatives were interviewed to understand the procedure adopted by the hospital for planning and rolling out such initiatives.
February 2015	HR team and IT team members who embraced and implemented the changes that came up due to the implementation of LT initiatives were interviewed. Data were collected before and after the initial LT initiatives to compare the improvements (if any) achieved.
March 2015 – May 2015	A final comprehensive report on LT implementation was prepared based on the observations made during the multiple visits to the case hospital in the five months period.

Table 5 - Details of the case study methodology adopted

S. No.	Step	Summary
1	Getting started	Framed the following *RQ*s to be addressed: *RQ1. What is the current status of literature that deals with "LT implementation in healthcare institutions"? As an outcome from this review, we also expect to answer the following:* *RQ1a: What are the principles, practices, procedures, tools, techniques (in short, it will be called as "elements" from now on) of LT that are getting implemented in the health care institutions?* *RQ1b: What are the different performance measures utilised to report the benefits of LT?* *RQ2. Is there a standard procedure available in the literature to implement LT? If so, what procedure is being adopted by an Indian hospital while implementing LT and how does it help in improving its operational performance?*
2	Selecting cases	Best-fit candidate for this study who satisfied the following characteristics was selected. i. Implementing process improvement initiatives by borrowing from the elements of LT ii. Willingness of the top management to provide access and encourage the involvement of external researchers iii. Employees of the hospital including the physicians are open and involved in improving the processes iv. Data collection process is convenient for authors (convenience sampling)
3	Crafting instruments and protocols	Semi-structured discussions with employees of the case hospital who were involved in the planning and implementation of process improvement initiatives.
4	Entering the field	After getting the consent, multiple visits were made to the case hospital.
5	Analyzing data	Data gathered through semi-structured interactions, direct observations and hospital documents were analyzed to study the procedure adopted for implementing LT and developed a framework for assisting other healthcare institutions in implementing LT.
6	Shaping hypothesis	Data analysis was performed to examine the impact of different lean practices on the processes. Based on the experience of the case hospital, a standard five-step framework for LT implementation in healthcare institutions is proposed which can be tested empirically in future.
7	Enfolding literature	Findings of this study were anchored on findings from the literature that deals with "lean implementation in healthcare institution" and a framework was contributed to this literature.
8	Reaching closure	Stopped iterative analysis when theoretical saturation was reached – the point at which new evidence did not

appear (Strauss and Corbin, 1990)

Source: Structure adapted from Eisenhardt (1989) and Narayanamurthy and Gurumurthy (2015).

Table 6 - Details of employees in the case hospital with whom author(s) interacted

Designation/ Role	Number of people	Details
Managing director	1	As LT implementation needs to be initiated and supported by top management, managing director (MD) was involved in the team. In addition, MD commanded great respect from all the employees as MD was instrumental in the growth of the hospital from its beginning.
Physicians from different departments	3	Physician's involvement plays a key role as they are the one interfacing with patients and add a significant amount of value by addressing their needs.
Quality manager	1	Presence of a team member who is knowledgeable about the basic quality and operations concepts and healthcare standards is a necessity. Quality manager has the responsibility of implementing lean initiatives in accordance with compliance regulations and training employees with required technical programs.
HR manager	1	Core of LT implementation is at the culture and employees attitude of the hospital. HR policies play a key role in motivating employees towards successfully implementing LT initiative. Most of the LT initiatives fail due to employee resistance to change or employee fear of losing their job.
IT manager	1	Involvement of IT manager was felt necessary to receive inputs on how IT can be used as an enabler to reduce the wastes identified and add value to patients. Responsibility for training the employees to overcome their resistance towards new IT systems lies with the IT manager.
Public relations officer	1	Public relations officer (PRO) was involved as a team member to ensure that the process improvements addressed by the hospital were actually those valued by the patients and visitors to the hospital. PRO received the grievances of the customers and circulated it to the concerned in charge.
Marketing manager	1	Involvement of marketing manager is necessary to bring in the initiatives taken by other hospitals in the country to improve their processes and also to communicate the improvement initiatives taken by the case hospital to customers.
Medical records manager	1	Medical records manager was involved in this team to receive inputs on the implementation of electronic medical records system in the hospital.
Assistant	1	Assistant nursing superintendent monitors the completion of improvement initiatives taken and updates the

Designation/ Role	Number of people	Details
nursing superintendent		team on the challenges and impact of the initiatives taken. Works closely with the employees to convey the accountability through open communication and ensures that they buy the hospital initiatives as their own responsibility.
Nursing assistant	2	Supports assistant nursing superintendent to achieve the objectives set for the processes.

Table 7 - List of practices implemented in case hospital

Practices employed in Case hospital	Lean Practice	Implementation Procedure
Scheduled calibration and checking of equipment's	1) Zero defect principle 2) Safety improvement programs 3)Total preventive maintenance	Equipment was tracked by giving a particular serial number or asset number. Preventive maintenance of the equipment was ensured through a separate checklist against each asset number. Daily maintenance, weekly maintenance, monthly maintenance (calibration and functioning), and half yearly maintenance (servicing equipment by service engineer) were regularly performed.
Capacity Requirement Planning	1) Customer focus by maintaining spare capacity 2) Lead time reduction	Dialysis units were required by the case hospital and a number of units of dialysis machines required were found by estimating the number of patients every day. Due to capacity constraints, only 3 patients in place of 4 were provided service/machine in one day. By purchasing 7 new machines with a capacity cushion of 12.5%, lead time and back logging were reduced as patients were not scheduled for treatment on the next day.
Decision analysis in equipment maintenance	1) Employee participation 2) Suggestion schemes	Biomedical engineers were provided with autonomy to take decisions and provide suggestions based on their past experience with the equipment and process.
Scheduling staff cyclically	1) Production smoothing or load leveling 2) Workload balancing 3) Job rotation	Initially, two separate set of employees used to work for day shifts and night shifts but after implementing cyclical scheduling for all the employees, number of night-shift a single employee as a whole has to attend for a month significantly reduced.
Statistical process control of biomedical equipment's	1) Statistical process control (SPC) 2) Successive checking 3) Defect prevention	Several types of biomedical equipment were subjected to SPC. Especially equipment's which could be life threatening for minute variations in its output were consistently monitored using SPC.
Hospital equipment and accessories inventory control	1) Electronic data interface 2) Supplier involvement	IT-enabled bio-medical stores management system was developed and employed to store and keep a track of work orders, equipment master maintenance, purchase/indents, AMC/Insurance, reports, etc. Suppliers were interfaced with this portal to share the information and the onus

Practices employed in Case hospital	Lean Practice	Implementation Procedure
		was left on the supplier to manage the inventory, servicing, and maintenance.
Scheduling for outdoor patient department	1) Process simplification 2) Customer involvement 3) Cycle time and lead time reduction 4) Work in progress reduction	Patient can fix their appointment either by calling the hospital or using the hospital website where they have the option of selecting the timings and doctor of their choice.
Grievance management system	1) Customer focus and involvement 2) Defect prevention 3) Employee participation 4) Use of problem-solving tools	Cause and effect analysis (Ishikawa diagram) was used to reason the problems received through grievance management system from the visitors to the hospital. For example, high waiting time was reported by visitors at pharmacy counters and using the cause and effect analysis, some of the reasons were identified to be a lack of skill of pharmacy counter employees, irregular supply of drugs, space unavailability at counters and multiple prescription medicine cross checks in the pharmacy store.
Integrated Pharmaceutical Information System (IHIS)	1) Electronic data interface 2) Information sharing 3) Supplier involvement 4) Sole sourcing and supplier reduction	Pharmacy department through this information system was able to leverage on special deals given by the drug suppliers for bulk orders on the medicine with reduced shelf life as consumption pattern of each drug could be better tracked using IHIS. IHIS also enabled supplier inventory monitoring by interfacing the information system with suppliers.

Table 8 - Comparison of the performance measures pre and post implementation of LT solutions

Process	Performance measures	Before	After	Percentage Improvement
Outpatient department scheduling	Average waiting time at different nodes in the hospital	1 hours 20 minutes	30 Minutes	62.5% decrease
	Average total lead time from entering and leaving the hospital	115 minutes	35 minutes	70% decrease
	Average redundant patient walking distance	1770 meter	475 meter	73% decrease
	Average percentage of cases rescheduled per day	27 %	3.5%	23.5% decrease
Integrated Pharmaceutical Information System (IHIS)	Average number of medicine stock outs in a month	22	4	82% decrease
	Average lead time between order and delivery	3 days	1 day	67% decrease
	Average number of emails transacted for an order placement	6	1	83% reduction
	Number of instances of wrong billing in a month	13	3	77% reduction

Table 9 - LT implementation team

Role/Designation	Number	Details
Lean Sensei	1	Can be in-house (permanently recruited) or an external (temporarily recruited) depending on the funding availability with the hospital. Responsible for building the process improvement team and implementing the process improvement initiatives at the hospital.
Director of Lean	1	Recruited by the HR manager of the hospital. Lean sensei can provide potential references for this role. The hospital can also recruit one of its senior employees who has been active in improving the processes of the hospital in the past. Act as the link between the lean sensei and the hospital. Compatibility between the lean sensei and director of lean plays a key role in achieving success in the lean initiatives.
Process Improvement Consultant for Employees	3%-5% of the employee strength	Recruited by lean sensei and director of lean in consultation with the top management and HR manager of the hospital. Process improvement consultants directly interact with frontline employees and facilitate the implementation of process improvement initiatives. They conduct training workshops as instructed by the lean sensei.
Process Improvement Advisor	5% of the employee strength	Recruited by lean sensei and director of lean in consultation with the top management team and HR manager of the hospital. Already existing employees at the hospital can also be transferred to this role as they are expected to have a richer knowledge of the processes in the hospital. Process improvement advisor work on developing training materials for the employees under the guidance of lean sensei and process improvement consultants. They document the experience of LT implementation at the hospital in detail. They act as a bridge between process improvement consultant and employees and help in smooth training and implementation of LT by providing requisite materials.

Experience of Implementing Lean Thinking in an Indian Healthcare Institution

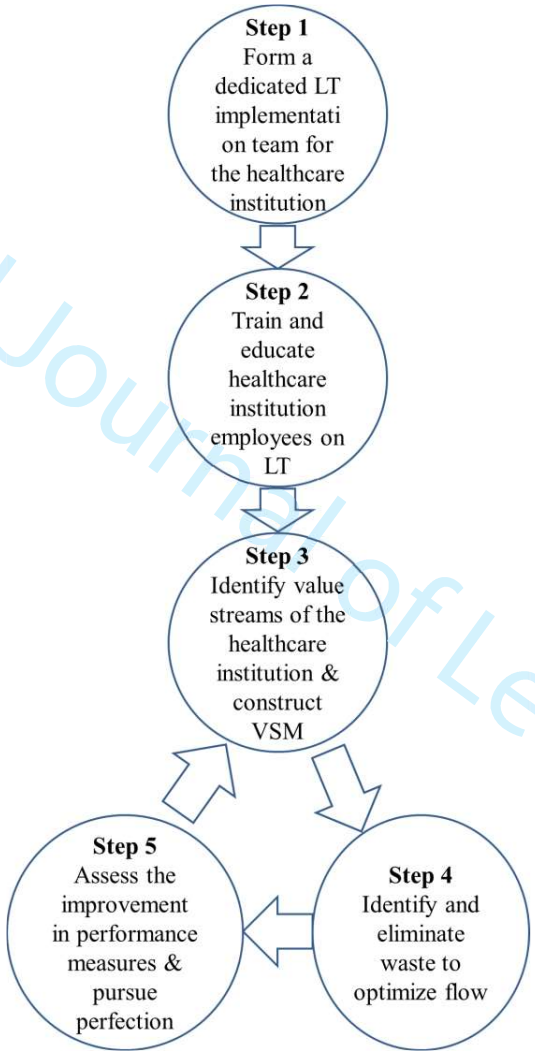

Figure 1 - Framework for LT implementation in healthcare institutions

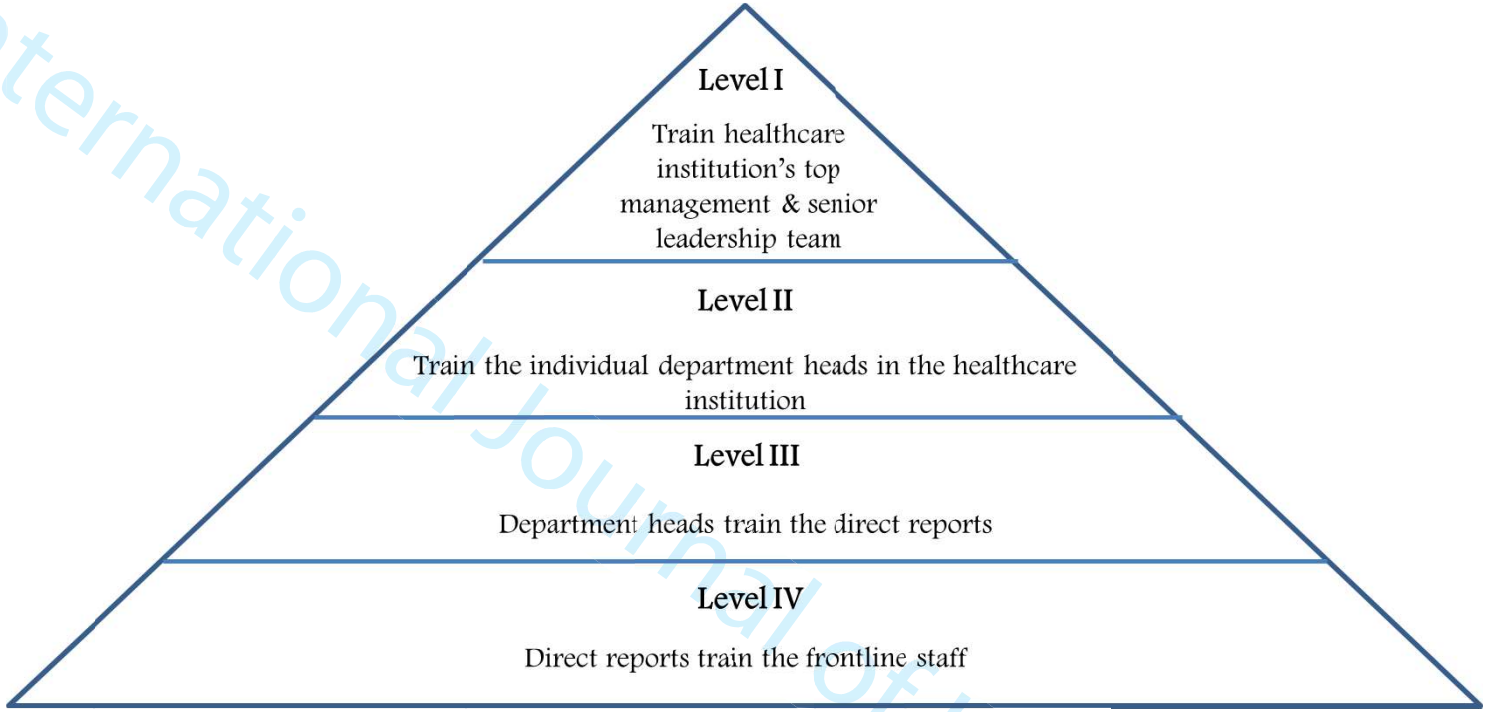

Figure 2 - Sequence of training employees in a healthcare institution

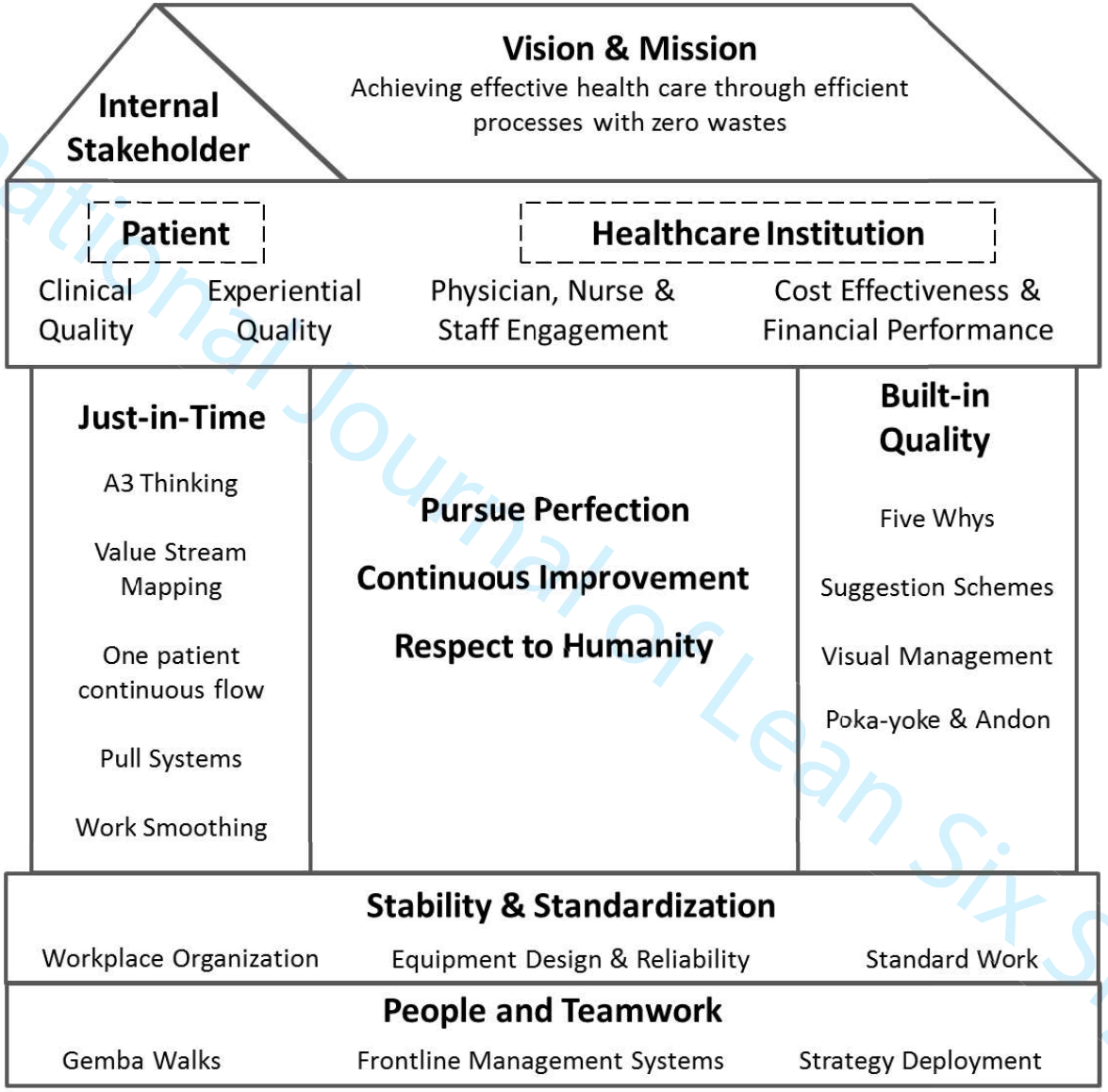

Figure 3 - Hospital of Lean (adapted from House of Lean)

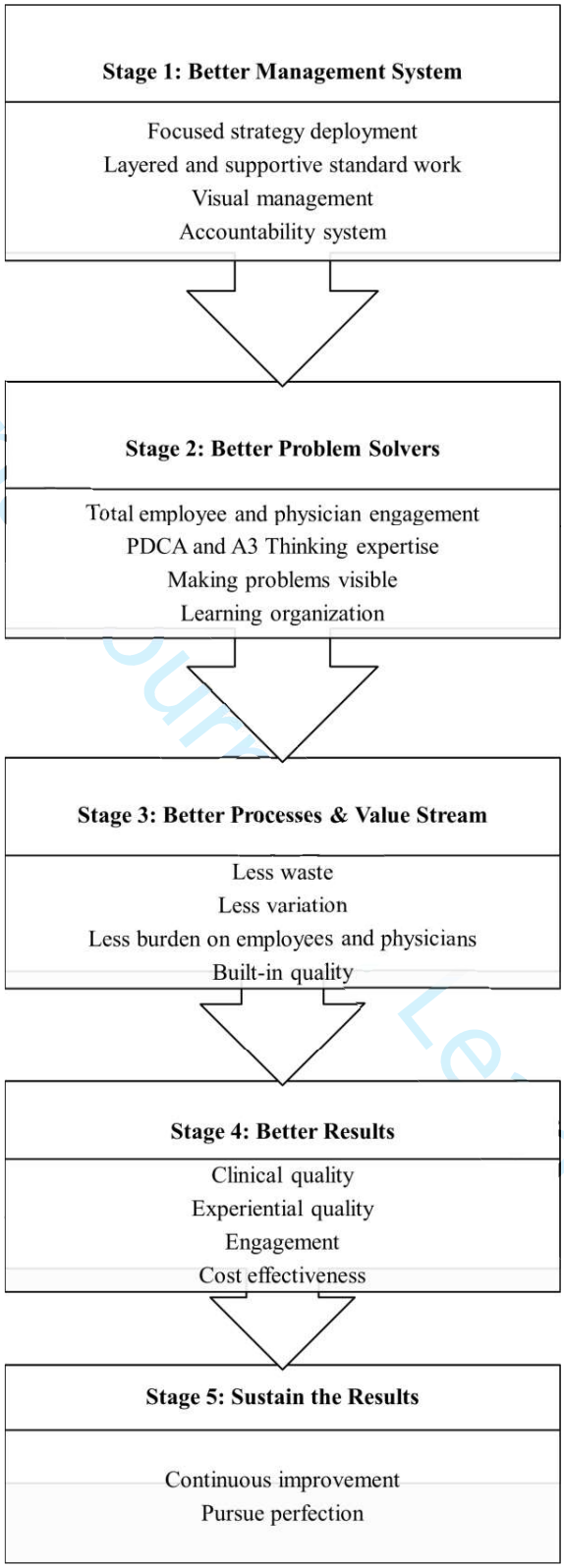

Figure 4 - Different stages of a healthcare institution in its LT journey