

Lean Healthcare Framework for Sri Lankan Healthcare Supply Chains: A Case Study of Teaching Hospitals

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Abstract This paper aims to show how lean six-sigma philosophy can be integrated to improve productivity of the patient care supply chains. Case study approach was used and three main hospitals in Sri Lanka were studied where the results can be generalized as applicable to other contexts. The main outcome of the research, lean six sigma process improvement framework was developed to address cost effectiveness, waste reduction and quality improvements in terms facilities, input resources and processes through blending lean six sigma best practices. Efforts to apply lean healthcare concept into different aspects of healthcare supply chain is rare in existing literature thus the paper fills the gap in the literature through addressing wide range of supply chain components.

Keywords Lean, Six Sigma, Healthcare Supply Chain

1. Introduction

Healthcare refers to diagnosis, treatment and prevention of diseases, injuries and other physical and mental disorders is associated with the primary care, secondary care, tertiary care and public health. Healthcare policies and accessibility are differed across countries due to being influenced by macro and micro environmental factors.

Sri Lanka spends around 5% of the total government expenditure for public healthcare. The network of government curative care institutions accounting to 80% of inpatient volumes ranges from sophisticated Teaching Hospitals including National Hospital with specialized consultative services to small central dispensaries [1]. Healthcare treatment process starts with the patients' registration at the Emergency and Accident Service or Out Patient Department (Figure 1).

State spending is leading to stagnation in capacity. Restricted availability of medicine and resources indicate the capacity constraints. Operational inefficiencies such as resource wastages, poor health information systems and unsystematic health referral systems act as obstacles for capacity utilization [22]. To improve healthcare facilities with existing resources, Sri Lanka need to find new methods or adopt available methods which are practically applicable.

Though lean principles were initially used to improve production of automobiles, lean principles could be applied to manufacturing, service and healthcare systems. Lean theory which focuses eliminating seven types of waste to develop customer value is generally based on five key principals [15]. Lean tools and techniques provide best practices and lay basis for key principals when adopting lean philosophy. It has been proven that lean concept contributes to increase service and results while reducing costs.

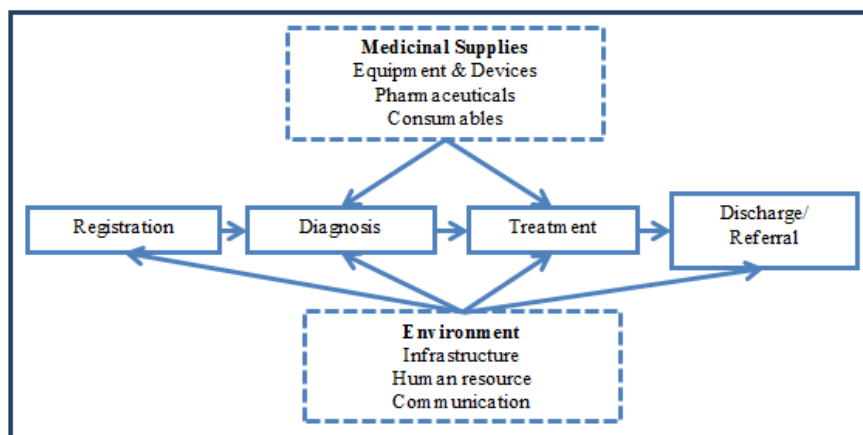


Figure 1. Scope of the healthcare supply chain

2. Literature Review

2.1. Commercial Supply Chains and Lean and Six Sigma

The supply chain can generally be described with upstream, downstream and internal organizational activities. Upstream activities, flows and relationships include purchasing and procurement functions. Included amongst these topics are outsourcing, vendor auditing, management and selection, supplier collaboration, supplier development and strategic dimensions instead of operational considerations. Internal organizational supply chain activities are related to traditional production and operations management of the organization including research and design, quality, inventory, materials, and technology management. Downstream of a supply chain focuses upon the outbound and downstream relationships and flows including functions of outbound logistics and transportation, marketing, distribution, packaging, and warehousing where the downstream customers may be commercial or individual consumers [20].

Jones, et al., 1997 provides a framework for production and manufacturing supply chains in terms of lean logistics. Pareto analysis was done for one particular value stream where it provides generic view which can be used in Healthcare [13]. The downstream of lean value stream includes Lean manufacturing, Lean warehousing and lean retailing. Four parts of lean are lean tools and techniques, involvement of people, continuous improvement and removal of waste [7].

Lean and Six Sigma can be combined in parallel to earn the advantage of synergy through clever cross-fertilization, such as taking variations in project complexity into consideration. Lean contributes to strategy and structure that would drive improvements, while Six Sigma contained the “tools to leverage improvement to its full potential”. Since it is unfeasible to apply one standardized approach to improvements in one company, yet it is difficult to generalize as it is to healthcare sector.

A research based on a case study of UK National health service has identified similarity between healthcare delivery and commercial logistics with the purpose to show that material flow concepts for commercial products and services can form equally well architectural infrastructure of effective healthcare delivery systems. Its approach was to healthcare delivery pipeline design using power of analogue method. Opportunities exist to transform new thinking in commercial and industrial logistics and supply chain management in to healthcare delivery to good effect [18].

2.2. Lean in Healthcare

Healthcare supply chains start from raw material supplier of medical supplies such as pharmaceuticals and medical equipment to patients, the final service recipient Critical point of the healthcare supply chain exists where hospitals acts as health care service supplier and patient receiving the

service.

Burgess & Randor (2013) discuss and evaluate how lean is implemented in English hospitals by content analyzing all annual reports and web sites which indicates lean approaches taken by staff considering large number of data (300) within two time periods to increase accuracy [5].

Lean implementations may not be actually in the process though it is stated in those sources. Sources can be biased, incomplete, distorted and not updated. This method cannot be used since annual reports are not available where public sector hospitals are not business organizations. In the other hand there is no evidence that Sri Lanka has transferred lean into healthcare.

A qualitative case study on UK National Health Service addressed a gap to identify the role of dynamic actor associations in shaping continuous improvements in a public sector context. Continuous improvements aim to achieve operational effectiveness, efficiency and strategic flexibility through cost effectiveness, administration efficiency and waste reduction. This UK based research mainly focused on actor associations using Kaizen blitz and Value Stream mapping as lean tools [23].

Kollberg, et al., (2007) looked for performance measuring system to measure changes in lean thinking in Swedish healthcare system following five elements of lean. Their studies included acute care model with two hierarchies namely administrative and medical, referral system and appointment system.

Performance indicators developed for implemented system [11] are:

- Median waiting time
- Number of appointments
- Comparison of Demand for different type of medical centers
- Number of incoming referrals

A qualitative case study on UK National Health Service [23] addressed a gap to identify the role of dynamic actor associations in shaping continuous improvements in a public sector context. This UK based research mainly focused on actor associations using Kaizen blitz and Value Stream mapping as lean tools.

Cost components of healthcare inclusive of medications, durable medical equipment, long term care, consultations and referrals, diagnostic tests and procedures can be reduced while level of service quality and results are uplifting through lean applications [4].

2.3. Lean Healthcare models

Chadha & Kalra (2012) suggested a LEAN-HC model that consists of three steps. First, the arriving patient flow must be evaluated against the capacity of the health care facility. The LEAN-HC model uses Physician Directed Priority Class Queuing (PDPCQ), which separates emergency patients at triage into major, medium, and minor injury classes. After the patients are separated, the three categories each have a single queue of patients, which await services that are

delivered in multiple phases. The second step involves creating a cross-functional team to understand and develop the value equation for their health care facility. At the third stage, the process must be continually de-bottlenecked, for which a Continuous Flow Cell (CFC) must be created [4].

A model for lean implementation suggested by Zidel model begins with the hospital's strategic plan and cascades toward organizational transformation via a quality culture and an enhanced care delivery system [10].

2.4. Evidence for Successful Lean Implementations

Empirical evidence for successful lean implementations obtained through the literature review favors the applicability of lean. Literature review indicates that benefits are possible in similar ways for similar issues (Table 1).

Table 1. Evidence for successful lean implementations

Implementation	Results
Pathology unit, NHSCO hospital in UK NHS[23]	Improved flow, Removed duplicate steps, More productive staff, Extra space has been created, Minimized staff movements, Standard work
Bolton hospitals- UKNHS[3]	42% Reduction in paperwork, Better multidisciplinary team working, Reduction in time taken to get patient into theatre by 38%, Faster recovery and lower demand on the rehabilitation ward, Total length of stay reduced by 33%, Mortality reduced by 36% , 50% reduction of floor space in pathology, 10% Increase in income
Indian healthcare industry [4]	Improved process flow and capacity, Length of stay for all patient classes in emergency department is decreased., Detecting opportunities to reduce patient turn around, Identify and shift service bottlenecks, No changes in resource availability, safety and quality, Reduced customer dissatisfaction level

3. Methodology

The research is followed as a case study and combination of a qualitative and quantitative research approach. Research questions are formulated for a combination of descriptive and exploratory research which is conducted as a study and analysis of Sri Lankan healthcare system with the review of existing literature available on lean healthcare adopted in Asia, Europe, and United States.

Annual health bulletins published by Sri Lanka Health ministry, Central bank Annual report and International Journal papers are used to identify the background, approaches, needs and current standing of the healthcare supply chains compared to developed nations. Non participant observations, interviews and set of questionnaires targeting the stakeholders of three main healthcare institutions have been used to gather information related to healthcare practices, issues in treatment and material procurement process, disease patterns and waste management in healthcare supply chains of Sri Lanka. The

targeted three samples include National Hospital of Sri Lanka (NHSL - the final referral center of country's healthcare system) and Colombo North Teaching Hospital (CNTH) and Colombo South teaching Hospital (CSTH). The sample frame consisted of a sample size of 130 stakeholders.

Since this research is more into qualitative research, quota sampling which is a non-probability sampling method is applied while having quotas as Doctors, Nurses, Medical Laboratory Technicians, Radiographers, Physiotherapists, Pharmacists, Medical Students and Patients in the study setting and people who wish to provide more information effective and efficiently will be selected for each quota.

Data gathering instruments focused on healthcare process at above teaching hospitals considering issues in current scenarios, policies and procedures and expected best practices to be achieved in terms of different aspects from different perspectives. The survey instrument consisted of 36 questions fallen into 12 categories was given to final year medical students to identify the current operational status and response rate remains at 87%. Ranked data in questionnaires was further analyzed subjecting to Kruskal-Wallis test using IBM SPSS® software to find whether the samples are originated from a same distribution through a comparison of variances by ranks.

Qualitative and descriptive data were analyzed using RQDA technique in R studio environment. Identified problems through RQDA were further analyzed using lean six sigma tools. Lean best practices derived from the lean six sigma tools such as JIT, Poka Yoke, Continuous improvement were applied to remove waste which is non-value adding activities. Current best practices in the studied hospitals and suggestions for improvements raised by the stakeholders were filtered for the compatibility with the lean six sigma approaches. Process Improvement framework developed with the use of lean tools and the outcomes were externally and internally validated through expert opinion, comparative analysis and empirical evidence.

For this study, the authors are reporting the results related to medicinal supplies and environment aspects only.

4. Results

In relation to the thorough data analyses current status of three hospitals were identified in terms of factors depicted from Supply Chain Operational Reference (SCOR) model. The current performance levels of the hospitals were recognized through the descriptive statistics of the scores given by respondents of the survey instrument.

Mean values of their responses remains at the range of 2.5 to 4.0 reflecting that the performance of CSTH is comparatively higher than the others and in overall performance level stands at moderate level. Standard deviation values range from 0.5 to 0.7 and show that overall standard deviation values remain at average level of values of each hospital (Figures 2 and 3).

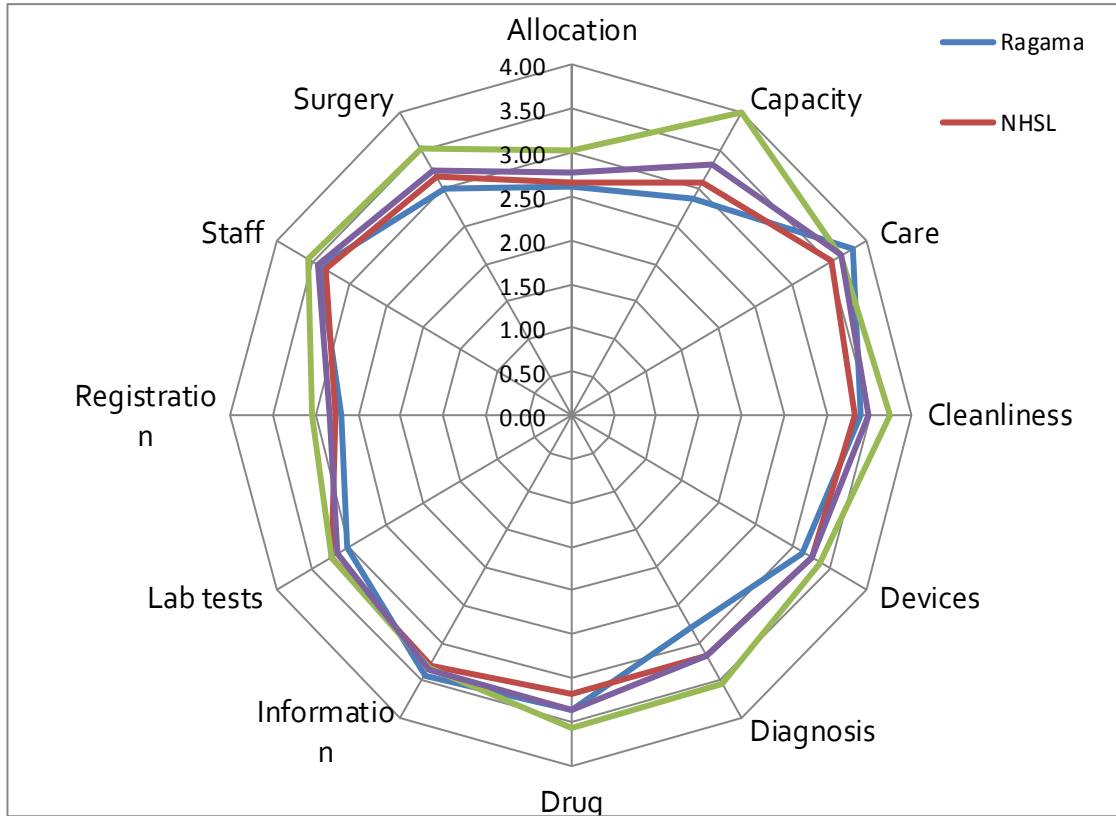


Figure 2. Mean Value Comparison

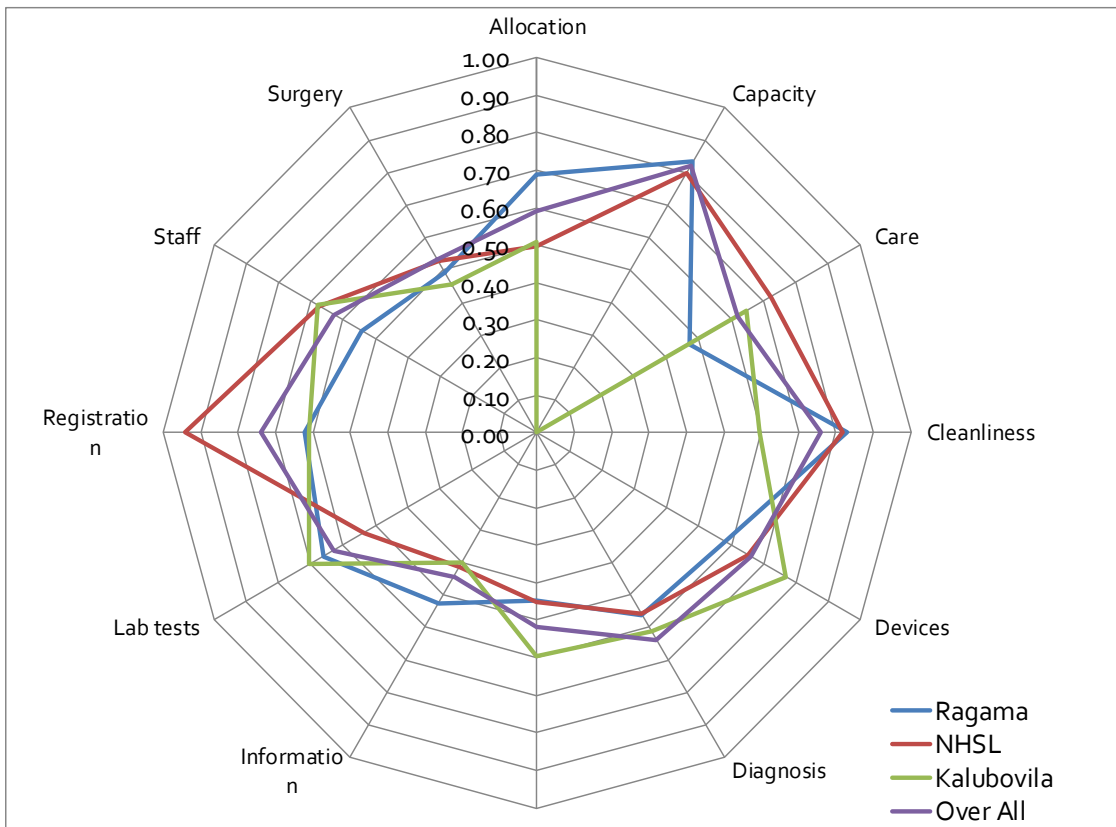


Figure 3. Standard deviation Value Comparison

According to questionnaire analysis current status of three teaching hospitals were identified in terms of factors depicted from Supply Chain Operational Reference (SOCR) model. The current performance levels of the hospitals were identified through mean and standard deviation of scores given by respondents for the questionnaires.

Mean values of their responses remains at the range of 2.5 to 4.0 reflecting that the performance of CSTH is comparatively higher than the others and in overall performance level stands at moderate level. Standard deviation values range from 0.5 to 0.7 and show that overall standard deviation values remain at average level of values of each hospital. Results from Kruskal Wallis test show

that the samples are originated from a same distribution through a comparison of variances by ranks.

Derived information from qualitative data analysis supported (Figure 4) to identify problems, causes for problems, current best practices currently followed by teaching hospitals and suggestions to improve. Actual causes for problematic issues are identified through root cause analysis (Figure 5). Suggestions to improve the medicinal supply process raised by stakeholders of healthcare institutions are mainly based on Information Technology. Many of the current best practices were identified from CSTH are worth expanding to the other processes.

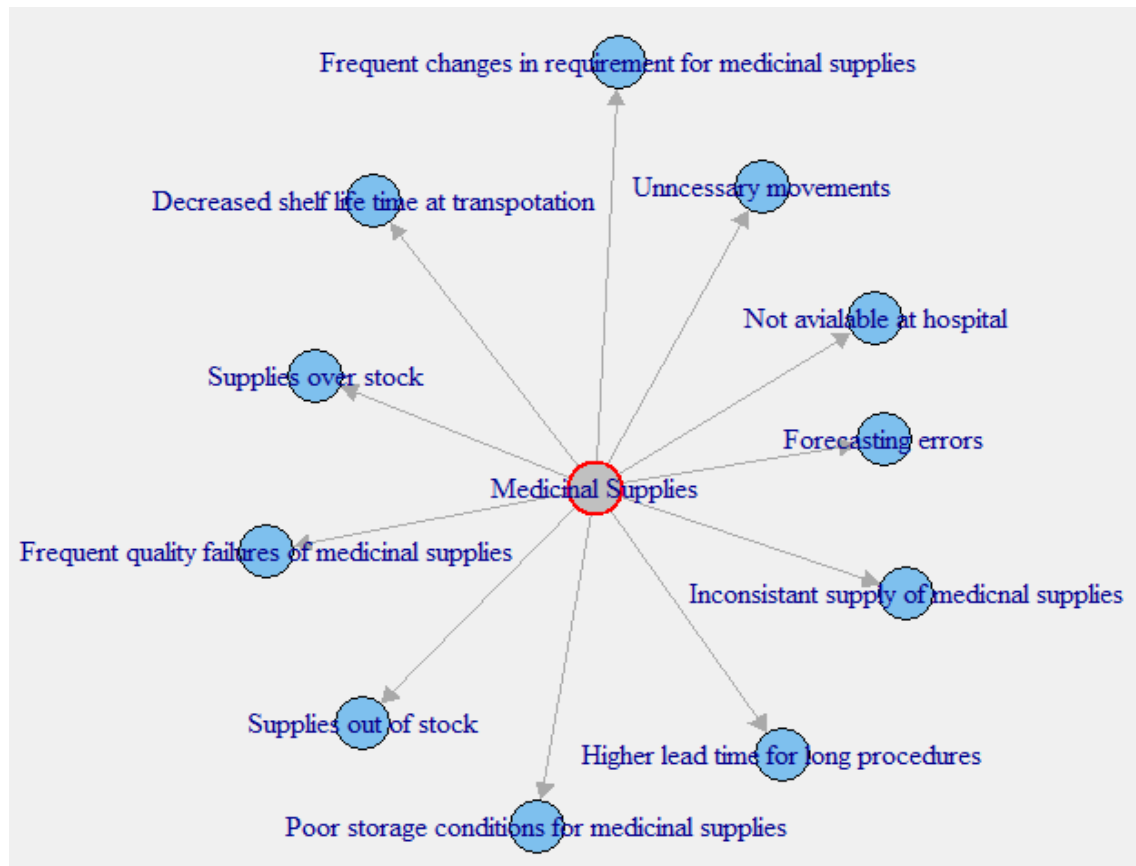


Figure 4. Problems in medicinal supplies

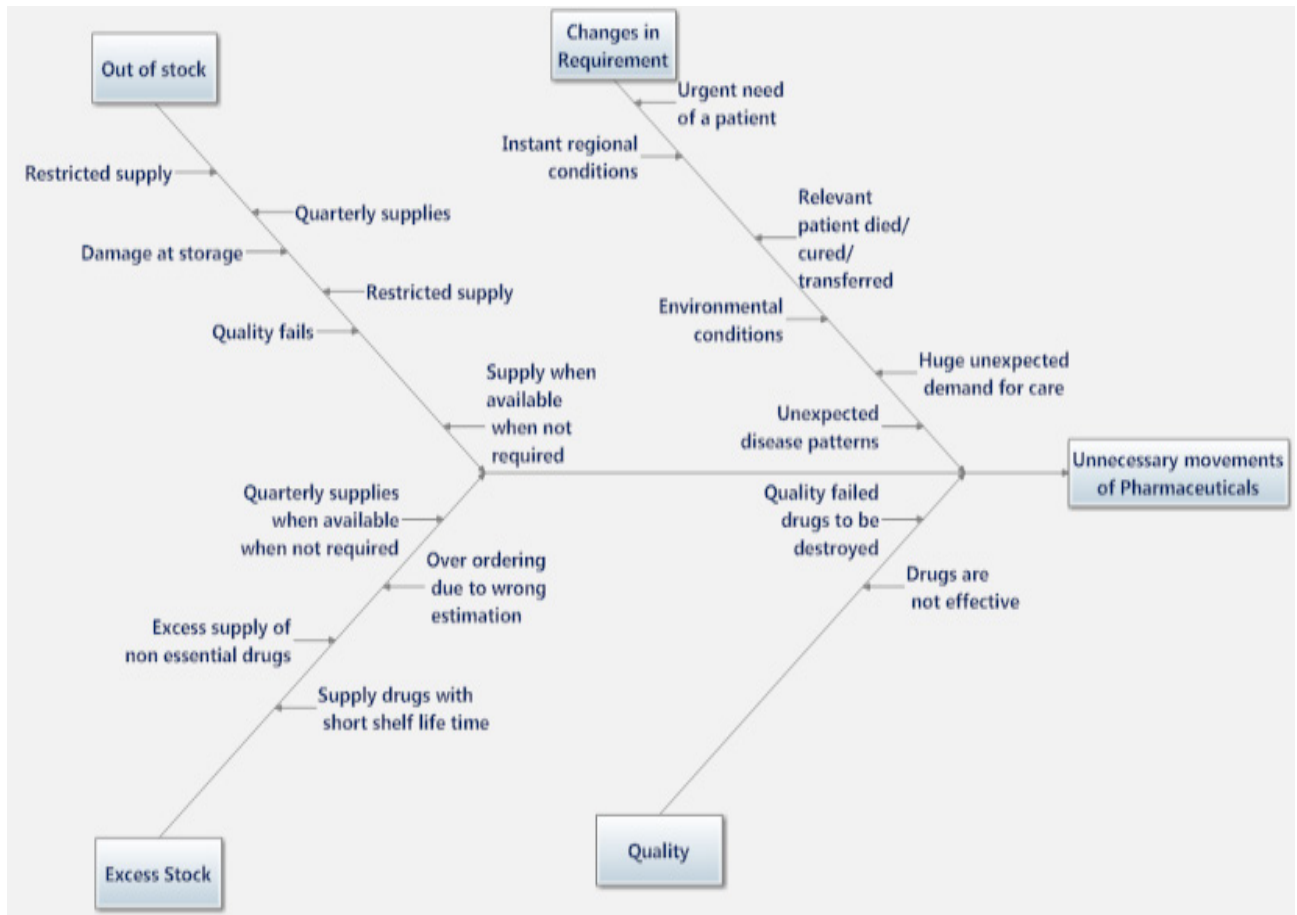


Figure 5. Root Cause Analysis–Unnecessary movements of pharmaceuticals

The issues identified in term of different factors are categorized into lean waste types. With the identification of relevant waste type, lean best practice approaches are mapped to eliminate waste incurred by the issues in different aspects.

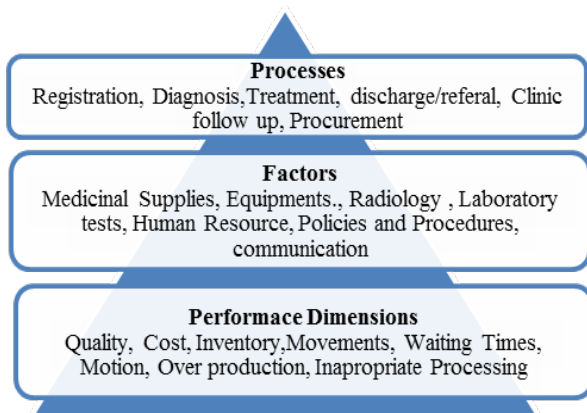


Figure 6. SCOR model for patient care supply chain

For the development of the framework, the factors and lean waste types as performance dimensions are considered with the assistance of SCOR supply chain model (Figure 6). The Lean waste types which contribute to non-value adding activities are considered as performance dimensions for

process improvement through lean six sigma approaches. The final outcome of the research, a lean six sigma process improvement framework for Sri Lankan healthcare supply chains has been developed to increase performance in stated dimensions by removing waste types appear in factors as a result of blending lean best practices, current best practices and suggestions to improve along with action plans for the enhancement of range of aspects. Strategic framework for change management was defined to work together with system creating rules as culture creating path.

Highest level of the framework is included the factors and processes of patient care supply chains, wastages in lean perspective, lean best practices and appropriate lean tools. (Figure 7)

Descriptive form of the framework is developed with lean six sigma action plans for each factor or process in the studied supply chains (Table 2) and performance measures are suggested to evaluate the process in order to take corrective actions (Figure 8)

When developing action plans, the importance-performance matrix concept was used to identify functions with urgent actions needed and required to improve. Selected areas were below the lower bound of acceptability since current performance is bad and importance is high.

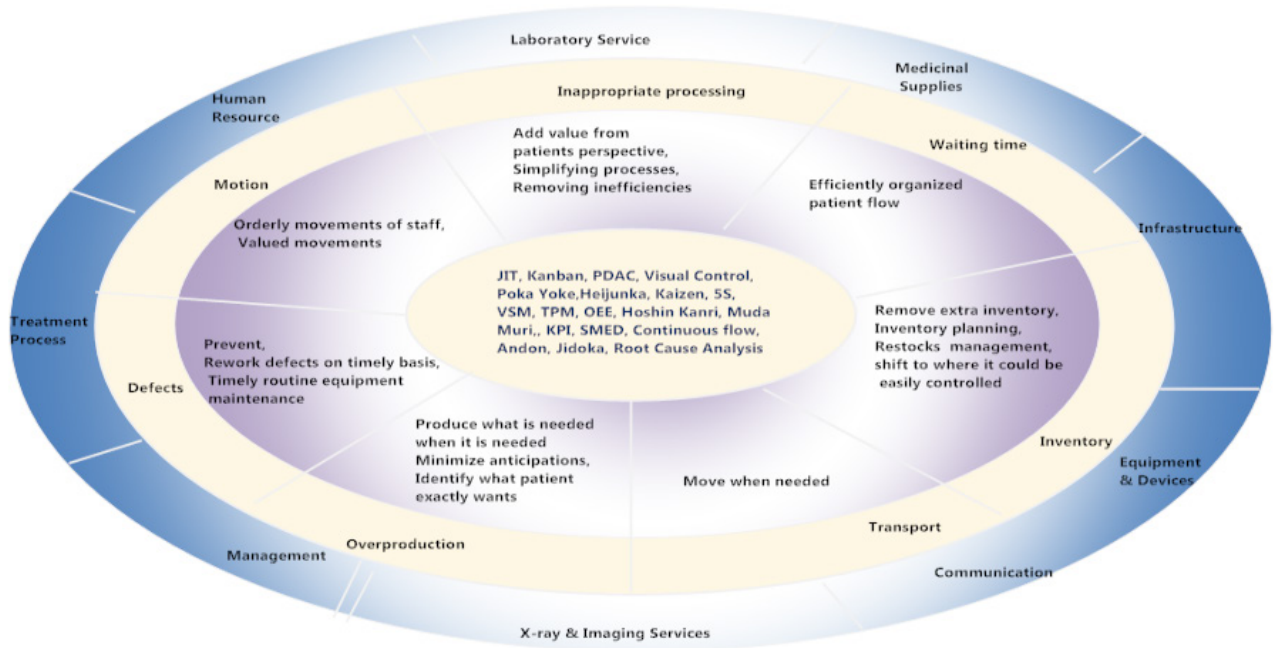


Figure 7. Overview-Lean Six Sigma Process Improvement Framework

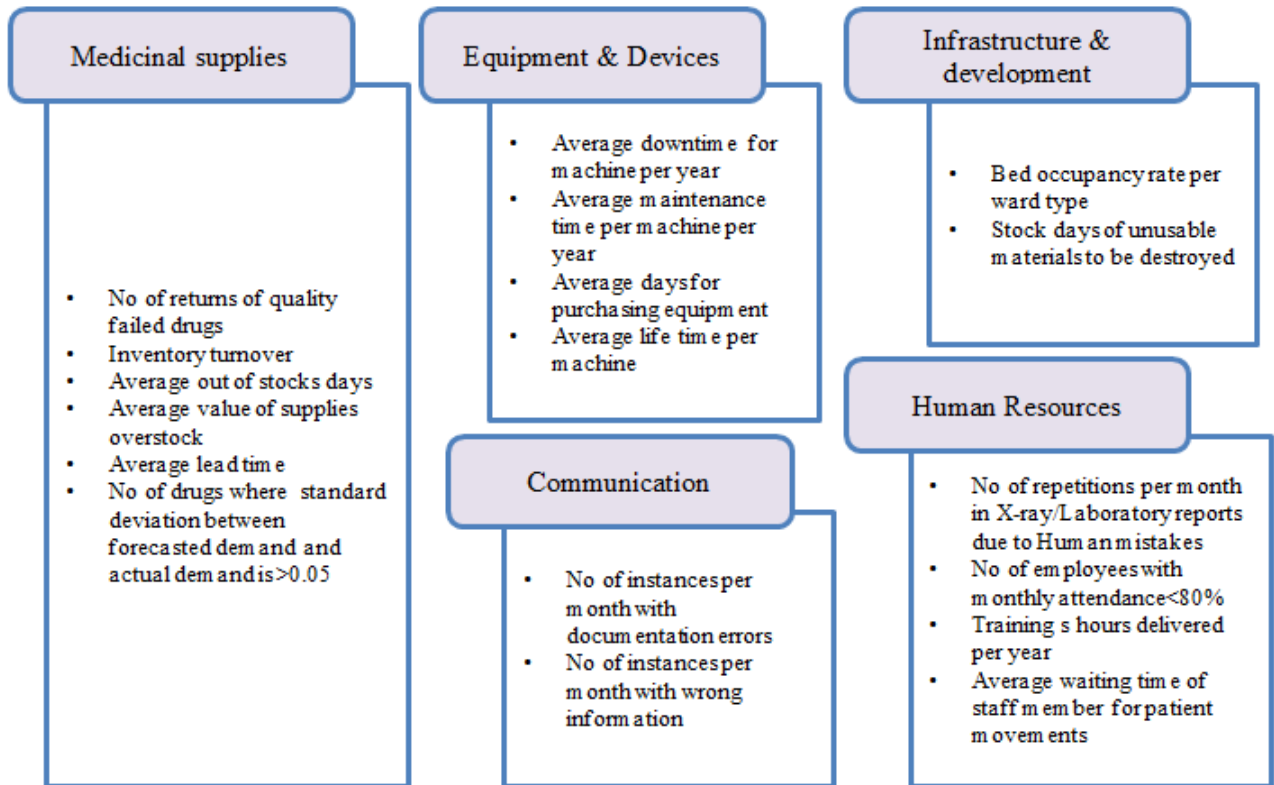

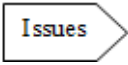
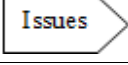
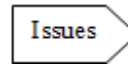


Figure 8. Performance Measures Suggested

Table 2. Lean six Sigma Process Improvement Framework for Sri Lankan healthcare supply Chains

Medicinal Supplies								
	Frequent changes in requirements for medicinal supplies, Unnecessary movements, Not available at hospital, Forecasting errors, Inconsistent supply, Higher lead time for long procedures, Poor storage conditions for medicinal supplies, Supplies out of stock, Frequent quality failures of medicinal supplies, Decreased shelf life time at transportation							
Value Stream Mapping	Standard work	JIT	Poka Yoke	Kaizen	Heijunka	POS	Muda	Mura
Identify value stream of materials and treatment process. Minimize wasteful transportation Minimize lead time and waiting time	Local purchase -lifesaving drugs from Osu Sala	Buffer stock for supplies based on standard deviation of demand. JIT and agile issues for urgent cases JIT material ordering through IT facilities	Use identifications for expiry date to help use before expiration when storing	Health Information System. Update knowledge on new equipments, concepts and drugs	Scheduled issues of by stores Use substitute when drugs are out of stock Exchange materials with nearest hospitals FIFO inventory management	Store frequently used parts near where they are used.	Economic and small batches supplies	Small frequent and continuous supplies eliminating fluctuation and unequal supplies
Equipment and Devices								
	Damages to equipment and materials, Poor quality and less durable equipment, Long lead time for maintenance, Poor handling, Higher lead time for long procedures, Variation of equipments depending on supplier, Machines with closed systems, No clear policy, Loss of economies of scale at purchasing, Absence of actual user in procurement process							
TPM	Standard work	Jidoka	Kaizen		5S	Overall equipment maintenance		
Check performance of devices regularly Small maintenance jobs done by operator Equipment maintenance by supplier	Use analyzers with open systems to avoid compatibility issues with regents Share resources at a shortage Get economies of scale through purchasing standard machines with less variations	Automated analyzers	Participation of real user in the tender process Use flexible user and patient friendly machines Update knowledge on new equipments, concepts and drugs Minimize unnecessary dependency on machines		Transfer machines which are not useful	Measure productivity loss for patient care process. Tracks losses of imaging machines , analyzers and devices in terms of Availability (down time) Performance (slow cycles)		
Infrastructure and environment								
	Poor storage conditions for supplies, Surplus of beds in wards, Shortage of beds in wards, Inadequate facilities, Discarding unusable materials, Space is limited, Excess level of staff waiting and movements, Difficult to share resources, Poorly organized layout, Movements to search places, Constraints in staff, Disorganized and unclean environments							
Jidoka	Kaizen			Heijunka	Visual controls	5S		
Automated patient information system	Wards maintained by private companies Automated patient/health information system Wards with different capacity as per occupancy Establish chronic patient wards nearby washing area Higher management support Maintain productivity unit Share resources at a shortage			Prioritize requirements	Colour zones and display directions	Dispose plastic for money Use one sided paper to pass messages Reimbursement scheme for condemned and quality failed supplies		
Human Resources								
	No proper method to attract B.Sc. Nurses, Mistakes by human, Lack of opportunities to learn, Highly stressed staff, Lower level of knowledge / awareness, No cross functional team effort, Poor attention, Poor attendance, Poor attitudes, Lower level of staff motivation							
Kaizen				Hoshin Kanri			Muri	
Dedicated and punctual service by staff Increase employee motivation Provide learning opportunities and transfer tacit knowledge Foster team concept Improve patient awareness Educate minor staff and change Attitudes Receptionist to provide information to patients				Empower employees to take minor decisions Minimize unnecessary dependency on machines Training for teams consisting different stakeholders Training by trainees Continuous training Update knowledge on equipments, concepts and designs			Delegated work	

Communication		
Issues	No cross functional team effect, Conflicting information, Inadequate information, Poor communication links, Poor documentation and record maintenance	
Kaizen	Andon	KPI
Cross functional teams with different stakeholders for collaborative planning Health information system Conduct ward conferences Contact senior nurse when patient cannot be reached Keep relations of patients informed Information flow and written communication Receptionist to provide information to patients	Visual feedback system for staff in wards and material stores Indicate patient records with given drugs, collected specimens with time Specify supply requirements within specification and brand	Maintain daily statistics Yearly estimations Cost and statistics evaluation

4. Discussion

This research focuses a wide range of healthcare supply chain components including medicinal supplies, equipment & devices, X-ray & imaging services, communication, human resources, laboratory services, treatment process, registration & discharge, infrastructure & environment. The Performance of Sri Lankan patient care supply chains can be improved through following the lean process improvement ladder (Figure 9).

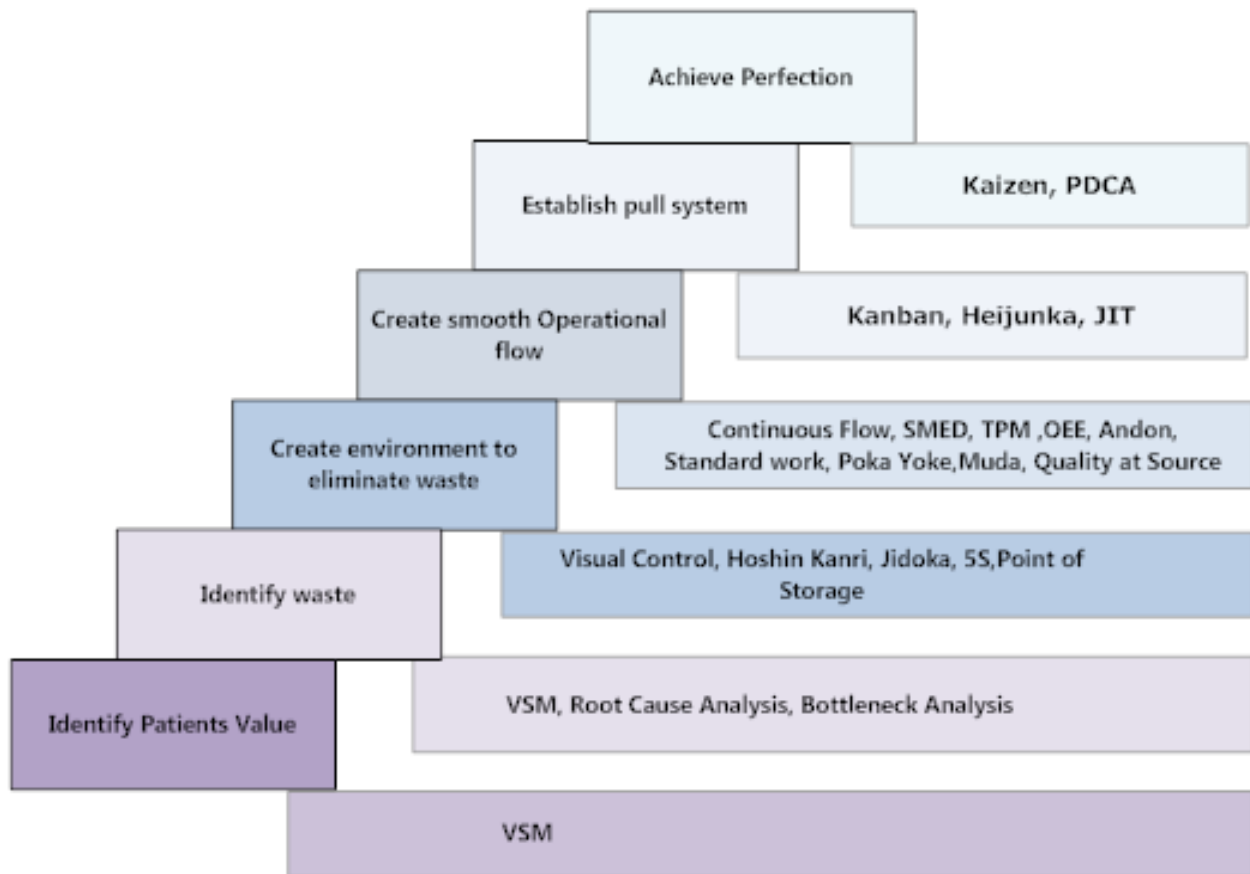


Figure 9. Lean six sigma process improvement ladder

Lean process improvement framework will not work alone where, it only represents the rules creating system. Since creating a path does not deal with creating a culture required to implement the research outcome, culture creating rules should be generated to work together with the rules for creating systems (Figure 10).

It is recommended to develop the institutional strategy as a culture creating path to attain higher level of quality and productivity in delivering patient care service through identifying strategic focus areas as Knowledge and Skill development, Operational process Management, Policy deployment, Information technology and factor and resource management. This is derived from the developed

process improvement framework.



Figure 10. Strategic map for lean hospital

5. Conclusions

Healthcare administration, medical staff and patients will be benefited through applying lean thinking. Lean Six Sigma tools and techniques suggests approaches for analyzing issues in the current system and provide lean best practices for better and quality service delivery with the application of lean healthcare framework results can be directly visible. If quick change over is applied in operation theatre, patient transferring time will be minimized thus, efficiency will be increased (Figure 11).

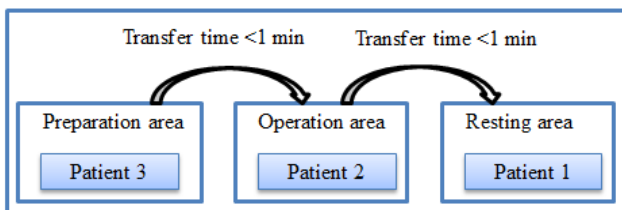


Figure 11. Application of ‘quick change over’ in theater

Medicinal supplies are being unnecessarily moved in current scenario (Figure 12) with the implementation of lean process improvement framework, supplies flow will be well organized and efficient (Figure 13).

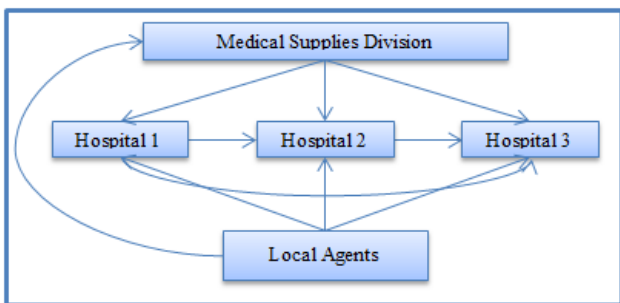


Figure 12. Current scenario for movements of medicinal supplies

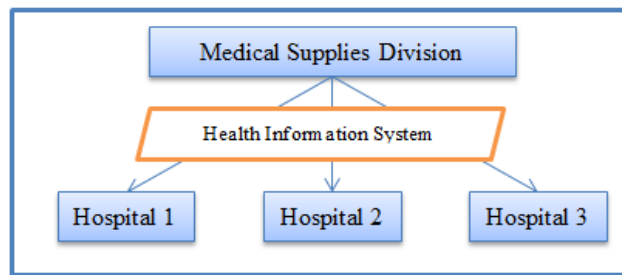


Figure 13. Future scenario for movements of medicinal supplies

6. Future Research

This research can be extended to a comparative study between public sector hospitals and private sector hospitals. It would help to extract best practices from private sector institutions to improve the public sector hospitals for the betterment of majority of the people and benchmarks can be set for improvements of public sector hospitals. This research is in the form of operational case study can be conducted to improve specialized service pipelines with in depth study of the above function. A study can be conducted to case study of patients with particular healthcare requirement such as circulatory systems, heart, diabetes etc. The study area of the research can be spread to focus on upstream medicinal supply chains and carry out in depth study of medicinal supply chains.

This research can be further extended to address the need of carrying out a research to design more effective and efficient health care service using available techniques and tools which has been achieved by manufacturing and service organizations in terms of operational excellence and cost effectiveness through adopting lean and six sigma applications.

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