

## INDUSTRIAL ENGINEERING CONCEPTS IN EMERGENCY DEPARTMENT OF HEALTHCARE USING LEAN – A ROAD MAP

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### ABSTRACT

**Background:** “Lean” is business improvement methodology focusing on delivering of services or products at better, faster and at low cost. **Objective:** Emergency Departments (EDs) face the challenges of crowding, waiting times, and cost containment. This review focuses on literature on how lean principles and tools can be applied for overall improvement and working in ED. **Materials and methods:** Primary studies showing Lean interventions and implementation in manufacturing, healthcare and ED where studied which focused on patient satisfaction, waiting times, left without being seen were selected. **Results:** A road map was prepared to reduce waste and to increase the overall performance of the ED. Medical issues and the impact of roadmap on medical processes are not part of the review. **Conclusions:** A road map will be able to reduce the waste in ED and higher quality studies are required before large-scale implementation of Lean interventions in ED following the proposed road map.

**KEYWORDS:** Lean. Emergency department, Road map.

### INTRODUCTION

In western countries Governments spend around ten percent of their gross domestic product on health issues.<sup>[1]</sup> This is not only due to the increasing life expectancy but also because people nowadays care more about their health. Both trends have led to the fact that health budgets have to be increased year by year. Hence, governments take a closer look at their budgets and increase pressure in order to implement more efficient delivery methods. On the other hand, vulnerable members of the community seek treatment at health care centres. These people who may be friends, neighbours, family members or strangers all deserve the best service available and no one wants to see them suffer.

Emergency Department (ED) plays a vital role in risk management of a mankind. In the present age, there is a growing risk of sudden epidemic and increased accident rate that put burden on ED. Natural or man-made disasters, accidents, sudden surge of infectious virus borne diseases, etc. are the major reasons for crowding the ED.

Emergency Departments (EDs) worldwide face challenges of crowding, cost containment, and excessive waiting times.<sup>[2,3]</sup> These issues represent larger problems in developed countries, resulting in disruption and inefficiencies to elective health care, patient discomfort, and higher in-hospital length of stay (LOS).<sup>[4,5]</sup>

Solving EDs problems requires a revision of the entire process of EDs care and needs integration and collaboration of all healthcare professionals involved within all organizational levels. While it is well known that acute hospitals have to set aside a defined number of beds for emergency admission, the optimal organization of unplanned admission to hospitals and the effective and efficient management of admitted patients flow in EDs is still uncertain. Although many external causes for EDs inefficiencies exist (i.e. social or financial) the internal organization of Eds also contributes to these inefficiencies.<sup>[6]</sup> During the last decades, many healthcare organizations worldwide began adopting approaches such as Lean Thinking (Lean) to integrate better health care delivery. Lean is a set of business operating principles developed by Toyota Motor Corporation in 1950s.<sup>[7]</sup> Lean is considered a quality

improvement method.<sup>[8]</sup> The key element in Lean is waste elimination through the identification of non-value-added activities, such as wasteful steps that don't give any value to the patient in terms of care (e.g. waiting times). This organizational philosophy emphasizes the identification of the root cause of a delay or problem with a bottom-up approach, starting from the workers and workplaces to understand the issues. Indeed, the starting point in a Lean re-engineering project is not a potential solution, but the development of a detailed understanding of how a complex process is actually performed.

Thus In ED, Lean can be defined as maximising the value of activities and processes for the patient whilst removing waste and improving quality and safety to ensure no harm is caused to the patient in the hospital environment.<sup>[9]</sup> Team work, communication and the breaking down of barriers for employee empowerment are social attributes required for success in Lean.<sup>[10]</sup>

Lean thinking methodology focuses on continual process improvement, worker partnership, problem solving, and the elimination of seven types of waste that defined by Taiicho Ohno.<sup>[11,12,13,14,15]</sup> Lean thinking has already been widely utilized across many healthcare facilities and organization in order to eliminate unnecessary waste, improve patients flow, reduce waiting times, maximize value to the customer, improve quality and increase efficiency.<sup>[16,17,18,19,20,21,22]</sup> Consequently, it is a tool of quality improvement that can considerably enhance efficiency and service quality.<sup>[23,24]</sup>

Dart<sup>[19]</sup> stated that lean thinking principles have gone far in the last decade and applied in manufacturing, production and service organization for thousands of times and the application of this approach in emergency departments will not be an exception. As a result, lean thinking can be considered as a different method for achieving efficiency in the ED. Therefore, lean thinking has been applied in healthcare systems and emergency departments for reducing waste and improving patient flow. However, the application of lean thinking to measure and improve the efficiency in ED did not receive enough attention in research and, hence, the relationship between lean thinking and efficiency enhancement in ED is still vague and requires a thorough study and investigation.

Expanding the EDs capacity is not enough to tackle the crowding issue or improve the quality and efficiency of the provided services.<sup>[25]</sup> yet the EDs should enhance patient flow, resources and processes efficiency. Therefore, establishing efficient and effective strategies to increase the emergency departments' efficiency should receive higher priority from hospitals management. Abdelhadi and Shakoor.<sup>[26]</sup> reported that improving efficiency within the healthcare system or emergency department is the key component for increasing quality and sustainability of the provided

services to patients. Also, reducing wastes and enhancing service efficiency of the process leads to a significant decrease in the operating cost.<sup>[27]</sup> Thus, several researchers and scientists paid an attention to efficiency issue in healthcare systems and deeply investigated the factors that affect this problem and proposed suggestions for improving efficiencies in healthcare facilities and organization.<sup>[28,29]</sup>

Obviously, the research effort on healthcare efficiency and particularly attempts to improve efficiency in emergency departments is still in the infancy stage. Different and inconsistent criteria for estimating efficiency in the emergency departments were investigated and tested, such as patient Length of Stay (LOS).<sup>[30,31,32]</sup> ratio-based measures.<sup>[33]</sup> frontier techniques.<sup>[34]</sup> etc. This inconsistency in standards for measuring the efficiency in EDs has stimulated various agencies to support the efforts for the development of new techniques to measure the EDs efficiency

In this regard a road map was prepared in which in stress is laid on the tasks in the ED. It also defines who is responsible for each tasks and how it is to followed, so that each task becomes standardised and can be implemented in the ED.

## LITERATURE REVIEW

Literarily review is divided into the following

1. Lean History at Toyota
2. Lean in Health
3. Lean Hospital Wide
4. Lean in Emergency Care and critical success factors.
5. Lean in a Challenging Environment
6. Leadership and the change process
7. Team Building and Lean Training
8. Lean and the Organizations Strategy

**Lean History at Toyota-**In the early part of twentieth century Toyota a small engineering company was suffering because of high demand of varieties of cars, less human resources and limited financial capital. The company realised the problem and designed a concept that if parts were preassembled instead of first manufacturing all the parts and then assembling it, by doing so the errors were detected early and pre measures was applied.

**Lean in Health-** Lean implementation in a hospital can be found in "Leadership in Health".<sup>[35]</sup> in which article mentions the implementation of lean was first done in 1988 when many hospitals considered it as a business philosophy.

### Lean Hospital-wide

Lean's intention is not to reduce the number of employees, but more importantly to improve the quality delivered to patients by reducing waste generated.<sup>[36]</sup> It reduces mortality rate, readmission rate, waiting time,

time spent in hospital, paperwork, costs and increases patient satisfaction rate, interdisciplinary team work.

Patients recover faster and need less attention in wards so staff have much needed time to start and improve the existing process.

Seven flows have been identified as critical in healthcare.<sup>[37,38]</sup> which are:

1. Patient flow- to reduce the walking distance and the sickest patient need not to walk for long for treatment.
2. Clinicians flow- Clinicians have to move very frequently to different location if their walking distance is reduced, it reduces stress and improves patient- clinician relationship.
3. Medication flow- Optimal medication flow supports the patient and occurs if right dose is provided at the right time.
4. Supplies flow- An optimised supply of consumables provides high quality patient treatment.
5. Information flow- Reliable and consistent information must be provided for timely, high quality and safe patient care.
6. Equipment flow- Equipment must be available all the time so that treatment is not delayed as delay due to unavailability affects patient care.
7. Process engineering or Kaizen leaders- In hospitals process engineers are often clinicians. They should have the experience and knowledge to identify the process gaps.

#### **Lean in Emergency Care and critical success factors**

Staff before implementation of lean was engaged in patient complaints, reorganising appointments due to late arrivals or had to deal with patients who were assigned to another triage group.<sup>[39]</sup> so the patient care was under threat and correct action has to be taken. Overcrowding in ED is a major patient safety concern and was occurring because the staff and clinicians where batching people for next treatment to reduce their walking time.

After implementation of lean the assessment time, patient waiting time, discharge time and waiting for beds in wards was significantly reduced. It changed the work environment in ED after the new process was implemented and roles and responsibilities were assigned the nonurgent patient was tracked early and serious patient was given bed immediately and their registration was done later. Data collection, monitoring and technical issues were addressed and training and communication tools were changed. It led to change in work and it changed the work environment and staff became more friendly.

Some of the critical success factors in installation of lean are

Hospital's executive members must commit to the lean transformation.<sup>[40]</sup> and set clear and measurable goals.<sup>[41]</sup>

and spend time implementing lean. They should be engaged in continuous improvement process.

It should be understood that how lean can transform structure, work process and how its effects patient and employees, in this transformation communication is a major key factor which should be ongoing and on frequent basis. This is achieved by training which can be in a group or in mass education and should address insufficient supervisory, workforce and managerial skills.

It should be noted that lean is not just about implementing tools or methods but to create a program which addresses several problems simultaneously.

#### **Lean in a Challenging Environment**

Introducing lean manufacturing in a hospital challenges Leaders, doctors' physicians and nurses at their daily work and this is taking place in an environment where staff are already at their limit.<sup>[42]</sup>

#### **Leadership and the change process**

Leadership as a key factor in the success of a lean project whereas poor leadership can kill your organisation. A successful lean implementation is dependent on the leader, it is important that top leaders bring non-managerial staff, such as physicians on board as it improves key performance indicators (KPI) right from the start.

Leaders in transformational environments need to be skilled and have charisma, loyalty and respect and must be able to bring people together, form effective teams to achieve goals. They should create a vision and transform the environment from low to high performance with a long-term perspective.

They should be aware that a new thing is shown resistance which is of four types organisational, political, individual and technical resistance and they should address them quickly otherwise the transformation will fail. Resistance towards new technology is most common as people fear that they do not have the right skills to learn how to use new equipment. Political resistance is, caused by the fear that people will have a lack of control. Organisational resistance is if people feel a loss of pride or ownership and finally, individual resistance where staff ask how they benefit from the change. This resistance can be achieved by Establishing a sense of urgency, forming a powerful guiding coalition, creating a vision, Communicating the vision, Empowering others to act on the vision, Planning for & creating short term wins, consolidating improvements & producing still more change and Institutionalizing new approaches.

#### **Team Building and Lean Training**

Team building is five stage model namely forming, storming, norming, performing and adjourning. It is achieved by Lean training which should be done prior to

starting of the project by training sessions and workshops. It should include a basic understanding about lean and its methods and tools. These trainings can be mass trainings or top down approach in some leaders first get training and then train their peers.

### Lean and the Organizations Strategy

For implementation of lean tremendous discipline is required to set up long- and short-term targets which is best achieved by applying KPI's in the organisation for continuous improvement.

Lean concept has found its place, not only in manufacturing, but also in healthcare where it is spreading rapidly. Literature covering success stories are widespread whereas literature discussing lean critically is rare. Often mentioned is the involvement of management and leaders in the transformation phase and their role in the change process.

### METHODOLOGY

#### AIM OF THE RESEARCH

To increase a patient's wellbeing while in a hospital's Emergency department.<sup>[43]</sup>

To increase the patient's satisfaction and, in lean terms expressed, reduce waste in an emergency department (ED), which in turn can have a positive impact on cost.

#### RESEARCH QUESTION

How can the lean concept be successfully implemented in an emergency department and what has to be considered throughout the implementation?

#### SCOPE

To collect current literature and design a lean roadmap for a team of staff in ED in a hospital which focuses on patient flow and the processes applied.

#### DATA SOURCES AND SEARCH STRATEGY

This narrative review was conducted. The search was conducted independently in the following electronic databases: PubMed, Scopus, CINAHL, EconLit, NHS Economic Evaluation Database, Business Sources Complete, Health Technology Assessment, without any limits on time or language in order to consider the whole existing body of literature. Each database was explored with the same combination of subject headings and text words. The primary search was conducted using the following algorithm: "emergency department" , "healthcare emergency", "Lean thinking" , " Toyota", "Lean in healthcare" , "Lean in emergency care" , "lean in challenging environment" , "Lean in organisational strategy" , "Leadership and change process" , "Team Building" and " Lean Training".

#### STUDY SELECTION

The data was selected which focused on lean history, lean in health care, lean in emergency department and

data which focused on reducing waste in an healthcare specially emergency department (ED).

#### BOUNDARIES

As it is applied in a hospital, medical issues and the impact of the proposed roadmap on medical processes are not part of the review.

#### INTERVENTION

The broad perspective for intervention of interest, the literature was framed focused on Lean applications (also reported as lean methodology) and Lean-related tools and principles.

#### DATA EXTRACTION, ANALYSIS, AND SYNTHESIS

The literature review was framed from all the data available. The data was reassessed with respect to study selection to reach to a final outcome to understand the history and present implementation of lean and necessity of a road map for implementation of lean in Emergency department.

#### EXPECTED OUTCOME

The expected outcome are as follows

Sponsors recognize the benefit of lean and openly support and promote a lean campaign. By selecting an effective team.

A selected lean team can organize and manage themselves so that little supervision is needed.

#### FINDINGS AND DISCUSSION

After reviewing the literature, it was observed that among the various lean tools the most applicable to healthcare and particular to ED are as follows.

- 1.) Methods to understand processes in order to identify and analyse problems
- 2.) Methods to organise more effective and/or efficient processes
- 3.) Methods to improve error detection, relay information to problem solver, and prevent errors from causing harm
- 4.) Methods to manage change and solve problems with a scientific approach

#### Processes and Process Analysis

Value stream mapping (VSM) has been identified as the most often used tool in healthcare.<sup>[44,45]</sup> VSM' goal is to differentiate between services that provide a value to the patient.<sup>[46]</sup> and to monitor waste generated during treatment. The seven wastes are, defects, overprocessing, overproduction, transportation, motion, inventory and waiting.

#### Effective and Efficient Processes

Effective or efficient processes can be distinguished by their different goals. They are: Doing the right things for effectiveness and doing the things right for efficiency.

Greater emphasis is laid on designing efficient processes. Often the layout of an ED limits efficient processes. The layout should be in such a way that the patients and clinicians have the shortest possible distance to go for their treatment.

### Improve Error Detection

The responding staff noticed that their patient experienced an error occurrence i.e. adverse event at the interface between ED and the ward. Its flow risks can be mitigated by having good communication between the departments. In addition, the process should be standardised and defined which identify a deviation from best practises and includes directives, guidelines, working procedures or checklists to address near misses.

### Manage Change and Solve Problems

The change causes distress among people and in order to support the change process members of the executive need to break away from their well-established pattern. A practical way for participation of leaders in current problems or situations can be found in Gemba walking. For a member of the executive Gemba walking is to go to the place where lean is applied, get an impression of the process and talk to staff. The Leader not only shows interest in the process but also gets an understanding of the way lean is applied and by talking to people the leader can take people's fear of change away.

The lean tools are applied not only to reduce waste but also to gain a better understanding of occurring problems and how to overcome these in order to design effective and efficient standardized processes and workplaces.

### LIMITATION OF PREVIOUS STUDIES

After reviewing the literature, it was observed that maximum studies are based on lean application on hospital wide or it focuses on the medical issues in the hospital or ED. There was no study found which focuses the various tasks that are present in the ED, and the responsibilities of the staff who are performing this task.

### PROPOSED ROAD MAP

As there was no particular guidelines in a systemic way, a roadmap was designed on reviewing the literature, which will guide those who are interested to apply in Lean in Emergency department and to those who have already started a Lean initiative it is thought that this roadmap will help them to keep on track and recall the commitment made.

The road map is divided into five stages

**Get Ready** – In the first step only the management of the organisation is involved. This may differ from other roadmaps, but as previously discussed, management's united participation and powerful support for lean is crucial.

**Set up** - Since management has agreed on starting a lean initiative and funds are available the process involving key stakeholders can start. Literature identified middle management (MMA) as the biggest obstacles.<sup>[47]</sup> for a successful lean implementation. As a result, they are addressed foremost in the set-up step.

**Roll out**- Now that a Project Manager (PM) is selected and resistance amongst middle management is extinguished, it is time to address all workforce in the ED and select the lean team.

**Perform** - The performing stage is where shifts start to improve the ED but not to forget that the lean team coordinates all activities. However, it is important to recall that lean's intention is to improve the patient flow by considering value added. In addition, the lean concepts asks for small steps to be taken<sup>47</sup>. This is especially important in an ED in order to control arising risks.

**Sustain**- Now that the ED is frequently having lean events and staff have understood that lean can add value to a patient's treatment, it is time to move on to a stage where the main focus is to consolidate the lean initiative. Leaders, for example top and middle management but also clinicians, are the drivers for this stage. The theory applied is based on the change management process where it is mentioned that change stops if victory is declared too early.<sup>[48,49]</sup>

Flow Chart of the Road map													
Get Ready		Set Up		Roll out		Perform		Sustain					
Identify Urgency	MGMT	Create sense of urgency among MMA	MGMT	Create sense of urgency among workforce	MGMT	Focus only on tasks within the department	Team	Reward staff	MGMT				
<ul style="list-style-type: none"> <li>Changes are inevitable.</li> <li>Increasing error rate.</li> <li>Frequently changing staff...</li> </ul>				<ul style="list-style-type: none"> <li>MGMT's obligation to outline start, commitment and outcome</li> </ul>		<ul style="list-style-type: none"> <li>Task must be completed in ED to avoid chaos and resistance.</li> </ul>		<ul style="list-style-type: none"> <li>Ask shifts what to do first and let them work on a chosen Task</li> </ul>	Team	<ul style="list-style-type: none"> <li>Management recognise achieved results and respond with adequate rewards.</li> <li>Rewards according to organization policy.</li> <li>Sponsored barbeque to improve team building.</li> </ul>			
Create a vision	MGMT	Lean has significant potential for improvements	MGMT	Wide spread lean	PM	Create quick Wins	Team/MMA	Adjust strategy	MGMT				
<ul style="list-style-type: none"> <li>Management discusses- Current and future state of ED.</li> <li>Need of written vision.</li> </ul>				<ul style="list-style-type: none"> <li>Ask Questions</li> <li>Identify hidden resistance</li> </ul>		<ul style="list-style-type: none"> <li>Project manager presents project to staff.</li> <li>MGMT in unison at event.</li> <li>General information, mass education is provided.</li> </ul>		<ul style="list-style-type: none"> <li>Choose and work on task which causes hindrance in efficiency</li> <li>Support feeling what counts is there work.</li> </ul>		<ul style="list-style-type: none"> <li>Make sure shifts are effective to achieve quick win.</li> <li>Feedback by recognising that change is for better</li> </ul>		<ul style="list-style-type: none"> <li>Adjust business strategy according to results.</li> <li>Recall and renew the commitment</li> </ul>	
Agreement on long term involvement	MGMT	External expert provide training on Ed situations	MGMT / MMA	Create sense of worth doing	MMA	Show interest	MMA/MGMT	Set KPI's	MGMT/ MMA				
<ul style="list-style-type: none"> <li>Defining a strategy</li> <li>Reach formulated vision</li> <li>Addition to the strategic plan</li> </ul>				<ul style="list-style-type: none"> <li>Management participate fully in event</li> <li>Simulation game creates process optimization.</li> </ul>		<ul style="list-style-type: none"> <li>Middle manager set lean goal like patient and staff satisfaction and no reduction in staff.</li> </ul>		<ul style="list-style-type: none"> <li>Management to attend time to time 10- minute meeting</li> <li>Honour achieved results and commitment and support for lean</li> </ul>		<ul style="list-style-type: none"> <li>Information board at central to improve communication.</li> <li>Bulletin shifts' work to know changes and where results are expected.</li> <li>Introduce 10-minute meeting.</li> </ul>		<ul style="list-style-type: none"> <li>KPI's as steering element to achieve results among middle management and clinicians.</li> <li>Set new KPI's.</li> <li>Keep staff busy is they are following lean</li> <li>Do not appoint new staff for lean.</li> </ul>	
Taking off the MGMT hat	MGMT	Address resistance within middle managers	MGMT	Improve value adding thinking	MMA	Address resistance	MGMT	Retraining staff	MMA/Team				
<ul style="list-style-type: none"> <li>Support of management on a regular basis.</li> <li>Management equals to member of the workforce</li> </ul>				<ul style="list-style-type: none"> <li>Feedback</li> <li>Identify concerns and address</li> <li>Management to demonstrate unity, support and willingness</li> </ul>		<ul style="list-style-type: none"> <li>Training to understand value and non-value adding tasks.</li> </ul>		<ul style="list-style-type: none"> <li>Do Gemba walking</li> </ul>		<ul style="list-style-type: none"> <li>Value stream mapping to observe work performed</li> <li>Make notes of task completed and involved flows.</li> </ul>		<ul style="list-style-type: none"> <li>Assess risks</li> <li>Before implementation analysis risks of designed process.</li> <li>Mitigate risks or create intervention plans.</li> </ul>	
Define worthiness	MGMT	MMA choose project Manager	MGMT / MMA	Building the team	Team	Share risk	MGMT	Gemba Walking	MGMT/ MMA				
<ul style="list-style-type: none"> <li>Management define and approve funds.</li> </ul>				<ul style="list-style-type: none"> <li>Creation of multidisciplinary team.</li> <li>Inclusion of all shifts</li> <li>Not to include or exclude people depending on rank.</li> </ul>		<ul style="list-style-type: none"> <li>Team evaluates how best to work together.</li> <li>Accept the difference and see opportunities in difference</li> <li>Define involvement and expertise above day-to-day role.</li> </ul>		<ul style="list-style-type: none"> <li>Inform management about risks and actions planned so risk is shared.</li> </ul>		<ul style="list-style-type: none"> <li>Training on new processes</li> <li>Training about newly process, possible risk and how to react.</li> <li>Feedback for redesign.</li> </ul>		<ul style="list-style-type: none"> <li>Implement new process under supervision and observe efficiency.</li> <li>Use of Deming circle (PDCA) to understand and improve.</li> </ul>	
Passing the Gate	ALL	MGMT to take their hat off.	MGMT	Set 'smart' goals	Team/MGMT	Standardize new processes	ALL	Optimise Layout	Team				
<ul style="list-style-type: none"> <li>Management supports above points</li> <li>Project should start.</li> </ul>				<ul style="list-style-type: none"> <li>Middle management select project manager and their direction</li> <li>Project manager is MMA with transformational leadership qualities.</li> </ul>		<ul style="list-style-type: none"> <li>Select goal carefully for team lacking lean experience</li> </ul>		<ul style="list-style-type: none"> <li>New process as standard.</li> <li>Staff training on new process.</li> <li>Repeat training on regular basis</li> <li>Take those on board who fall back to old ways</li> <li>Monitor effectiveness of new changes.</li> <li>Show participants benefits of new processes and provide leadership.</li> </ul>		<ul style="list-style-type: none"> <li>Optimize processes within ED so team reaches level of maturity.</li> <li>Time to include processes which are beyond the department.</li> </ul>		<ul style="list-style-type: none"> <li>Small changes in layout.</li> <li>No major construction activities.</li> <li>Recall: Lean executing small but persistent steps.</li> </ul>	

**CONCLUSION**

The purpose of this study was to discuss the lean concept and its applicability in an ED. Due to the fact that emergency departments are often overcrowded, the population is ageing and government funds are limited, ways to reduce inefficient processes or to improve these are urgently required. However, in the centre of interest there is the patient who often is vulnerable once arriving at the ED. It is widely recognised that ED's standard processes provide poor additional value to them. Hence, improvements are then successful if patients receive treatment processes which provide additional value.

This roadmap provides guidance to the process of installing and keeping the lean concept in their organization as a strategic approach. A critical point is reached at the end of the "Get ready" stage.

Lean road map will improve the value of the care delivered to patients. Lean represents a fundamental change in the way of delivering care. The specific process changes employed tended to be simple, small procedure modifications specific to unique people, process, and place.

In order to clarify the link between the business strategy and the lean implementation further research is required to for continuous improvement, resolve the interactions and close the gap of research.

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