Application of Lean-Six Sigma to Improve Quality in Healthcare Industry

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1. Abstract

Using Lean-Six Sigma is one of the best solutions to tackle weaknesses in the U.S. health system. General manufacturing companies have used Lean management & Six Sigma successfully for the last few decades. Lean methodology focuses on removing all waste throughout a given process, so that output efficiency, quality and profit all increase. The main steps in Lean manufacturing involve identifying value-added and non-value-added processes. In order to use this Lean thinking in organizations, all leaders must start thinking in terms of cutting waste and developing an ongoing culture to sustain such habits. In addition, all employees in the targeted organization must be involved in developing and redesigning significant processes to reduce waste and improve quality. This paper will discuss the current challenges being faced by health care industry and ways to tackle them using Lean-Six Sigma. It will give information about Lean-Six Sigma, its implementation and challenges faced during its use.

2. Introduction:

The USA spends more than any other country on health care: $7,500 per person per year. Even so, USA ranks lower than 49 other countries in average life expectancy.[15] In 2004, the United States ranked 29th in the world in infant mortality, tied with Poland and Slovakia. USA has an infant mortality rate of around 6.71. [16]The main reason for our country's health care issues is a considerable shortage of primary care physicians. Many other deficiencies also exist in the U.S. health sector.

Primary care is provided by family physicians, general internists, general pediatricians, nurse practitioners, physician assistants, and others who work in the primary care sector.[35] These clinicians are responsible for delivering accessible first-contact care; providing continuity of care through ongoing relationships; comprehensively addressing the majority of patient needs, whether they are urgent care problems, chronic care needs, preventive care needs, or psychosocial needs; and integrating specialty referrals and ancillary services to provide patient-centered, whole-person care.

Over the past decades, the number of U.S. allopathic medical school graduates entering family medicine residencies has dropped by 50 percent.[36] A decade ago, half of all residents in internal medicine residency programs planned to practice primary care general internal medicine, but today only 20 percent plan to go into primary care. [20]The same trends are apparent when you look at the nurse practitioner workforce and the physician assistant workforce: Fewer and fewer graduates are going into primary care fields.

Our most conservative estimates say that by 2020 USA will be short about 340,000 nurses. The Bureau of Labor Statistics thinks that the number will be as large as 1.4 million. But even if it is 340,000, that shortage number is three times greater than what USA have experienced to date[18].

This health care issue is bigger in Louisiana State. When compared to other states, Louisiana spends a great deal of money on health care with a very low return. Louisiana has ranked 50 in health care for 15 of the last 17 years, according to the United Health Foundation. [19] The state's challenge to improve health and health care delivery has only intensified due to the impact of the 2005 hurricanes. The storms caused substantial damage to the private and public health care infrastructure and intensified chronic shortages of health care workers. The migration of people in need of health care compromised access to care for the insured, underinsured and uninsured in those locations.

3. What is Lean?

Lean focuses on reducing waste and increasing customer value. It provides more value to customer using fewer resources. To implement Lean into organization it must understand customer value and focus on to increase it. [14]Using Lean a perfect value can be delivered to customer by developing a perfect value creation. Ideally processes will have zero waste after implementing Lean into them

To accomplish this, lean thinking gives focus on optimizing flow of products and services rather than focusing on technologies, assets and departments. [22,23]As waste is eliminated from entire value streams it produces processes which require less effort, resources, less cost and less delivery time. .[8,9]Due to lean thinking companies can keep up to changing customer expectations with high quality, less cost and less time. The workflow in lean process is defined as follows:

3.1 Just-In-Time: In this method product is developed when ever necessary and how much is necessary. This reduces non value added inventory time in a product cycle.

3.2 Kanban: Limited number stock of each product is kept in a specific area of market. When a particular product stock is sold a card will be shown indicating which product has been sold.

3.3 Production leveling: Balance production over a period of time.

3.4 Setup time reduction: Reducing the time to adjust between different processes.

3.5 Standardized work: Having documentation of every process followed so that all processes are followed every time.

3.6 Multi-skilled workers: Workers will be trained in multiple areas so that different jobs can be assigned to each worker.

4. What is six sigma?

Six Sigma is measure of quality near perfection. It is method of eliminating defects using disciplined, data driven approach. In Six Sigma all processes are driven towards six standard deviations between the mean and the nearest specification limit, in any process related to any industry like manufacturing, services, health care.

Six Sigma shows the statistical representation of a process and how it is performing. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities. Anything outside customer expectations is called as six sigma defect. [12]Total quantity of chances for a defect is called as six sigma opportunity.

The main objective of the Six Sigma methodology is the implementation of a measurement-based strategy which focuses on process improvement and variation reduction. This is achieved by implanting Six Sigma improvement projects.[13] There are two main sub methods of six sigma

The Six Sigma DMAIC process (define measure, analyze, improve, control) is used for existing processes in an organization.

- Define: the Customer, their quality issues and project goals.
- Measure: the performance of the processes involved
- Analyze: the data collected and process map. Identify root cause of defect and find solution to improve it.
- Improve: the target process by designing creative solutions to fix and prevent problems.
- Control: the processes to keep it improved.

The Six Sigma DMADV process (define, measure, analyze, design, verify) is used to develop new processes in the organization which sticks to six sigma level.
- Define: the Customer, their quality issues and project goals.
- Measure: the performance of the processes involved.
- Analyze: the data collected and process map. Identify process options to meet customer needs.
- Design: Design the process to meet customer needs.
- Verification: Verify the performance and quality of design.

5. Importance of Lean-Six Sigma:

Lean-Six Sigma is the integration of Lean and Six Sigma process improvement methodologies. Six Sigma and Lean are both business improvement methodologies, more specifically business process improvement methodologies [21]

- Six Sigma: Methodology to focus on the key factors that drive the performance of a process, optimizes them, and sustains improvement.
- Lean: Methodology to reduce complexity and streamline a process by eliminating sources of waste in the process.

In simple terms, Lean looks at what should not be done and aims to remove it; Six Sigma looks at what should be done and aims to get it right first time and every time, for all time.[7] Lean-Six Sigma is all about linkage of tools, and not using tools individually. In fact, none of the tools are new. The strength of the approach is in the sequence of tools.

There are many versions of the Six Sigma Roadmap, but not so many that fully incorporate Lean in a truly integrated Lean-Six Sigma form. The roadmap follows the basic tried and tested DMAIC (Define, Measure, Analyze, Improve and Control) approach from Six Sigma, but with Lean flow tools as well as Six Sigma statistical tools threaded together throughout. [10]

Lean-Six Sigma approaches sustainable continuous improvement with the goal of improving patient care, safety, and satisfaction while simultaneously reducing costs and increasing revenues. [2]Using Six Sigma, Columbus Regional Hospital analyzes variation and determines the root causes of that variation. Through Lean, participants eliminate no value added activities and design new processes around steps that add value. [1]Lean-Six Sigma puts controls in place to sustain the gains and ensure continued success.

6. Importance of Lean-Six Sigma in Healthcare Industry:

In health care industry patients are considered as customers. So keeping customer satisfied is high priority in health care industry .[34]Traditional concept of health care was that people need health care and will continue to use same health care services out of necessity ,though they are not happy with services ,are changing rapidly now. Nowadays patients have lots of choices between different health care providers. [4, 32]So quality has become very important in health care industry.

At the same time many hospital administrators have already started using the views and perceptions of their patients to organize their service and staff and for continuous improvement in the overall organizational performance.[3]

Health care industry is different from manufacturing industry. But still there is lot of similarities. If an organization wants to develop a machine or give good treatment to patients, it has to develop good processes. Waste of money, time, supplies, or good will decreases

value in every sector. This can be achieved by using Lean-Six Sigma into Health Care industry.

7. Approaches to improve patient satisfaction using Six Sigma

To implement Six Sigma in an organization there should be commitment from management level towards six sigma quality goals. Then a particular area where six sigma needs to be implemented should be selected and all data regarding that should be gathered. This helps to find deficiencies in the processes and measurement of quality.

Six sigma requires huge amount of organizational change and management should be supportive and encouraging for this. [12]Various training program for all employees should be held. After identifying defects, solutions can be found regarding them by changing processes.[6] This implementation should be aimed at continuous improvement of an organization so that best quality can be achieved.

7.1 Six Sigma tools used in healthcare-Pareto Chart:

A pareto chart is used to summarize and display the relative importance of the differences between groups of data. A pareto chart can be constructed by segmenting the range of the data into groups. The left-side vertical axis of the pareto chart is labeled Frequency (the number of counts for each category), the right-side vertical axis of the pareto chart is the cumulative percentage, and the horizontal axis of the pareto chart is labeled with the group names of your response variables. Following figure gives an example of use of pareto chart in health care industry. The pareto chart helps us realize most important factor which is causing defects.In the figure shown below it can be found that wrong weight conversion is causing highest defects.
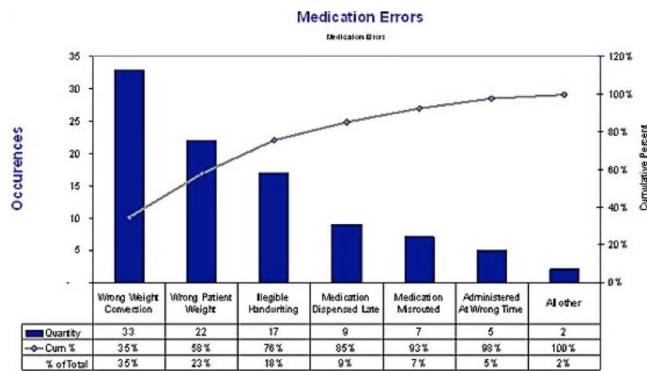

Fig 4: Pareto Chart in Health Care [37]

7.2 Six Sigma tools used in healthcare-FMEA:

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. "Failure modes" means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be

potential or actual. "Effects analysis" refers to studying the consequences of those failures.

Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones. The following figure shows FMEA application into health care. From the FMEA sheet it can be seen that misreading of medication name is most important defect and it should be given highest priority to fix.

Fig 5: FMEA Analysis in Health Care [37]

7.3 Six Sigma tools used in healthcare-Fishbone Diagram:

A fishbone diagram, also known as an Ishikawa or "cause-effect" diagram is used to explore and display the possible causes of a certain event. When causes group naturally under the categories of Materials, Methods, Equipment, Environment, and People then classic fishbone diagram is used. While when we have to show causes of problems at each step in the process then a process-type cause and effect diagram is used. The following figure shows fishbone diagram used in healthcare industry.
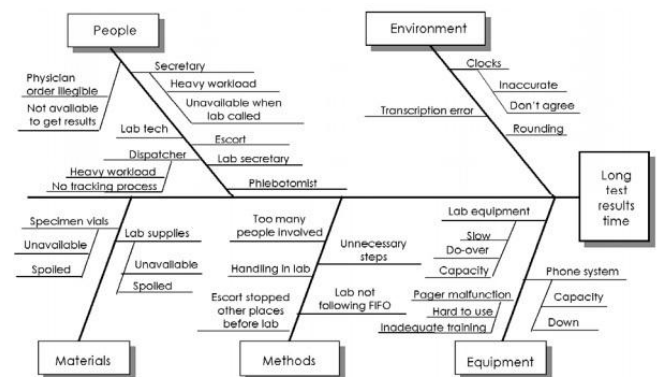

Fig 6: Fishbone diagram used in Healthcare [38]

8. Approaches to increase patient satisfaction using Lean:

The main aim of Lean methodology is to eliminate waste. Waste can be of time, resource or many other factors. Any kind of waste in the process or organization should be identified and removed. In addition all the resources should be used in a way that they provide some value to customers. After identifying waste in process redesign of the process flow should be done such that it should be maintained continuous. All the non-value added processes should be removed here. As it results in more resource utilization and less waste, quality is improved.Then standardization of best practices identified and these should be followed by all employees in organization.Expertise of Lean-Six Sigma professional should be utilized at various stages of implementation.

8.1 Application of Value Stream Mapping of Lean in Emergency Department:

In emergency department of hospitals patients are treated according to the severity of their problems. Walk in patients are treated least emergent and patient coming through ambulance are given most importance. [28,29]. Patients requiring immediate attention are directly treated by physicians while others are treated according to waiting list. In general it takes around 1 hour waiting time for these patients.ED serves patients on Let average annual ED visits is 40000 which is equivalent to 110 visits per day.24/7 basis in shifts.ED care activities can be categorized as following main activities and their Takt time is also calculated:

- Registration = 86000/110 = 782 sec per patient

- Evaluation = 86000/110 = 782 sec per patient

- Diagnostic tests = 86000/110 = 782 sec per patient

- Therapy = 86000/110 = 782 sec per patient

- Results evaluation = 86000/110 = 782 sec per patient

After collecting the information needed with regard to the patient and information flow, it is easy now to draw the value stream map VSM for the current state. A value stream is defined as all the actions (both value added and none value added) required to bring a specific product, service or a combination of products and services, to a customer. The normal ED work flow is shown by figure below:

Data collected from ED operations is given in below table:

Table 1: ED Department-Time Data

No	Description	Cycle Time(sec)	Available time
1	Registration	300	86400
2	Evaluation	900	86400
3	Diagnostic Tests	1200	86400
4	Therapy	1800	86400
5	Results evaluation	600	86400
Total		4800	345600
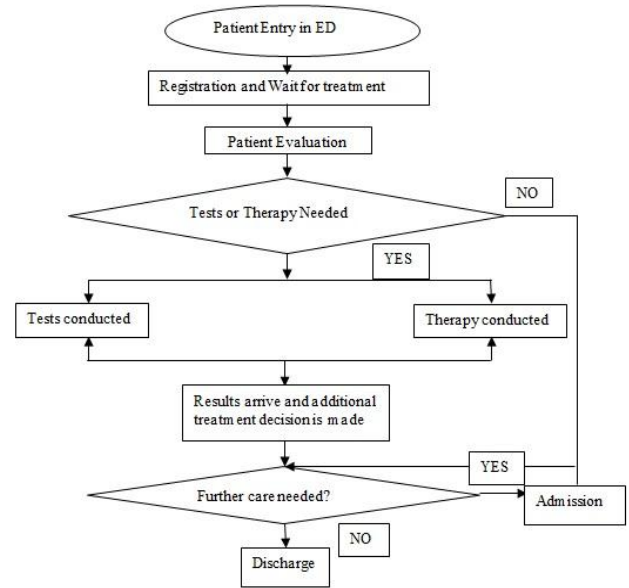
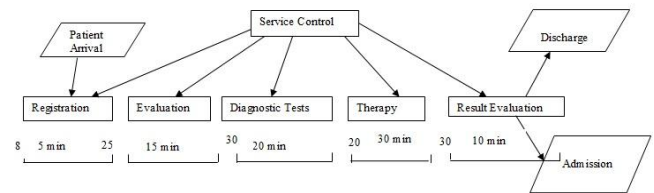The current state map for ED department is as given follows:

Figure 7: Current State Map for ED

Here,
Lead time = 130 min
Value added time =80min

Proposed improvement plan:
In proposed plan patient evaluation operation is combined with diagnostic testing and therapy so that same staff doing the diagnostic testing or therapy can read the reports and make the decision for admission or discharge. Also one new physician will be added to therapy and diagnostic operations. The future state map for this is given as follows:
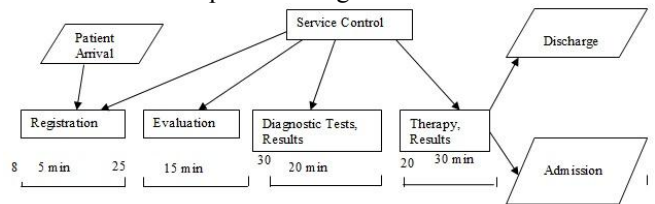

Figure 8: Future State Map for ED

By this proposed approach Lead time = 153 min and Value added time = 70 min
By utilizing this approach ED of a hospital can gain lot of benefits. Table below shows comparison between current state map output and proposed future state map output:

Item	Current State	Future State	Improvement %
Capacity	48	72	50
Idle Time	201600 sec	129600 sec	36
Utilized Time	230400 sec	302400 sec	31
Number of Operations	5	4	20

Table 2: Comparison of current state and future state performance

8.2 Wastage in Healthcare Sector according to Lean:

Anything which does not add value to customer is defined as waste by Lean Manufacturing.[30]

In general following type of wastage occur in health care industry which should be eliminated.

Waste	Definition	Example in Healthcare
Over production	Producing more than the customer needs right now	Pills given early to suit staff schedules, Testing ahead of time to suit lab schedule
Transportation	Movement of product that does not add value	Moving samples, Moving patients for testing, Moving patients for treatment
Motion	Movement of people that does not add value	Searching for patients, physicians, documentation, supplies, equipments, etc.
Waiting	Idle time created when material, information, people or equipment is not ready	Patients waiting for bed assignments, admission to Emergency Dept., testing & treatment, discharge, lab test results
Over processing	Effort that adds no value from the customer's viewpoint	Retesting, Excessive paperwork, Unnecessary procedures
Inventory	More materials, parts, or products on hand than the customer needs	Bed assignments, Pharmacy stock, Lab supplies, Specimens waiting analysis

	right now	
Defects	Work that contains errors, rework, mistakes or lacks something necessary	Medication error, Wrong patient, Wrong procedure, Missing information, Poor clinical outcomes

Table 3: Examples of Waste in Healthcare industry

8.3 Improvement of Insurance Claim Processing in Health Care by using Lean Manufacturing:

An example of current state map for processing an insurance claim is shown in Figure 7. The map depicts the current process containing nine steps (as indicated in the lower left corner), with the actual required work time and elapsed process time indicated below each step in the process.[31] Note in the lower right corner that, because of excessive delays between steps, the 19 minutes of actual work required to complete the process takes place over a 28-day period.
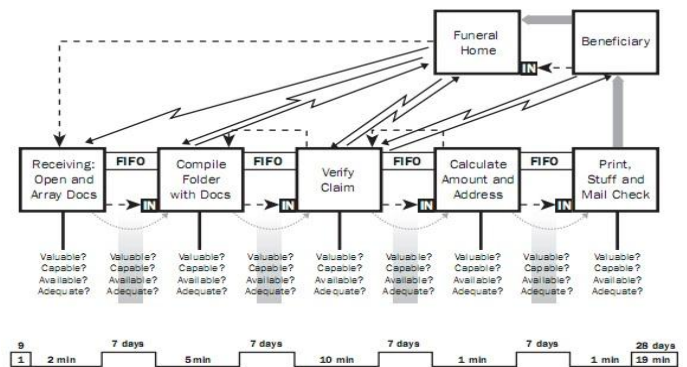

Figure 9: Current State Map for Insurance Claim Process in Healthcare [36]

Using the future state value stream map(Figure 8), the group reorganizes staff if necessary to match the requirements of the process. Notice that most processes flow horizontally, while most organizations are organized vertically. This is a fundamental challenge, because the process must flow across organizational impediments and boundaries.
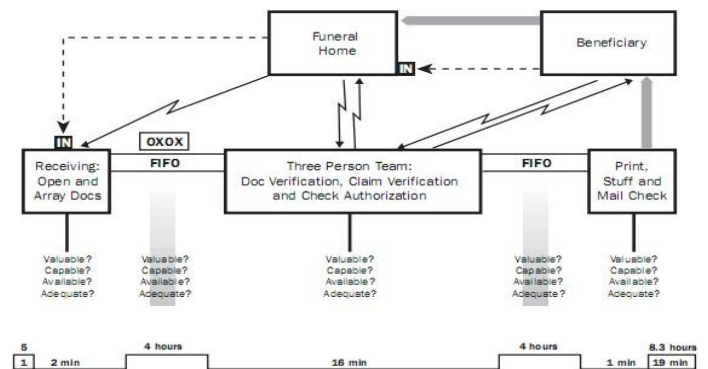

Figure 10: Future State Map for Insurance Claim Process in Healthcare [36]

8.4 5-S Implementation in medical storage room

5-S is one of the most important tool in application of Lean Manufacturing. It can be applied to keep minimal wastage at medical rooms.The explanation for each step in 5-S is as follows:

1) Seiri :
   It refers to the practice of going through all the tools, materials, etc., in the work area and keeping only essential items. Everything else is stored or discarded. This leads to fewer hazards and less clutter to interfere with productive work.

2) Seiton :
   This step focuses on the need for an orderly workplace. "Orderly" means arranging the tools and equipment in an order that promotes work flow. The tools and equipment should be kept where they will be used, and the process should be ordered in a manner that eliminates extra motion.

3) Seison :
   It indicates the need to keep the workplace clean as well as neat. This step makes it easy to know what goes where and to know when everything is where it should be are essential here.The key point is that maintaining cleanliness should be part of the daily work - not an occasional activity.

4) Seiketsu :
   This refers to standardized work practices. Everyone knows exactly what his or her responsibilities. Workplace should reflect the process of work, these imply standardized work practice and workstation layout.

5) Shitsuke :
   This refers to maintaining and reviewing standards. Maintain the focus on this new way of operating, and do not allow a gradual decline back to the old ways of operating.
   However, when an issue arises such as a suggested improvement or a new way of working, or a new tool, or a new output requirement then a review of the first 4S's is appropriate.

9. Challenges in implementation of Lean-Six Sigma in Health Care:

Implementing Lean-Six Sigma in Health Care industry can encounter many challenges as health care industry work differently than other manufacturing industries [27]. Main challenges which can be faced are discussed here.

9.1 Customer satisfaction

Implementing Lean-Six Sigma principles requires different mindset from management as well as employees of organization. Customer satisfaction is of very high importance in health care industry as it involves focus on various customer requirements and the services provided. Many times there is lack of resources or lack of time due to which poor service may be delivered to customers.

9.2 Changing customer numbers

There are lots of changes in customers who want to receive any kind of health care service. These numbers are not predictable and tend to change according to situation. For implementing Lean-Six Sigma getting this data is very important as implementation will be based on previous data.

9.3 Wide number of services

Health care industry offers wide number of services to customers and they vary from customer to customer. It becomes highly difficult to track record and deficiencies in these many services.

9.4 Lack of information

In manufacturing sector data between different processes can be recorded easily. This data does not change much and can be used for similar kind of different process. But health care industry has different information management challenges. Most of these challenges arise from:

1. Less attention to quality
2. Highly variable customer needs
3. Less attention towards data management
4. Lack of resources

10. Conclusion:

Health care industry is becoming very competitive now and implementing Lean-Six Sigma is very important to improve the quality of health care services. Lean-Six Sigma can be used to identify and rectify many wastes and errors in patient care and improve patient satisfaction.

This method can be applied in various departments of health care facility like emergency, primary care, radiology, information management, prescription errors etc. Also Lean-Six Sigma uses a data driven approach to fix problems and it creates continuous improvement in industry.

11. References:

1. Fleishman, R. (1996), " Evaluating intervention programs for quality assurance in hospitals",
2. International Journal of Health Care Quality Assurance, Bradford, U.K
   Giffith, J.R., " Championship Management for health care organization", Journal of
   Health care Management
3. Hansson, J. "Quality in Health care: medical or managerial". Journal of Management
   in Medicine
4. Hertz, H.S. , Reiman C.W., and Boswick, M.C. (1994)"The Malcolmn Baldridge National Quality

Award concepts could help accelerate health care quality improvement", Quality Management in Health Care

5. Lanser E.G. " Effective use of performance indicators"
6. Lazarus, Ian R. and Cindy Neely, "Six Sigma: Raising the Bar"
7. McLauglin, C.P. " Evaluating the quality control system for managed care in the U.S."Quality Management in Health care
8. National Institute of Science and Technology (2001) website http:quality.nist.gov
9. Panko,R. " The health care game: cutting cost but not quality" Best's Review (Life/Health),
10. Revere, Lee, Ken Black, Ahsan Huq, "Integrating Six Sigma and CQI for Improving Patient Care"
11. Sehwail, Loay and Camille DeYoung, "Six Sigma in Health Care", International Journal of Health Care Quality Assurance"
12. Young Hoon Kwaka,*, Frank T. Anbarib,Benefits, obstacles, and future of six sigma approach, Andy Ganti ,GE Medical Systems, Dr. Anita G. Ganti ,Six Sigma and Health care
13. Christine Corum ,Lean Six Sigma (LSS) in Healthcare
14. State of the USA Health Report,Institute of Medicine,December 2008 The U.S. Commitment to Global Health:Recommendations for the Public and Private Sectors,Institute of Medicine http://www.nap.edu/catalog/12642.html
15. Creating a Business Case for Quality Improvement Research: Expert Views, Workshop Summary ,Samantha Chao, Rapporteur, Forum on the Science of Health Care Quality Improvement and Implementation
16. The Richard and Hinda Rosenthal Lecture 2007: Transforming Today's Health Care   W orkforce to Meet Tomorrow's Demands http://www.nap.edu/catalog/12137.html
17. www.macneil-lehrer.com/btp/Louisiana%20Healthcare%20Issues.doc Evaluating
18. Occupational Health and Safety Research Programs: Framework and Next Steps Committee on the Review of NIOSH Research Programs; Institute of Medicine and National Research Council http://www.nap.edu/catalog/12639.html
19. The Richard and Hinda Rosenthal Lecture 2008: Prospects for Health Reform in 2009 and Beyond
20. http://www.isixsigma.com/sixsigma/six_sigma.asp
21. http://www.lean.org/WhatsLean/
22. http://www.lean.org/WhatsLean/Principles.cfm
23. http://www.sixsigmainstitute.com/images/service%20lean%20sigma%20DMAIC.png
24. http://www.bec.msoe.edu/graphics/lshcx_graphic.jpg
25. http://www.labautopedia.com/mw/images/LeanSigmaLabFig2.jpg
26. Mohammad Abdolshah,Azad university of Semnan and Rosnah Mohd. Yusuff,UPM University ,Fundamental elements for the successful performance of Six Sigma projects in service industries.
27. Fawaz Abdullah, "Lean Manufacturing Tools and techniques in the Process Industry with a Focus on Steel", PhD Thesis, University of Pittsburgh, 2003.
28. Osama M. Erfan, Bany Suief University,Egypt,Application of Lean Manufacturing to Improve the Performance of Healthcare Sector In Libiya
29. E. W. Dickson, Z. Anguelov, D. Vetterick, A. Eller, and S. Singh, "Use of Lean in the Emergency Department: A Case Series of 4 Hospitals", Journal of Annals of Emergency Medicine, 2009.
30. Francisco Aguado Correa,, María José Álvarez Gil, and Lucía Barcos Redín,Benefits of connecting RFID and Lean Principles in Healthcare
31. Institute for Healthcare Improveent,Going Lean in Healthcare
32. Womack, J.P. and Jones, D.T., "Lean Thinking", Simon & Schuster, London, 2003.
33. Karlsson, C., Rognes, J. and Nordgren, H., " Model for Lean Production", Institute for Management of Innovation and Technology, Goteborg, 1995.
34. Young, T., Brailsford, S., Connell, C., Davies, R., Harper, P. and Klein, J.H., "Using industrial processes to improve patient care", British Medical Journal, Vol. 328 No. 7432, pp. 162-4, 2004.
35. Breyfogle, F. and Salveker, A., "Lean Six Sigma in Sickness and in Health", Smarter Solutions, Austin, TX, 2004.
36. Miller, D., "Going Lean in Health Care", Institute for Healthcare Improvement, Cambridge, MA, 2005.
37. Dr. Gary Wadhva,Breakthrough Improvements in Healthcare using TOC,Lean,Six Sigma
38. http://nciph.sph.unc.edu/mlc/presentations/perf_imp/CauseandEffect1.pdf