

Lean in Healthcare

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Lean Thinking, or Lean for short, originated in Toyota factories in the 1960s, was “transplanted” to the U.S. in 1992 with the publication of Womack and Jones' *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (2003), and evolved globally to practically all work domains: healthcare, engineering and systems engineering, science, administration, supply chain, government, banking, aviation, and many others (Oppenheim 2011). Lean has proven itself as the most effective methodology for improving operations identifying and eliminating waste from work processes. (E.g. Womack and Jones 2003; Oppenheim 2011; Graban 2012; Toussaint and Gerard 2010; and Oehmen 2012) Since 2003, Lean has established itself in healthcare operations.



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Overview of Lean in Healthcare

Entire medical organizations (e.g., Theda Care, WI; Jefferson Healthcare, WA; Virginia Mason, WA; Geisinger Health (now called ProvenCare), PA; St. Elizabeth, Tilburg, The Netherlands, and numerous others (e.g. Graban 2012; Toussaint and Gerard 2010)) have been transformed with Lean. These sources contain rich data on specific improvements. Most leading healthcare institutions now have Lean centers of excellence or use Lean consultants, including Kaiser Permanente, Mayo Clinic, UCLA, Veterans Administration, and others. Lean has proven itself in reducing turnaround time of clinical tests, the time spent by patients in emergency departments, operating suites, pharmacies and clinics. Lean improvements in healthcare on the order of 30-50% are routine because traditional healthcare operations are burdened with this much waste, which remains “unseen” by the employees unless they are trained in Lean. Lean is now an established paradigm for improving healthcare delivery operations: increasing quality of healthcare, delivering care faster, shortening patient time in the system, increasing the time of medical professionals with the patient, reducing bureaucracy, increasing capacity of operations, and reducing healthcare costs and frustrations. (Graban 2012; Toussaint and Gerard 2010)

Lean does not mean that people have to work faster or “attach roller blades to move around faster”. In Lean, systems employees work at their regular ergonomic and intellectual speeds. The time savings come from finding and eliminating idle states (e.g., waiting in numerous queues in the emergency departments), reduction of mistakes and rework, elimination of non-value adding tasks, and more streamlined movements of patients, staff, equipment, and supplies. And, most emphatically, Lean does not mean “mean layoffs”. Quite the opposite is true: Lean improves human relations at work and changes the culture from the traditional “blaming and shaming” to teamwork and cooperation focused on the good of the patient. (Graban 2012 (in particular see the endorsements from eight medical professionals on pages ii and iii) and (Toussaint and Gerard 2010)

With the endorsement of *Lean for Systems Engineering with Lean Enablers for Systems Engineering in the Wiley Series*, (Oppenheim 2011) the International Council on Systems Engineering (INCOSE) has effectively adopted

Lean as one of its essential competencies. This book was followed with a major joint Project Management Institute (PMI)-INCOSE-MIT publication of (Oehmen 2012) integrating Lean with Systems Engineering and Program Management. Indeed, when applied with Systems Engineering and Systems Thinking, Lean becomes a powerful weapon in bending the healthcare cost curve and improving the quality of care.

Three concepts are critical to the understanding of Lean: value, waste, and the process of creating value without waste, which has been captured into the so-called Six Lean Principles, as follows.

- **Value:** M. Porter (2010) suggested that patients value three levels of care: (1) survival and the degree of recovery; (2) the time required to get back to normal activities, and (3) the sustainability (individual and social cost) of treatments.
- **Waste:** Table 1 lists the eight categories of waste used in healthcare. (Graban 2012; Toussaint 2010)

Table 1. Eight Waste Categories Used in Lean Healthcare (SEBoK Original).

Waste Type	Healthcare Examples
1. Waiting	Patients wait in numerous queues in clinics, test facilities, ERs, pharmacies, and for insurance approvals; MDs wait for next activity to occur (e.g. test results, information, approvals.)
2. Over-processing	Performing work that is not valued or needed, e.g. MDs and RNs spending time on computer filling out bureaucratic forms that nobody will review.
3. Over-production	Performing more work than needed for value. Transport of a patient in a wheelchair performed by expensive medical professionals because of the lack of transporters.
4. Inventory	Excess inventory costs. Expired supplies that must be thrown away.
5. Transportation of Patients	Transportation of patients over long distances to test offices in hospitals. Poor layout of hospitals, EDs, or test facilities.
6. Motion of Staff	Staff walking over long distances to fetch supplies, and between patients and central hospital stations.
7. Defects	Treatment of hospital infections. Failed and repeated tests, repeated paperwork. Surgical cart missing an item. Wrong medicine.

8. Waste of Human Potential	Burnout of medical staff. Frustrated employees quit making suggestions for improvements.
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Table 2 lists the six Lean Principles (Graban 2012) and provides healthcare examples.

Table 2. Six Lean Principles (SEBoK Original)

Principle Name	Explanation
1. Value	Specify value from the perspective of the customer: the patient.
2. Value Stream	Identify all the value-added steps across the entire process, crossing all departmental boundaries, linking the steps into a seamless process, and eliminating all steps that do not create value.
3. Flow	Keep the processes flowing smoothly through all the steps, eliminating all causes of delay, such as batches of patients or items, and quality problems.
4. Pull	Avoid pushing work onto the next step or department; let work and supplied be pulled, as needed, when needed.
5. Perfection	Pursue perfection through continuous improvement, Kaizen events, implement best work standards, checklists, training, and promote improvement teams and employee suggestions.
6. Respect People	Create work environment based on synergy of cooperation, teamwork, great communication and coordination. Institute leadership. Abandon the culture of blaming and shaming.

Lean Practices

Lean healthcare strongly promotes engaging and leading employees. Lean places a big value on continuous education and training of employees at all levels. Lean management promotes standardization of best practices (“the best known way of doing it”, but not necessarily “identical”), checklists, redundancies, patient safety and privacy rules, and patient data security and cybersecurity. Lean advocates visual management, with electronic or “black” boards updated in real time and displaying all information important for the local employees to manage their operation efficiently. Patient safety is still a significant problem in the U.S., in 1999 causing almost 250,000 deaths (Institute of Medicine, 1999) and medical errors occur in one of three admissions. Instead of “blaming and shaming” Lean promotes error and harm prevention and deep root-

cause analysis, implementing processes and tools that make it impossible to create an error.

Systems Thinking and Lean

Healthcare is the most complex socio-technological system in our society, consuming nearly 20% of the U.S. GDP. Healthcare should be safe, effective and evidence based (Berwick 2011), as well as affordable and accessible, efficient, patient centered, timely, well integrated, and inclusive of latest science. (Oppenheim 2015) Healthcare has many stakeholders: the patients, medical professionals, medical facilities, hospitals, clinics, labs, medical equipment makers and users, pharmaceuticals, healthcare researchers and academia, insurances, employers, federal & state governments and international disease prevention centers, military and veteran's administration, fire departments and ambulances and others. The number of potential interactions (interfaces) in this hyper-system is extensive, and many interfaces are nonlinear, "wicked" (interacting with unpredictable humans), often creating unintended consequences and emergent behaviors. Because of these vast complexities, healthcare leaders (e.g. Kanter 2015) point out the need for intensive application of systems thinking and Lean when addressing these challenges. Attempting to solve the complex healthcare problems without systems thinking risks myopic and unsafe attempts which create more problems than they solve. Attempting to solve the challenges without Lean inevitably promotes excessive wastes, costs, and inefficiencies. Good healthcare needs both, Systems Thinking and Lean, to be applied simultaneously.

Lean and Agile in Six Healthcare Value Streams

The Healthcare Working Group of INCOSE identified six following value streams for HSE: A. Systems Engineering for medical devices B. Systems Engineering for healthcare informatics and medical records C. Healthcare delivery (operations) D. Biomedicine and big data analytics E. Pharmaceutical value streams F. Healthcare public policy

As described above, Lean is extraordinarily effective and well established in improving healthcare delivery operations (C). Agile is highly effective in (B) because this value stream works with software, the domain from

which Agile originated. Since the stream (A) is the most similar to traditional systems engineering, Agile is expected to be effective therein, although Agile is not yet highly popular in healthcare outside of the software domain. Elements of Lean improvements which are localized and weakly convoluted (e.g., Kaizen events) have strong overlap with Agile/Scrum methodology. (Medinilla 2014)

MBSE and Lean

A highly powerful Model Based Systems Engineering (MBSE) is clearly the tool of choice for those applications where the benefit from multiple use of a standardized (reference) architecture and standard model compensates for the significant effort of creating such a model or architecture. (OMG 2016) In healthcare the value streams (A), (B), (E) and potentially F are the most conducive to the application of MBSE. Lean thinking is applicable to any healthcare operation without limitation. The Lean improvements always begin with the so-called Gemba waste walks, during which experts together with local process stakeholders walk along all the process steps, interviewing stakeholders and identifying and measuring the wastes wherever they occur. The rich menu of Lean thinking processes and tools is then applied to eliminate the wastes. Training and active participation of local stakeholders is always required.

Examples of Lean Improvements

1. In Jefferson Healthcare, WA: (Murman 2010)
 - In Acute Myocardial Infarction (a severe heart attack) time is critical as the greatest loss of heart muscle is in the first two hours. Recommended treatment is catheter insertion of balloon within 90 min of the contact with the patient (wherever the patient happens to be located). The Lean approach has reduced the treatment time from 165 min to 20-60 min at the patient site, vastly increasing patient survival rate.
 - The five Jefferson Healthcare clinics increased the cumulative available clinic hours from 1400 to 5600 in two years of Lean improvements which were focused on reorganizing medical staff schedules and eliminating wasted times, with no staff additions. The available clinic hours directly

translate into billable visits: 1175 additional patients have been seen in 2009 compared to 2008 across the five clinics.

- The Operating Room daily “on time start” of actual operations went from 14% to 96% using Lean tools for process planning and workplace organization.
- Harder to measure is the culture change, although the staff participation at Lean improvement events was at 50%.

2. In Kaiser Permanente Southern California:
(Oppenheim 2015)

- In nine regional clinical laboratories Lean improvements cut the turnaround time for laboratory results by between 30 and 70%, with significant corresponding reductions of cost, rework, errors and work morale, and without hiring new staff or adding equipment.
- In two Emergency Departments (ED) the average patient length of stay was reduced by 40% by the elimination of various idle states. The ED capacity increased accordingly.
- The amount and cost of inventory of supplies on hand was reduced by nearly 30% by introducing the Just-in-Time tools of Lean.

3. In Alegent Health, NE (Graban 2012) the turnaround time for clinical laboratory results was reduced by 60% in 2004 without adding new staff or equipment; and by another 33% from 2008 to 2010.
4. In Kingston General Hospital, Ontario (Oehmen) the instrument decontamination and sterilization cycle time was reduced by 54% while improving productivity by 16%.
5. In Allegheny Hospital, PA the central-line associated bloodstream infections were reduced by 76%, reducing patient death from such infections by 95% and saving \$1 million.
6. In UPMC St. Margaret Hospital, PA (Graban 2012) the readmission rates for chronic obstructive pulmonary disease (COPD) patients were reduced by 48%.
7. In ThedaCare, WI [3] the waiting time for orthopedic surgery was reduced from 14 weeks to 31 hours (from first call to surgery); improved inpatient satisfaction scores of “very satisfied” rose from 68% to 90%.
8. In Avera McKennan, SD [3] the patient length of stay

was reduced by 29%, and \$1.25 million in new ED construction was avoided.

9. In Denver Health, CO [3] the bottom-line Lean benefit was increased by \$54 million through cost reduction and revenue growth, and layoffs were avoided.
10. In Seattle Children's Hospital, WA \$180 million in capital spending was avoided through Lean improvements.

These examples demonstrate that Lean is successful in cost and throughput time reductions, and improvements in quality and patient and staff satisfaction. The improvements of this level are possible, even routine - because the amount of initially-invisible waste in traditional healthcare organizations is so high. The broad range of operations described in the examples manifest that Lean is applicable across the board to healthcare operations, without limitations.

Education in Lean Healthcare

Increasingly, Lean Healthcare becomes an inherent part of Healthcare Systems Engineering (HSE) Master's Programs, e.g. (Loyola Marymount University 2016) which has been developed in collaboration with Kaiser Permanente. The program includes two courses in Lean, basic and advanced, focused on improving operations in clinics, hospitals, emergency departments, clinical laboratories, radiology testing, operating rooms, pharmacies, supply chain, and healthcare administration. After the basic courses in systems engineering, project management, and systems thinking, the students also take courses on healthcare system architecting, modeling and simulations; medical data mining and analytics; systems engineering for medical devices, healthcare enterprise informatics; and healthcare delivery systems. All these advanced courses contain elements of Lean thinking because all these subdomains risk being burdened with waste and poor quality if Lean is ignored. Simply put, Lean is not really an optional extra if you want to achieve efficiency and effectiveness.

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None.

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None.

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