Chapter 4
The Application of Lean in the Healthcare Sector: Theory and Practical Examples

Nathan Houchens and Christopher S. Kim

Abstract Many companies in the manufacturing sector, such as Toyota, have enjoyed immense financial and commercial success by utilizing lean principles to identify value for the customer, eliminate waste in the production process, and deliver high-quality products. Lean encourages participation by the "frontline" workers to generate ideas, enact changes in workflow, and constantly pursue perfection in learning systems. Modern healthcare organizations comprise complex processes and are in significant need of improvement in the domains of safe, efficient, timely, and appropriate delivery of care to patients. It is these complex processes that are targets for improvement using the systematic and scientific lean approach. Lean has been implemented in numerous healthcare organizations within the United States and other nations. From decreased patient wait times to improved patient throughput in emergency departments to more efficient bedside rounding practices, lean has improved the quality of healthcare delivery in institutions that teach its ideals and goals. By going and observing where the work is performed, asking why to determine the root cause of problems, and respecting and supporting involved parties, organizations may have a positive transformative effect on the way healthcare is delivered.

Keywords Lean approach • Healthcare systems • Patient safety • Efficiency • Problem solving

Key Questions

1. What is the lean approach?
2. How can lean principles be applied in healthcare?
3. Who are the customers in the healthcare system and what are the values specific to each?

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4. How are value and waste defined in the healthcare arena?
5. What is the lean practitioner's approach to solving healthcare process problems?
   What are the steps involved and how is quality improvement executed?
6. What are examples of effects of the lean approach in healthcare?

4.1 The History of Lean: A Quality Revolution from Manufacturing to Healthcare

Provision of a high-quality product with maximal value to the customer and minimal waste to the organization is the critical endeavor of any industry. Toyota Motor Corporation epitomizes this statement by maintaining its unremitting devotion to continuous quality improvement and safety for both its employees and its customers. In doing so, it has achieved remarkable success. Toyota is widely recognized as a world-class automotive manufacturer and consistently garners top rankings and awards for quality and customer satisfaction by reporting agencies (Liker 2004). Much can be learned from the ways in which this industry giant conducts its business.

The management philosophy of the Toyota Production System, known generically as lean production, is a set of principles and practices that assist in delivering the ultimate goal of improving quality by the constant transformation of waste into value from the customer's perspective. Waste can be defined as anything that does not add value to the final product or service; conversely, value is the capability to provide the right product or service, at the right time, and at an appropriate price (Womack and Jones 2003). Lean production refined twentieth-century scientific management concepts pioneered by Frederick Winslow Taylor and Henry Ford. Taiichi Ohno, an engineer at Toyota during the 1940s, identified deficiencies in Western automotive production systems. He believed that excess inventory led to costly capital, increased need for storage space, and product defects. He also noted the inability of inflexible systems to honor dynamic customer preferences due to line-based production systems (Holweg 2007).

With these insights, he developed the principles of *jidoka* and "just-in-time." *Jidoka* can be loosely translated as "automation with a human touch" and refers to automated and standardized processes that are able to detect problems requiring human attention in real time, thereby preventing defects in the final product. The "just-in-time" philosophy leads to production of only that which is needed by the next process in order to achieve a smooth and continuous workflow. These process-oriented concepts, combined with methods suggested by American statistician and quality expert W. Edwards Deming, serve as the foundation for the Toyota Production System and lean thinking. Over generations, Toyota as an evolving organization, has undergone continuous iterative learning cycles with a goal of eliminating waste and creating value (Womack et al. 1990).

A derivation of this strategy is known as lean thinking or the lean approach. A descendent of the quality improvement method known as the Plan-Do-Study-Act (PDSA) cycle, lean has been incorporated into numerous other industries such as construction, aerospace, and insurance in an effort to improve performance and productivity. This philosophy has also extended to healthcare. Indeed, many hospitals, clinics, and medical groups are rapidly adopting its tenets across the world and establishing it as the systematic approach to enhancing quality, efficiency, and patient safety (Blackmore et al. 2011; Kim et al. 2009; Waldhausen et al. 2010). In this chapter, we will investigate the numerous challenges the healthcare industry faces, the key steps and tools of lean as it relates to the care of patients, and examples of successful execution of lean principles by forward-thinking healthcare institutions.

4.2 Healthcare Challenges in the Twenty-First Century

Healthcare systems are intricate organizations that comprise not only the physical locations of care delivery but also a myriad of medical provider disciplines, varying acuity of patient disease processes, and an ever-expanding database of literature describing disease pathophysiology, diagnostic approaches, and therapies. Achievements in technology and innovation have equipped providers to deliver higher levels of care than ever before. However, as a natural by-product of this evolution, care of patients has become more subspecialized, and the processes that must coordinate to produce quality medical care are increasing in number and complexity.

More than a decade ago, the United States Institute of Medicine published two reports entitled *To Err Is Human* and *Crossing the Quality Chasm* that investigated the ways in which healthcare is delivered and placed focus on quality improvement and patient safety issues (Kohn et al. 2000; Committee on Quality Health Care in America, Institute of Medicine 2001). The recommendations put forth in these reports highlight patient care that should be safe, effective, efficient, patient-centered, timely, and equitable. Despite the time that has since passed and the substantial amount of resources that have been allocated toward achieving these goals, many challenges in the United States and other nations remain.

It is clear that healthcare delivery and financial systems require significant intervention in order to create the ideal care experience that patients require and deserve. While this represents a global view of the challenges facing healthcare, the processes and tools of change will likely need to be engaged at the local or individual organization level. The lean philosophy has been utilized in multiple industries such as automotive manufacturing, finance, and metalworking to improve processes with massive improvements in quality, efficiency, and profit margins. The time has come to harness the power of lean in order to improve the state of healthcare. Indeed, the Institute for Healthcare Improvement has advocated for healthcare leaders to take up the lean approach for this purpose (Institute for Healthcare Improvement 2005).

Those who state that patients are not composed of parts needing to be assembled correctly to function are correct. However, the healthcare system is a complex organization that comprises multiple processes similar to other industries, and it is these processes that are targets for improvement using lean techniques. In order to gain a better understanding of lean thinking, it is imperative to first consider the fundamental concepts of lean.

4.3 The Principles of Lean (in Healthcare)

In their book entitled *Lean Thinking*: *Banish Waste and Create Wealth in Your Corporation* (Womack and Jones 1996), James Womack and Daniel Jones specify the lean thinking approach as consisting of five steps:

1. Specify value from the customer's perspective.
2. Identify the value stream (from order to delivery) for each product or service and remove the waste.
3. Make value flow without interruption from the beginning to the end of the process.
4. Let the customers pull what they value from processes when they need it.
5. Pursue perfection through continuous improvement.

In healthcare, one can also view the approach to lean thinking following these five steps. The goal of lean thinking in healthcare is to focus continuously on how appropriate healthcare can be delivered most efficiently, safely, and with the highest quality by transforming waste into value from the perspective of the customer.

1. Value from the customer's perspective

Customers in healthcare do not solely refer to patients, but also include other internal and external partners of the healthcare system. In addition to patients, external customers could also include regulatory agencies such as the Joint Commission and the Centers for Medicare and Medicaid Services, as well as third-party payers such as private and public insurers. Internal customers could include providers referring to one another and other ancillary support staff collaborating to provide clinical and nonclinical healthcare service to patients. Organizations striving to provide the best care possible need to understand the value as determined by both its internal and external customers to the healthcare delivery process.

2. Identify the value stream and remove waste

The healthcare organization operates in a series of processes, where each successive step in a process should deliver a value-added piece of work in the overall goal of taking care of the needs of its patients. Many of these processes are far less than optimally efficient. Consider, for example, the number of steps and waiting time required for an outpatient office visit. The total time that elapses from when the patient picks up the phone to make an appointment until the time when she is seen

and evaluated at the clinic can be quite long and variable. The patient could spend minutes on hold waiting to speak to a scheduler and then wait up to several days to weeks before the actual appointment date. Upon arrival at the clinic, the patient again waits in a reception area prior to moving through other clinic areas at which point there is typically additional wait time (i.e., moving from the waiting room to the area where vital signs are taken, moving into the exam room, being evaluated by a medical assistant or nurse) before finally being seen by the medical provider. The patient may experience further wait time at checkout. If she needs a prescription, further diagnostic tests, or is referred to a specialist, she may need to repeat many aspects within this series of inefficient steps. This process, taken as a whole, often frustrates patients regarding the length of time required to schedule and be seen by their physicians. Yet, for all those involved in coordinating and providing the medical care for the patient, the overall primary goal *is* to help the patient with her medical problem as best they can. There appears to be a gap between what the patient desires from the healthcare delivery system and what the organization is actually delivering as its product.

A lean approach to investigating this problem example would (a) sort through which of these facets of the work would be considered of value to the patient, (b) try to ensure those parts are as closely linked to each other as possible, and (c) minimize (or eliminate) any other aspects the patient would not want as part of her healthcare utilization process. These steps comprise the process of creating a value stream map (VSM). Dohan et al. (2012) in this same volume discuss the use of VSM in lean healthcare with illustrative diagramming techniques. Delving deeper, the lean approach to identifying and eliminating waste would entail specifying the types of waste. In this example, waste would be defined to the customer as all aspects of the process that contribute to wait times either before or after being seen by the medical provider. The Toyota Production System categorized waste into seven areas of *muda*, a Japanese word describing waste or uselessness within a system (Womack and Jones 2003). Classifying waste into more specific areas may allow for organizations to better identify the underlying root causes of waste production that might serve as targets for improvement. Table 4.1 describes these categories of wastes and provides examples from the healthcare sector.

3. Make value flow without interruption
4. Pull what is valued from the process just in time

In analyzing the situation, the observer(s) and operator(s) of the process ask themselves if each of the steps is creating value for the customer and if the steps of this process can be accomplished with less waste. So often in healthcare, in their devotion to patient care, workers are focused only on their particular segment of the patient's journey and they often fail to see how their work affects other individuals who are also part of the process both upstream and downstream. Continuing on the previous example of the patient seeking an outpatient appointment, the overall goal of the lean thinking healthcare organization is to be able to make each of the steps involved in obtaining an appointment and evaluating the patient at the clinic visit flow as smoothly as possible with minimal interruptions. In fact, examples of these organizations exist.

Table 4.1 The seven types of waste (*muda*) in manufacturing and examples of their correlates in healthcare

Type of *muda*	Manufacturing example	Healthcare example
Correction: Rework to correct defects in work previously done	A car reaches the end of the assembly line and is found to have a part misplaced that needs to be corrected	Calling the lab for missing test results that were misdirected to the wrong clinician
Overproduction: Excess and unnecessary work	Production by a factory stamping group of several hundred more parts than are needed by the welding group (the next step in the process)	Ordering a computed tomography scan when clinical suspicion for a disease process is low and does not justify ordering the study
Motion of people: Unnecessary movement of people	An assembly line worker, who has 15 s to attach a part to each car moving down the assembly line, having to walk 5 steps every time to get the part	Nursing staff having to walk down the hall each time they need the key to the cabinet for narcotic pain medications
Material movement: Unnecessary transporting, rearranging, storing/moving materials great distances while waiting to be used	Storing parts for a production process in a warehouse on the other side of town, rather than at or near the production facility	Movement of laboratory specimens to a central receiving station for logging and sorting prior to being delivered to the final destination of various laboratories
Waiting: Waiting for equipment to finish running before the next phase can be initiated; or waiting for people, information, or materials before meetings	Waiting for equipment to finish running, before it can be changed to a different function, is idle time for the operator	Clinicians in the clinic waiting for patients to be put into exam rooms
Inventory: Excess supply that has no intended use in immediate future	A manufacturer has several months of completed products on hand, for which customers have not yet placed orders	Patients waiting in a long telephone queue to speak to a health provider
Processing: Doing something that the customer does not perceive as adding value	There are an excessive number of steps involved in ordering a part for the assembly line	Lengthy review and evaluation of patient records by the specialist before a patient can be scheduled in the specialty clinic

Source: Adapted from Womack and Jones (2003)

The mnemonic "COMMWIP" can be used to remember the seven types of *muda*, as originally described by Taiichi Ohno of Toyota: *C* correction, *O* overproduction, *M* motion of people, *M* material movement, *W* waiting, *I* inventory, *P* processing

Depending on the needs of the particular patient, there have been clinics established to allow for patients to make an appointment, show up to the clinic that same day, be seen by a provider, have their prescriptions sent to the pharmacy electronically via "e-prescribing," and have the medication ready for patient pick up, all without significant delays.

5. Pursue perfection through continuous improvement

An ultimate intention of a lean organization and management is to have the individual workers in the front line continuously work to improve processes of their everyday activity. When this happens, as Toyota has been able to achieve, a lean organization can start to become a learning organization. This type of organization addresses problems immediately through onsite, timely experimentation that identifies further problems and waste in the process steps. As individuals work and identify these problems, rapid deployment of improvement ideas can lead to dissemination to other individuals doing the same type of work. Once the improvement ideas are depicted and implemented as a new way of performing the work, further refinements can be made to stabilize and optimize the process, thereby becoming the "future state." Further experimentation leads to new process methods, further refinements and implementation ultimately determine the new current state, and the process repeats indefinitely in a continuous improvement cycle.

4.4 Lean Healthcare Organizations

The goal of lean thinking in healthcare is to focus continuously on the large and small changes that must be made in the processes of how clinical care is delivered, so that healthcare can be delivered in a way that simultaneously optimizes quality, safety, efficiency, and appropriateness. Some healthcare systems and organizations that were early adopters of lean production management have been able to demonstrate meaningful results.

- Virginia Mason Medical Center in Seattle, Washington, has been able to reduce the incidence of ventilator-associated pneumonias from 34 to 4 cases utilizing lean thinking methods (Institute for Healthcare Improvement 2005; Spear 2005). Their ongoing commitment to improve patient care and safety utilizing the approaches of lean healthcare has propelled them to become recognized as one of the safest hospitals in the country.
- ThedaCare Inc. is a health delivery system located in northeast Wisconsin that utilizes the ideals and tools of ThedaCare Improvement System. This organization has been able to achieve a $3.3 million cost savings in 2004; reduce the number of days outstanding in accounts receivable by 21 %, equating to about $12 million in cash flow; and redeploy staff in several areas by improving the efficiency of their operations, which have led to a savings of 33 full-time equivalent employees (Institute for Healthcare Improvement 2005).

- At the University of Pittsburgh Medical Center, nursing administration utilized the Toyota Production System model of Lean production to improve the quality and first-time accuracy of medication delivery which has led to cost savings of more than $200,000; increased the percent of patients who received their medications on time as scheduled; virtually eliminated a non-value-added work of searching for a special narcotics key, leading to 2,900 nursing hours saved annually and patients obtaining pain relief on demand; and reduced the preparation time for antibiotic administration by 4 min per dose, thus leading to an estimated savings of nearly 5,000 nursing hours per year (Thompson et al. 2003).
- At Flinders Medical Center in South Australia, Emergency Department (ED) overcrowding was such a significant issue that providers were forced to see patients outside of the usual ED space. Through a series of value stream mapping exercises and process improvement work groups, this group was able to visualize their workflow and separate patient cases out into distinct "streams" based on their triage categories. Flinders was able to reduce the total amount of time spent in the ED by all types of patients, and the average number of patients being seen in the ED at any given time was also reduced, both of which led to the goal of decreasing ED overcrowding (King et al. 2006).

Case Example

Hospital-based rounding physicians have traditionally utilized batched processing in their approach to evaluation of patients. This process usually prioritizes the examination of patients who are reported to be the most ill, followed by those with urgent questions or issues, followed by routine patients who are likely to need ongoing hospital care services, and finally those patients who will be discharged that day. It is not clear as to the reason for this rounding order, but the behavior has been passed on from one generation of physicians to the next. However, it is not necessarily the order of patients that matters to workflow, but rather the order of provider actions.

To illustrate this concept, a process flow map of a typical rounding order and the subsequent batched work steps of calling specialty consultants and entering orders (daily orders, discharge orders, etc.) is shown in the figure below. Even this simplified depiction of a hospital-based provider's morning workflow demonstrates that batching activities together, while possibly convenient for the provider, can lead to the untoward by-products of wait times for other healthcare workers—such as providers receiving consult calls or allied health professionals having to carry out physician orders—as well as "bursts" of activity among these groups (e.g., specialty consultants, nurses, phlebotomists, pharmacists). This alternation between idling and overload leads to a lack of efficient and effective workflow that can produce delays in providing timely care to patients.

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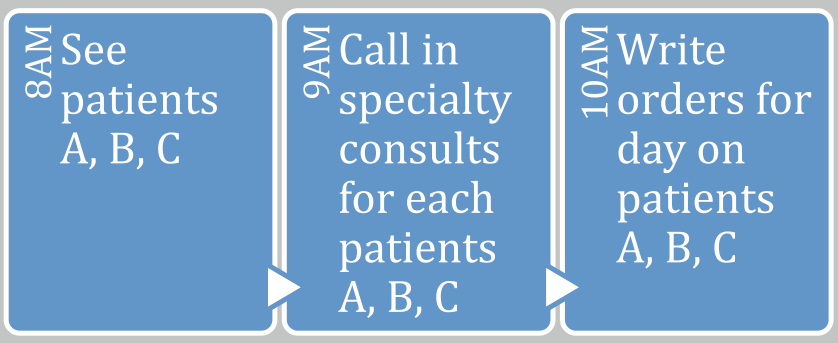
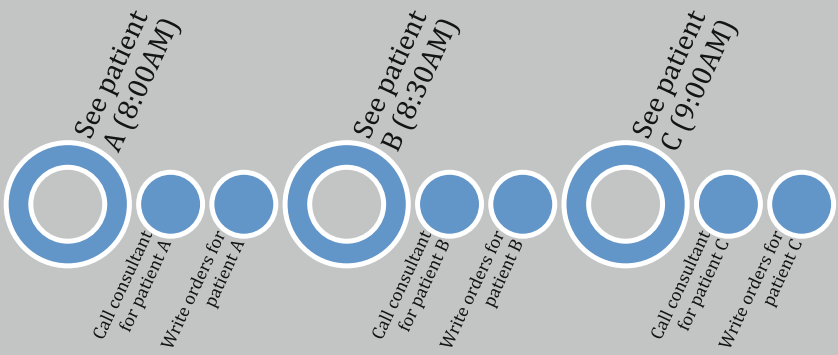


Source: Author

A practitioner utilizing lean principles, however, may envision an alternative approach for the same set of work steps. By redesigning the workflow to allow patient-related tasks to be started and completed for one patient at a time (also known as one-piece work), the patients as customers reap the benefits that are less directly apparent. Care delivered is safer and more efficacious because it is more efficient. Downstream healthcare workers are no longer sitting idle but are instead examining patients and executing orders in sync with the provider as he or she sets the cadence for the healthcare delivery process.



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A keen observer will also note that by working in a one-piece workflow process, the opportunities to catch and correct defects or errors are much more rapid and close to the source of the error than in the traditional batching workflow process. One can see that in the batching process, entering orders for all the patients together creates an opportunity for error if the hospital-based provider is trying to toggle among multiple patients to enter orders. Further, if an error in order entry is going to be caught by an allied health professional—a clinical pharmacist, for example—he or she will not have all the information on patient A until well after 10:00 AM, the point at which the provider has completed writing all orders for all patients in a batched fashion. Alternatively, a pharmacist could catch and prevent an order error for patient A immediately after the provider enters orders on that patient if the provider utilizes one-piece workflow. The opportunity to fix the error becomes easier also as all involved parties are still proximal to the work and the needs of the patient as customer.

As hospitals have sought to improve the efficiency of care delivered in the hospital, they should consider incorporating a one-piece workflow from the patient's perspective to allow for quicker processing of each patient and to allow for opportunities to catch errors as proximal to the situation as possible. It is obvious to see the benefits of improving hospital and patient flow if one simply substitutes "writing a discharge order for patient A" to replace "writing a prescription order for patient A." In a busy health system, increasing efficiency of bed turnover even hours earlier can have a significant impact on the overall operation of all care settings including the hospital, the emergency department, and the clinic from which the patient was admitted.

4.5 Conclusions

Lean thinking has clearly been demonstrated to be a highly successful process and quality improvement method in the manufacturing industry (Womack and Jones 2003; Womack et al. 1990). Healthcare abounds with opportunities for improvement in quality, safety, efficiency, and appropriateness of care delivery. Organizations that oversee various perspectives of healthcare delivery, from quality and safety to economics and efficiency, recognize that delivery of healthcare can and should operate at a much higher level of performance. The practice of lean thinking has the potential for great application in the healthcare arena, where it may have a transformative effect on how care is delivered to our patients. Those able to adapt to the ways of lean healthcare methods can anticipate that they will benefit as an institution, but

more importantly the "customers" will receive greater value in the form of higher quality, safer, more efficient, and more appropriate care, as those organizations focus on the "customers'" journey through the complex maze of the healthcare system.

As healthcare providers, we are rooted in the belief of scientific experimentation and evidence-based practice. Lean is designed to make work a series of experiments that immediately reveal problems. These problems can be acted upon rapidly to develop, implement, and disseminate a successful solution across the health system to work toward continuous improvement. This type of systemic learning based on sound theoretical and quantitatively driven change has been dubbed as "pragmatic science" (Berwick 2005) which we hope the scientific community will embrace for its capability to improve the delivery and practice of healthcare.

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