

The Promise of Lean in Health Care

John S. Toussaint, MD, and Leonard L. Berry, PhD

Abstract

An urgent need in American health care is improving quality and efficiency while controlling costs. One promising management approach implemented by some leading health care institutions is Lean, a quality improvement philosophy and set of principles originated by the Toyota Motor Company. Health care cases reveal that Lean is as applicable in complex knowledge work as it is in assembly-line manufacturing. When well executed, Lean transforms how an organization works and creates an insatiable quest for improvement. In this article, we define Lean and present 6 principles that constitute the essential dynamic of Lean management: attitude of continuous improvement, value creation, unity of purpose, respect for front-line workers, visual tracking, and flexible regimentation. Health care case studies illustrate each principle. The goal of this article is to provide a template for health care leaders to use in considering the implementation of the Lean management system or in assessing the current state of implementation in their organizations.

© 2013 Mayo Foundation for Medical Education and Research ■ Mayo Clin Proc. 2013;88(1):74-82



From the ThedaCare Center for Healthcare Value, Appleton, WI (J.S.T.); and Department of Marketing, Mays Business School, Texas A&M University, College Station (L.L.B.).

Pediatric surgeons at Seattle Children's vie to perform surgery at their new Bellevue Clinic and Surgery Center because of the efficient flow for patients, families, and the care team. Nonoperative time, defined as the time when dressings are placed on patient A to incision time for patient B, is 50% less than for similar operations performed at the main campus surgery center. Operations start when scheduled 99% of the time. More than 90% of patients and families give the Bellevue Surgery Center a 9 or 10 rating for overall care. ThedaCare, a Wisconsin-based integrated health system, reduced inpatient total cost of care by 25% while improving patient satisfaction to nearly 100% of patients rating their care 5 of 5. For 5 years running, no medication reconciliation errors occurred for patients in hospital units served by care teams that include a pharmacist.¹ The staff of the otolaryngology department of the Christie Clinic in Champaign, Illinois, begins each day with a huddle to identify problems and discuss potential solutions. The daily rhythm of the huddles, which include physicians, has improved internal communications and teamwork. In less than 1 year after starting the huddles, waiting time for appointments decreased by 28%, departmental capacity improved by 10% with no increase in head count, and patient satisfaction increased from 4.3 to 4.7 on a 5-

point scale. Leadership of the huddles rotates weekly among the department's staff.

What links these 3 institutions is their journeys of implementing a quality improvement philosophy and set of principles originated by the Toyota Motor Company commonly referred to as Lean. The 3 health systems named and numerous others have clearly demonstrated that the Lean approach is just as applicable and useful in complex knowledge work as in assembly-line manufacturing. Early health system experiences with Lean also reveal the arduous nature of the journey.²

Lean is not a program; it is not a set of quality improvement tools; it is not a quick fix; it is not a responsibility that can be delegated. Rather, Lean is a cultural transformation that changes how an organization works; no one stays on the sidelines in the quest to discover how to improve the daily work. It requires new habits, new skills, and often a new attitude throughout the organization from senior management to front-line service providers. Lean is a journey, not a destination. Unlike specific programs, Lean has no finish line. Creating a culture of Lean is to create an insatiable appetite for improvement; there is no turning back. As Lean consultant Joan Wellman states, "With Lean, you will keep changing your definition of what 'good' is."³

The emergence of Lean success stories in health care, a rapidly changing reimbursement

environment that necessitates improved quality and efficiency, and the trend to public reporting of health care performance data^{4,5} are converging to encourage health care leaders to consider Lean for their institutions. No health care organizations or practicing clinicians are immune from the simultaneous pressures to improve quality and lower costs. As former Centers for Medicare & Medicaid Services administrator and Institute for Healthcare Improvement founder Donald Berwick, MD, states, “The only way we can rescue American healthcare is to improve it.... We know what to do—better care, better health, lower cost.”⁶

The growing health care interest in Lean creates fertile ground for rushing something that cannot be rushed, misunderstanding something that is not easily understood, and underinvesting in something that requires ongoing, multifaceted investment. Attempts to even define Lean have been elusive.⁷ Health care personnel have encountered various versions of Lean. We’ve been told it is a 5-day workshop on the one hand and a whole system cultural change on the other hand. In this article, we apply our collective experiences in leading a Lean transformation at ThedaCare and in visiting more than 100 health care systems applying Lean (J.S.T.) and in career-long service quality research inside and outside health care (L.L.B.) to define Lean and present its essential principles. The principles are illustrated by case studies from health care based on information provided by the institutions featured, personal visits, and follow-up communications. Our goal is to provide a template for health care leaders to use in considering the opportunity Lean offers their institutions or in assessing the state of its implementation in their organizations.

DEFINITION AND PRINCIPLES OF LEAN

Influenced by the work of Womack and Jones,⁸ we define Lean in health care as “an organization’s cultural commitment to applying the scientific method to designing, performing, and continuously improving the work delivered by teams of people, leading to measurably better value for patients and other stakeholders.” Lean is an operating system composed of 6 principles that constitute the essential dynamic of Lean management. To

miss on any one of these principles is to miss on Lean’s full potential to benefit the organization’s stakeholders.

Principle 1: Lean Is an Attitude of Continuous Improvement

Continuous improvement has its basis in a principle introduced by Shewhart⁹ and refined by quality improvement pioneer Edwards Deming. The Deming Cycle is the foundation of Plan-Do-Study-Act (PDSA), a central tenet of Lean.¹⁰ The PDSA approach is a scientific method applied to daily work: defining an explicit and measurable hypothesis about how a process can be improved, objectively testing the hypothesis, and, if improvement occurs, making the improved process “standard work” until such time as further improvement can be demonstrated.¹¹ Health care personnel are familiar with the scientific method in the form of controlled double-blind studies to test new treatments. Lean uses the same basic approach of measuring whether new process B is superior to existing process A.

For Lean to take hold in an organization and transform its culture to one of continuous improvement, senior management must relinquish the role of master problem solver to those who are closer to the problems to be solved—to benefit from their knowledge of the focal process, to give them hands-on experience in using Lean methods and to see first-hand the performance improvement and teamwork this can create, and to promote an attitude that what exists can likely be improved.

Clinical and nonclinical staff members who are given the encouragement, training, and time to make meaningful improvements in how the work is done are unlikely to want to retreat to an earlier period when formalized effort to improve existing processes was outside their domain of responsibility. As staff members gain confidence in their problem-solving skills and as they witness positive changes, momentum for even more improvement work is likely to build. This is Lean at its best; employees keep raising the bar, the organization becomes increasingly innovative, more staff want to be directly involved, and an attitude of continuous improvement becomes the driving force behind all work.

At St. Jude Medical Center in Fullerton, California, a team recognized a significant issue with scheduling radiology appointments.

The mean wait time on the telephone was 20 minutes, with a 17% to 20% dropped call rate. A process based on PDSA known as a rapid improvement event led to changes that include a staff huddle every morning to monitor and discuss the metrics of wait time, call volume, and dropped call rate, among other topics. The staff problem-solves issues from the previous day and anticipates issues for the upcoming day. At any time during the day, any team member can call for a huddle if performance issues arise. Such a huddle enables the staff to quickly identify and resolve problems. Total call volume has increased while wait time has decreased to under 1 minute and the dropped call rate to less than 3% with no increase in staffing.

Principle 2: Lean Is Value-Creating

Health care is for patients; health care resources, directly or indirectly, should be used to benefit patients. The underlying goal of Lean in health care is to improve value for patients. Doing so should also benefit other health care stakeholders. Fewer medication errors, fewer nosocomial infections, less nursing time away from the bedside, faster operating room turnover time, improved care team communication about patients, and faster response time for emergent cases not only benefit patients but also physicians, nurses, health care organizations, payers, and the community.

Value in health care has been conceptualized as health outcomes per dollar spent¹² and

outcomes per dollar spent *over time*.¹³ Patients, however, typically view value more broadly as benefits received for burdens endured.¹⁴ Burdens include both monetary costs and nonmonetary costs. The benefits vs burdens conceptualization of value includes medical outcomes and financial costs but extends beyond these constructs to also include patients' perceptions of the overall health care experience. A clinician's sensitivity in answering patients' questions, an operation that starts on time, and a quiet, calming medical facility may be ancillary to the medical outcome, but they can still be important to patients' assessment of value. Conversely, a clinician's insensitivity, a delayed operation, and a stress-increasing medical facility can be meaningful nonmonetary burdens to patients in their assessment of value.^{15,16} Measuring improvement in processes due to Lean interventions ideally should encompass a benefits vs burdens effect on all affected stakeholders. Who is affected by the changed processes and in what ways? Do benefits increase? Do burdens decrease? These are the questions that robust Lean measurement should answer.

Value stream maps are a principal Lean tool used to distinguish between discrete steps in a process that do or do not contribute value (Figure 1). A team close to the work creates a visual map of each step in an existing process to better understand it (ie, the current state). Clearly understanding the current state is essential to improving it, and creating a

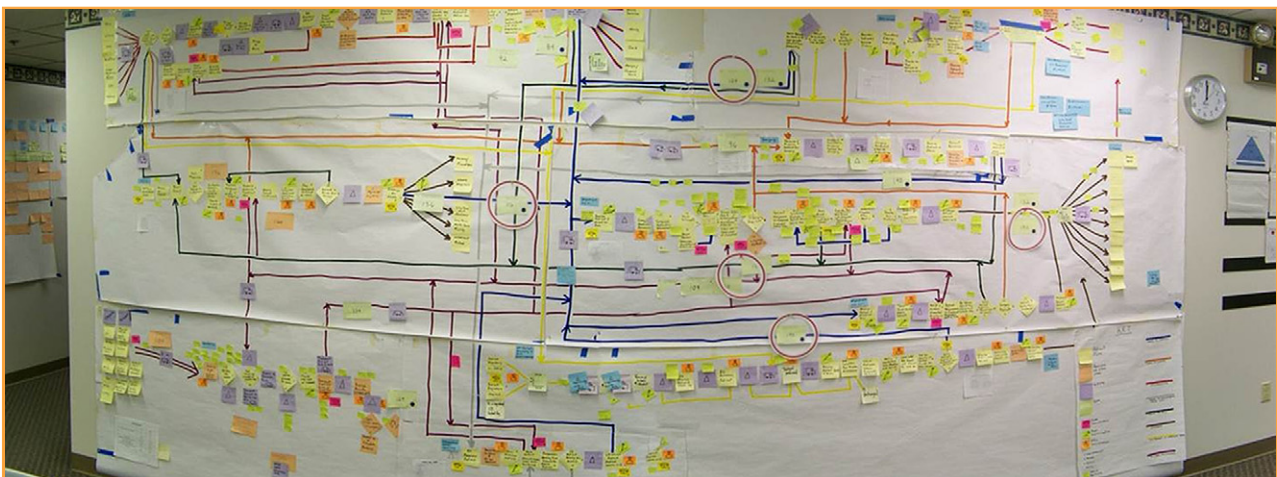


FIGURE 1. Example of a value stream map.

detailed depiction of the process facilitates understanding. A value stream map differs from other mapping by combining information flow and material and people flow; this enables the team to more clearly see a complex system's current state and offers a roadmap for improvement. By studying a value stream map, the team can ask questions such as, "Why do we do this step?" "Would a patient be willing to pay for this part of the process if he/she had a choice?" "Is there a more efficient or effective alternative?" "Which steps in the process are most vulnerable to errors?"

Value stream mapping requires attention to detail; each discrete step in a process should be captured on the map. Lean is primarily about "majoring in minors," that is, performing many small tasks better and creating value through the cumulative effect of small improvements. ThedaCare has a conference room that contains a large, finely detailed map of the patient's experience during a hospital stay. The admission process involves 124 steps, the discharge process 140 steps. This map has been through 7 stages of refinement at this writing. Various interfunctional teams work with different parts of the map in search of measurable improvement. One team, for example, has been working on reducing hospital readmission rates by improving the discharge process. The hospital value stream map room is where dozens of ThedaCare personnel working on various improvement teams seek to deeply understand the hospital care system's current state with the goal of improving the value it delivers—increasing the benefits and reducing the burdens for all stakeholders.¹⁷

In perioperative services at 8 member hospitals of the New York City Health and Hospitals Corporation, management recognized the need for a different infrastructure to support improvement. To engage interdisciplinary teams of front-line staff in the application of Lean tools, an external sensei (teacher) trained internal Lean facilitators at each site to design and lead improvement events. These teams sought to reduce handoffs and steps in presurgical testing, to increase on-time first case starts, to reduce turnaround time between cases, and to reduce the waste in searching for materials and the potential for errors caused by poorly managed inventory. Before the

improvement events, the facilitator and area managers collected data to study process steps, cycle and flow times, and handoffs, and they crafted problem statements. During 4.5-day rapid improvement events, teams reviewed the problem; mapped the current and target state; described the ideal state (perfection) and analyzed the gap between the current and target state; developed, tested, and implemented successful solutions; and crafted the metrics necessary to confirm achievement of the target state. Results as of spring 2012 generated from improvement events occurring between 2009 and 2011 at these 8 hospitals include the following:

- Percentage of on-time starts increased from a baseline of 50% of total to a mean of 70%.
- Number of operating room cases per month increased from a baseline of 329 to a mean of 351.
- Operating room turnaround time decreased from a mean of 60 minutes to less than 40 minutes.
- Percentage of cases rescheduled due to late starts decreased from a mean of 21% to a mean of 4.4% of total cases.
- Same-day surgery cancellations decreased from 7% to less than 3% of total cases.

Principle 3: Lean Is Unity of Purpose

Because health care organizations are complex systems, it is difficult for the staff to know what tasks are most important. Properly executed, Lean clarifies priorities and guides staff in improvement work accordingly. Lean work is focused work; priorities govern investment of improvement resources.

A key senior management role in Lean is to prioritize and clearly communicate a small number of strategic goal categories that are relevant throughout the organization and that have the most promise to strengthen the organization and create stakeholder value. Ideally, all Lean improvement projects fit within this strategic framework. Specific improvement projects (the "how") move the organization forward in its prioritized goal categories (the "what"). Management uses a process called "catchball." From chief executive officer to front-line supervisor, a series of conversations is constantly occurring. These conversations are documented on a single

sheet of paper and changed each time different team members' ideas are gathered. On the single sheet (called an A3 simply to denote paper size), background and current conditions are documented for the strategy being studied. A strategy statement is developed and goals are established. The opportunities in the marketplace the strategy is attempting to address are identified and countermeasures are suggested. Finally, a plan is established. Through the catchball process, it is not unusual to have 15 drafts of the A3, indicating that many people have been involved in defining the new strategy.¹⁸ This communication back and forth in the organization builds consensus, understanding, and engagement around the priorities.¹⁹

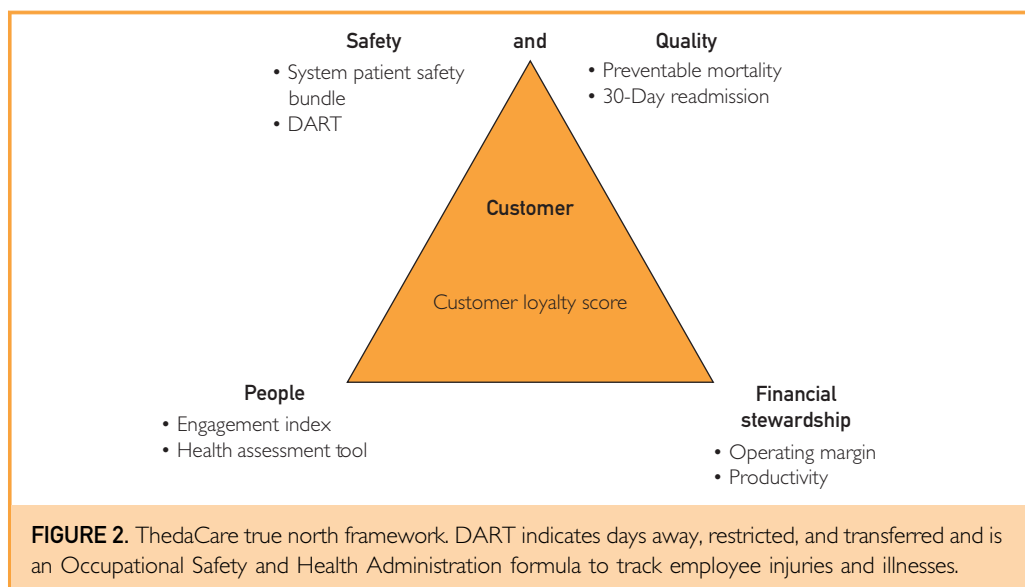
Lean organizations often use the symbolic term *true north* and visual expression to communicate and reinforce strategic priorities. ThedaCare's true north framework (Figure 2) puts the patient in the middle of a triangle and the strategic goal categories at the tips of the triangle. Two metrics are used to measure progress for each goal category and one for the patient, which is a customer loyalty score. This specific framework appears on improvement work boards in virtually every department and unit throughout ThedaCare's system of hospitals, clinics, and administrative offices. The several teams that conduct 4-day rapid improvement events every week at ThedaCare show how their work supports the true north

framework on day 5, when they present their findings at an employee gathering called "Report Out."

St. Jude Medical Center has defined its true north as "Perfect Care, Healthiest Communities, and Sacred Encounters." Perfect Care is translated into specific initiatives and metrics for inpatient, outpatient, and support areas. The Perfect Care focus on the critical care floor is the elimination of ventilator-acquired pneumonia. Before conducting a rapid improvement event, critical care staff believed they were doing everything possible to prevent ventilator-acquired pneumonia. The event showed otherwise, and staff implemented a visual management board outside each room of a patient receiving ventilatory assistance. On this board, red and green magnets are flipped every 2 hours as preventable measures are executed. This technique enables staff to quickly determine whether any preventable measure was missed. The care team meets regularly to review clinical evidence and discuss any misses in the preventable measures. The critical care unit has had zero preventable cases of ventilator-acquired pneumonia for more than 3 years at this writing, the result of unity of purpose around a true north metric.

Principle 4: Lean Is Respect for the People Who Do the Work

A Lean leadership and management system differs from a hierarchical system in which



higher-level managers and supervisors tell lower-level personnel what to do and how to do it.²⁰ This is perhaps the biggest challenge Lean implementation poses in many organizations: the people in charge may have to change the most for a Lean culture to develop.

Lean, in a sense, turns leadership upside down, with front-line workers doing much of the innovating and managers trusting them to do it and supporting them. Respect for the potential of front-line workers to have the brainpower and commitment to improve the work must pervade the organization. Respect flows downward, not just upward.

In Lean organizations, higher-level managers support the “improvers” by regularly visiting the worksites (or “Gemba” in Lean parlance) to learn firsthand about problems and barriers to improvement, by becoming teachers and role models of quality improvement, and by investing in the education, skills training, and tools necessary for front-line staff to be effective in improvement work. Management must make special efforts to create a safe environment for innovation, such as attacking processes rather than people so that staff members do not fear reporting problems.³ Lean health care organizations often commit to retaining and, if necessary, retraining employees whose positions are eliminated by productivity gains or structural innovations. Such a policy alleviates staff concerns about working themselves out of a job.

Leading a Lean transformation from the top of the organization demands perseverance (because setbacks are inevitable as are pockets of resistance) and humility (because Lean exposes many problems, some of which are caused by the senior leaders themselves). Lean has the potential to turn an organization into a community of innovators. However, this can happen only in a culture of respect.

Martin Health System, based in Stuart, Florida, had an incident in which an emergency department (ED) nurse at its satellite hospital could not quickly locate an intravenous (IV) pump for a patient in the ED. Critical time was wasted before a pump could be located. This incident led to a comprehensive evaluation of nursing care processes. One finding was that nurses were each spending a mean of 38 minutes per shift looking for needed equipment. If the equipment was not

available in the unit, additional time was then spent waiting for it to be provided. The effect on patients was less bedside nursing time and delayed treatments.

Nursing staff thought that there were never enough pumps and the solution was to order more. Lean concepts were applied to determine whether a shortage existed and, if so, how many more pumps were needed. The hospital had an inventory of 508 IV pumps to serve 344 beds. On the basis of a national IV pump-to-bed ratio of 1.2 pumps per bed, there was actually a surplus of 96 pumps. The issue was not a shortage but the lack of a procedure for nurses to access pumps quickly and easily. The lack of a procedure led to nurses hoarding unused pumps, which exacerbated the problem.

To improve, Martin installed “equipment supermarkets” in nursing units. The supermarkets contained all necessary equipment for specific units, for example, IV pumps, patient-controlled analgesia pumps, feeding pumps, sequential compression devices, and bed alerts. Standard work was developed to facilitate the availability of needed equipment. The equipment supermarket shelving was color coded and numbered with the quantity of items for each color: green indicates that supply is adequate; yellow, supply needs replenishing; and red, the need to call for immediate restocking of the item.

This process improvement has reduced mean nursing time spent gathering equipment to less than 1 minute, contributing to hard-dollar savings and productivity gains. For example, when use of a medication is discontinued, the IV pump is cleaned and returned to the equipment supermarket. By improving the use or “turns” of IV pumps, the hospital was able to replace the existing pump inventory with 100 fewer units, which yielded a direct savings of \$300,000. Total nursing time spent gathering supplies was reduced by 34 hours per day.

Multiple departments collaborated on developing, testing, and refining the nursing equipment flow process, including nursing, material management, housekeeping, and decontamination. These staff members became a community of innovators to find a better way to ensure that essential hospital equipment was available where and when it was needed while minimizing nonuse of the

equipment. One additional outcome at Martin: nurses have stopped hoarding IV pumps.

Principle 5: Lean Is Visual

Visual tracking centers exist in numerous locations within a Lean hospital or clinic. These tracking centers are information displays mounted on the walls in staff-only areas. Their purpose is multifold: to present daily and trend performance data on key metrics (eg, patient satisfaction, cost, and quality metrics); to provide a dedicated place for any staff member to communicate an issue that needs attention or to post an improvement idea; to organize all relevant improvement information in one place (including projects not yet started, work in progress, and projects completed); to provide a gathering spot for both scheduled and impromptu staff meetings; and to symbolize a culture of transparency. A common sight in a Lean health care facility is staff meeting in front of a tracking center with the meeting leader continually referring to the posted information. This practice is referred to as “working the wall.”

Visual tracking center information is ever-changing, and thus it is common practice to use erasable marking pens, pencils, or sticky notes to present it. Whereas conventional bulletin boards at worksites often become stale because information either is not relevant or rarely changes, the converse is more likely with Lean tracking centers; the information is dynamic and directly relates to what staff are thinking about in terms of how best to provide what patients need and want.

When Seattle Children’s built its new Bellevue Clinic and Surgery Center, it used Integrated Facility Design, a process based on Toyota’s Production Planning Process approach. The Integrated Facility Design process brings a diverse set of stakeholders together for planning before a shovel ever enters the ground. The early involvement of stakeholders typically results in fewer changed work orders and more efficient construction. During planning, Seattle Children’s brought together nurses, physicians, support staff, patients, architects, designers, and others to help determine the needs, goals, and metrics for the facility and to think through the most efficient flow and use of space. Value stream maps depicting the workflow were developed and agreed on by all vested parties, including patients and families. Families played

an important role in fostering understanding of their needs and wants. For example, parents stressed their desire to stay with their child in the preoperative area and the space was designed to accommodate the presence of parents.

The value stream maps helped prioritize design requirements that contributed to the facility being built for \$30 million less than initial estimates. The mapping allowed the team to see the waste in their existing care process, much of which they removed in designing a new ideal-state care process. The new ideal state was used to design the building space required, which cost less, rather than the space proposed in the original architectural design. The maps are still displayed in the back hall of the building and are regularly reviewed and updated. Metrics for both the clinic and surgery center are displayed in visual tracking centers throughout the facility.

Principle 6: Lean Is Flexible Regimentation

Processes are perfectly designed to produce the results that occur.²¹ But what if the results are not optimum? What if the results of specific processes indicate needless waiting, lost productivity, unexplained error rates, staff dissatisfaction, or patient harm? The key to improvement is determining the root cause (or causes) of performance shortfalls and ridding the process of the cause(s) through redesign. This is the essence of Lean: take nonstandard work processes and transform them into standard processes that improve performance and then continue to improve the standard work design through PDSA.

Standard work is best described as *flexible regimentation*, a phrase coined by Robert Wilson, MD, a ThedaCare cardiologist. *Regimentation* refers to developing a common or standard process for performing a specific service based on the best available evidence; *flexible* refers to ongoing efforts to improve the standard process. A paradox of standard work is that the standards established release creativity.³ With standard clinical approaches, patients who deviate from the standard are more easily appreciated, freeing up the clinicians to expend their mental energy on issues and patients. An example at Seattle Children’s is the asthma care unit, in which standardization of albuterol therapy has allowed physicians to better identify patients who are not following the typical

course. The fact that the standard approach to treatment does not work calls into question the diagnosis of asthma and forces the physician to search for other causes. The specific design of a standard process offers the opportunity for focused study and testing. Knowledge work is easier to study once it has been defined as a set of expected activities.

Process outcomes are sometimes so variable that they first must be stabilized before they can be standardized. Stabilizing a process involves finding a short-term method to contain unacceptable results until a standardized solution can be developed. For example, a patient falling off the fracture table in an operating room would be considered a “never event.” Should it happen, a hospital might decide to place a nurse on both sides of the table. Stabilizing this process with 2 nurses ensures the safety of the next patient in the same situation, but it may not be the final solution to fixing the problem. The root cause of the fall must be identified before new standard work can be designed to permanently eliminate the defect.

Inova, an integrated health system in Virginia, has 9 EDs that treat approximately 400,000 patients annually. At the beginning of 2008, Inova’s EDs were achieving average performance on quality, patient satisfaction, cost, and throughput measures. During 2008, Inova initiated process improvement in its EDs in conjunction with the implementation of a new electronic medical record system. Each ED completed staff-developed value stream maps that indicated significant flow issues in intake and triage. Patients were routinely ping-ponged back and forth among registration, triage, and the lobby, sometimes even when physicians were available in the back to see them. The prevailing culture in most of the EDs was that a nurse would always see a patient in the examination room before the physician. The value stream mapping work changed this so that physicians could enter the room at any time and their evaluation of the patient would take precedence.

Other new standards included quick registration (3 minutes) followed by quick triage (3 minutes) followed by the patient going directly to a treatment location. Several of the EDs elected to do all triage at the bedside. Use of the new electronic medical record system to measure and trend all stages of the process and to make performance visible was instrumental

in improvements realized across all EDs by 2011: length of stay for discharge patients decreased from 215 to 135 minutes, time to seeing a physician decreased from 55 to 22 minutes, diversion decreased from 1300 hours annually to approximately 50 hours, and patient satisfaction increased from the 60th percentile to the 80th percentile in the national database of a commercial research vendor. The EDs have provided approximately \$10 million in incremental income each year since 2009 based on a 2008 baseline. Volume has increased 6% to 7% each year with only a few ED beds added. By the end of 2012, the EDs will have provided more than \$6 million in labor productivity gains.

CONCLUSION

Lean is an innovative management approach that has proven successful in health care organizations. It offers promise for improving quality and efficiency while controlling costs in the provision of optimum patient care. To implement the Lean philosophy and principles, however, is to undertake an arduous, never-ending improvement journey. Because Lean transforms organizational culture from the inside out, it offers both challenges and opportunities. It requires a major shift in roles: managers and leaders must become facilitators, mentors, and teachers and allow front-line workers to make improvements. It engages the entire staff in identifying and solving problems based on a continuous improvement attitude, the driving force behind Lean work.

The underlying goal of Lean is to improve value for the patient. Innovation through Lean’s proven methods provides hope for better health care at less cost rather than worse health care at less cost. To us, this choice is clear.

Abbreviations and Acronyms: ED = emergency department; IV = intravenous; PDSA = Plan-Do-Study-Act

Correspondence: Address to Leonard L. Berry, PhD, Department of Marketing, Mays Business School, Texas A&M University, 4112 TAMU, College Station, TX 77843-4112 (BerryLe@tamu.edu).

REFERENCES

1. Bielaszka-DuVernay C. Redesigning acute care health services in Wisconsin. *Health Aff (Millwood)*. 2011;30(3):422-425.
2. Toussaint J, Gerard RA. *On the Mend: Revolutionizing Healthcare to Save Lives and Transform the Industry*. Cambridge, MA: Lean Enterprise Institute; 2010.

3. Wellman J. Paper presented at: Nemours Foundation Board of Directors Meeting; November 7, 2011; Orlando, FL.
4. Partnership for Healthcare Payment Reform. <http://www.phprwi.com/index.php>. Accessed May 13, 2012.
5. Toussaint J. *Potent Medicine: The Collaborative Cure for Healthcare*. Appleton, WI: ThedaCare Center for Healthcare Value; 2012.
6. Berwick D. Paper presented at: Institute for Healthcare Improvement National Forum; December 7, 2011; Orlando, FL.
7. Petersen J. Defining lean production: some conceptual and practical issues. *TQM J*. 2009;21(2):127-142.
8. Womack J, Jones D. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. 2nd ed. New York, NY: Free Press; 2003.
9. Shewhart WA. *Statistical Method from the Viewpoint of Quality Control*. Washington, DC: US Dept of Agriculture; 1939.
10. Moen R, Norman C. Evolution of the PDCA Cycle. <http://pkpinc.com/files/NA01MoenNormanFullpaper.pdf>. Accessed June 7, 2012.
11. Staats BR, Upton DM. Lean knowledge work. *Harv Bus Rev*. 2011;89(10):100-110.
12. Porter ME, Teisberg EO. *Redefining Health Care: Creating Value-Based Competition on Results*. Cambridge, MA: Harvard Business Review Press; 2006.
13. Smoldt RK, Cortese DA. Pay-for-performance or pay for value? *Mayo Clin Proc*. 2007;82(2):210-213.
14. Berry LL. *Discovering the Soul of Service*. New York, NY: Free Press; 1999:12-13.
15. Bendapudi NM, Berry LL, Frey KA, Parish JT, Rayburn WL. Patients' perspectives on ideal physician behaviors. *Mayo Clin Proc*. 2006;81(3):338-344.
16. Fung CH, Elliott MN, Hays RD, et al. Patients' preferences for technical versus interpersonal quality when selecting a primary care physician. *Health Serv Res*. 2005;40(4):957-977.
17. Toussaint J. Writing the new playbook for U.S. health care: lessons from Wisconsin. *Health Aff (Millwood)*. 2009;28(5):1343-1350.
18. Shook J. *Managing to Learn*. Cambridge, MA: Lean Enterprise Institute; 2008.
19. Dennis P. *Getting the Right Things Done*. Cambridge, MA: Lean Enterprise Institute; 2007.
20. Barnas K. ThedaCare's business performance system: sustaining continuous daily improvement through hospital management in a Lean environment. *Jt Comm J Qual Patient Saf*. 2011;37(9):387-399.
21. Deming WE. *Out of the Crisis*. Cambridge, MA: MIT Press; 1986.

Copyright of Mayo Clinic Proceedings is the property of Quadrant HealthCom Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.