

# Use of Lean in the Emergency Department: A Case Series of 4 Hospitals

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**Study objective:** We describe the effects of Lean, a process improvement strategy pioneered by Toyota, on quality of care in 4 emergency departments (EDs).

**Methods:** Participants in 2 academic and 2 community EDs that instituted Lean as their single process improvement strategy made observations of their behavioral changes over time. They also measured the following metrics related to patient flow, service, and growth from before and after implementation: time from ED arrival to ED departure (length of stay), patient satisfaction, percentage of patients who left without being seen by a physician (2 EDs), the time from ordering to reading radiographs (1 ED), and changes in patient volume.

**Results:** One year post-Lean, length of stay was reduced in 3 of the EDs despite an increase in patient volume in all 4. Each observed an increase of patient satisfaction lagging behind by at least a year. The narratives indicate that the closer Lean implementation was to the original Toyota principles, the better the initial outcomes. The immediate results were also greater in the EDs in which the frontline workers were actively participating in the Lean-driven process changes. A factor that considerably affected the outcomes in the second and third year postimplementation was the level of continuous leadership commitment to Lean.

**Conclusion:** Lean principles adapted to the local culture of care delivery can lead to behavioral changes and sustainable improvements in quality of care metrics in the ED. These improvements are not universal and are affected by leadership and frontline workforce engagement. [Ann Emerg Med. 2009;xx:xxx.]

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## INTRODUCTION

### Background

The most recent Institute of Medicine report on emergency care in the United States<sup>1,2</sup> warns of a looming crisis in emergency care and identifies crowding as the major contributing factor. Although there are a variety of medical, social, financial, and other external causes for crowding, there is also a tacit recognition that the internal organization of emergency departments (EDs) often is a source of inefficiencies.

The tactical tool traditionally used in the health care industry for quality improvement is plan-do-study-act, a cyclic process based on a trial and learning approach.<sup>3</sup> In the early years of this decade, the attention of the industry was drawn to 2 techniques created and successfully used in industries outside of health care: Six Sigma, which began at Motorola in the mid-1980s,<sup>3</sup> and Lean, which was pioneered by Toyota in the 1970s.<sup>4</sup> Reports in the media, at industry conferences, on institutional Web sites, and sometimes in quality of care journals suggest that a small

but increasing number of hospitals in the United States<sup>5-13</sup> and other Western countries<sup>14,15</sup> are adopting Six Sigma or Lean.

*Lean* is an iconic term for the philosophy behind the Toyota Production System of car manufacturing, also known as the "thinking people system." It defines a system designed to provide the tools for people to continually improve their work and add value to the product or service they are producing. It is based on a philosophy that abhors waste, that is, any action that does not add value to the product—or, in health care, to the patient experience. A core value of the Toyota Production System is continuous improvement (Kaizen) of all processes.<sup>16</sup> People often learn the Lean philosophy during a Kaizen event, which is a process improvement event that is often used to teach people about Lean while they improve specific processes. The Kaizen event is a way of learning by doing. During Kaizen events, participants—who always include frontline workers, managers, and often customers—use Lean tools to evaluate processes, identify waste, test new solutions, and increase the value of the product or service produced. The idea is that once

**Editor's Capsule Summary***What is already known on this topic*

The Lean approach to improving efficiency has clear benefits in many industries, but use in health care is limited and virtually no emergency department (ED) data exist.

*What question this study addressed*

Does a process improvement effort using Lean principles improve ED care?

*What this study adds to our knowledge*

Three of 4 hospitals showed process and patient satisfaction improvements despite higher ED volumes 1 year after initial implementation. Qualitative analysis suggests that leadership and ED provider "buy in" were keys in the successful sites.

*How this might change clinical practice*

Using a Lean approach could improve your department's care, though, like many successful improvement projects, it requires multilevel institutional commitment.

indoctrinated into the Lean philosophy by participating in a Kaizen event, participants will adopt the core value of continuous improvement and work endlessly to transform waste into value from the customer/patient's perspective. Lean uses a variety of tools to improve processes, including standardizing work, Just in Time, 5-S (sort, set in order, shine, standardize, and sustain), 5-Why (a problem-solving tool), and Kanban (a card visual system for feedback within the system). But the cornerstone of the Toyota Production System is workers' empowerment: providing workers with the tools and culture to effect changes in their area of work. In health care, this means that all providers must have 2 jobs: taking care of patients and finding better ways to take care of patients by constantly improving quality and flow.

**Importance**

Some health care providers are loath to break with their routines or accept standard work approaches. Health care managers often lead from behind the desk and have a very hard time delegating process improvement to the people doing the work. The Toyota Production System transformed Toyota by motivating its workers and managers to be flexible to change and continuously use standardized processes to improve quality and flow, and has thus challenged the whole automobile industry to change.<sup>4</sup> Lean could have similar effects in emergency health care. Thus far, a limited number of Lean adopters in health care have reported positive initial results, and none of them have clearly demonstrated that Lean can produce

long-term, continuous improvement or examined implementation between facilities.<sup>17</sup>

**Goals of This Investigation**

We sought to (1) describe how Lean was used as a tool for eliminating waste (fight crowding) and adding value (improve care quality) in 4 self-selected EDs with different culture of care and patient demographics, and (2) pinpoint some of the local factors leading to either identifiable process improvement when Lean is adopted as the single quality improvement tool or Lean's failure to produce such improvement.

**MATERIALS AND METHODS****Study Design**

EDs from 2 teaching and 2 community hospitals agreed to share their experience and data for this participant observation study. We used this approach because Lean implementation occurs in the real world and is contingent on people who interact in a manner that cannot be isolated and controlled. Each of the 4 EDs adopted Lean independently in its own way. In each of them, a team coordinator took field notes and informally assessed the team members and leadership interactions over time. All were using similar metrics to routinely measure performance, and this allowed a comparative description of the links between Lean implementation and outcomes. In all 4 settings, there were no other improvement initiatives overlapping in time with Lean.

The deployment of Lean began on different dates for each of the EDs, but always after the below metrics had been recorded for at least 1 year (pre-Lean year). The 1-year mean observations served as the base against which progress was measured in the years after full implementation of Lean (post-Lean years). There was no change in the manner in which length of stay, patient volume, patient satisfaction, and the other metrics were recorded during the post-Lean years because all of these are routine indicators of ED performance and, by extension, of quality of care. Also, there were no changes in the number of treatment rooms or physical plant pre-Lean versus post-Lean.

All of the EDs using Lean expected to reduce the global patient length of stay that was measured as the time from ED arrival to ED departure. Those who tracked the number or percentage of patients who left without being seen by a physician also expected this measure to show improvement. All measured growth by using the total number of patients (patient volume) treated before and after the implementation of Lean and the number of patients admitted to the hospital from the ED. Finally, all assessed progress in patient satisfaction as the change in the percentage of patients ranking the overall ED care as "very good" on Press Ganey or Gallup surveys.

As used in health care, the Lean technique relies almost exclusively on Kaizen (continuous improvement of both process and workforce). Each of the 4 EDs used an idiosyncratic version of the Kaizen event adapted from the Toyota Production System (Table 1, columns 3 to 5). Lean implementation typically begins with a Kaizen event: a 1- to 5-day rapid

**Table 1.** Ways of Lean implementation and post-Lean process management (Kaizen).

Hospital	Demographics	Kaizen Event	Kaizen Management	Leadership Involvement
Hospital A (teaching)	690-bed tertiary acute care hospital 29-bed ED ED volume: 38,000 visits annually Urban population	Moderated by Lean consultants 1.5-day boot camp that ends with identifying waste Value stream map Emphasis on training: pilot RAD, followed by 1-mo training and standardization	Local modification: achieve a future state identified as RAD process for lower-acuity patients Leadership driven; thus, frontline workers not initially asked to provide ideas for process redesign but in the course of implementation were inspired to suggest incremental process improvements Local culture of accountability: posting real-time metrics on a communication board and weekly reporting of progress through the Internet Different teams work in different focus areas	Chief executive officer involved (visibility) Senior hospital executive appointed as sponsor and champion Each focus area has its leader Lean consultants partner with the leader along the way All physicians embraced RAD Bimonthly meetings attended by executives Standing agenda item of the Hospital's Management Council
Hospital B	889-bed tertiary care community hospital 42-bed ED ED volume: 58,000 visits annually Urban population	Led by a consultant team Videotaped patient and staff experience (current status) and analyzed the tapes to eliminate, simplify, or combine processes Staff was taken off of their schedule for 3 months: Kaizen events also occurred Looked for waste or non-value-added steps Developed a plan for parallel processing Incorporated Lean tools	Redesigned staff work areas Designated physician examination rooms Quarterly audits Each new employee receives a Lean lecture and is mentored by an experienced staff member Frontline workers meet monthly to review progress, identify issues, and remove barriers to improvement Recognition of cultural shift that goes beyond the ED	No committed leadership Progress report to leadership 1 mo post-Kaizen
Hospital C	461-bed acute care hospital 44-bed Level II trauma center ED volume: 85,000 visits annually (199 patients daily) Mix of urban and rural population	No Kaizen event per se Examined radiology orders to evaluate turnaround time Observed patients and measured time from room to radiograph available for review Found time to radiograph efficient; thus, not a great opportunity for reducing LOS Patient wait times to see a physician found to be significant	Identified a set of steps, such as review study results, with ED physicians and radiology staff and used interventions to reduce wait times, and nurses to improve compliance with existing protocols Successfully improved laboratory turnaround time No consistent follow-up Ideas of frontline workers not sought	Minimal
Hospital D (teaching)	700-bed university hospital, tertiary care referral center for the state 20-bed Level I trauma center ED volume: 34,000 visits annually at baseline Mostly rural population	5-day Kaizen event directed by a Lean specialist from the hospital Office of Operational Improvement Closest to the generic outline In addition to ED staff, the team included 5 external participants whose role was to define value from a patient perspective.	2-day events to reassess process conducted regularly Communication board Periodic electronic communication Lean champion demands frontline workers' continuous involvement in improving process further along	Full involvement of the department chairperson from initiation and during the post-Lean period Broad commitment of hospital leadership, with no specific input or requests for reporting Lean implemented in other clinical units of the hospital but no interaction Chairperson constantly checks progress and champions for incremental changes

RAD, rapid assessment and disposition; LOS, length of stay.

**Table 2.** Changes in the key performance metrics during the post-Lean period compared with baseline.

Hospital/Indicators of change	Lean kickoff	Pre-Lean (baseline)	1 Year Post-Lean (% of Baseline)	2 Years Post-Lean (% of Baseline)	3 Years Post-Lean (% of Baseline)
<b>Hospital A</b>	July 2007				
LOS		459	376 (82)	NA	NA
PV		2549	2643 (104)	NA	NA
PS		56%	50% (89)	NA	NA
LWSD		8%	5% (64)	NA	NA
<b>Hospital B</b>	Apr 2005				
LOS		426	419 (98)	384 (90)	284 (67)
PV		4632	5016 (108)	5003 (108)	4796 (103)
PS		38%	36% (97)	42% (111)	46% (121)
LWSD		512	310 (61)	206 (40)	115 (22)
<b>Hospital C</b>	Jan 2006				
LOS		201	203 (101)	212 (105)	NA
PV		5612	5715 (102)	5987 (107)	NA
PS		55%	46% (84)	44% (79)	NA
<b>Hospital D</b>	Jan 2006				
LOS		160	157 (98)	156 (97)	NA
PV		2818	3078 (109)	3453 (122)	NA
PS		54%	59% (108)	61% (110)	NA
Adm		725	828 (114)	926 (128)	NA

NA, not applicable; PV, patient visits per month; PS, percent of patients ranking overall ED care as “very good”; LWSD, left without being seen by a physician; Adm, admissions per month.

Italics=better than baseline year. Underline=worse than baseline year.

improvement workshop designed to involve frontline caregivers and managers in the improvement of process using the principles of Lean. In addition, these initial workshops are used to initiate a never-ending process of continuous improvement according to the Lean principles. Kaizen events typically follow a 3-step process:

- First step: observation and thorough documentation of the existing process (current state), using a process map or value stream map<sup>20</sup>; the value stream map is a chart including all steps used to manage the patient from door to discharge.
- Second step: value analysis and process redesign: finding out and ranking waste (value-adding and non-value-adding steps) in the process according to the experience of frontline workers. The redesign process focuses on how to arrive at the future state (or ideal state).
- Third step: testing ideas (finding the low-hanging fruit) generated by frontline workers during the redesign step, which will start the journey toward the future state. The goal for all staff to work toward the ideal state is set by the future-state value stream map.

The future-state value stream map gives an overview of the improved patient flow at a glance. It is hoped that the initial Kaizen event sows the seeds for a culture of continuous improvement (Kaizen) and relentless pursuit of perfection (also known as the ideal state) to grow. As part of the adoption of Lean, the managers committed to Kaizen must acknowledge that frontline staff members have greater insight into the process and are therefore more likely to find ways of improving it. Frontline staff members, in turn, have to gain awareness of this fact and be encouraged to find solutions to problems that create waste, slow down flow, and decrease the ED quality of care.

The Kaizen event marks a watershed between the pre-Lean year and the post-Lean period. Usually, the process improvements coming from the workshop are not particularly novel. However, because frontline workers design them, they are more enthusiastically accepted and fully deployed. In the post-Kaizen event period, new recommendations are continuously sought, implemented, and added to the periodically updated process map. Process maps detailing patient flow are often posted in public areas to help define standard work. All relevant metrics recording progress are also displayed or sent out electronically so that staff can see the effects their recommendations have on patient flow and the overall ED improvement. Staff satisfaction as a motivational force needs to be coupled with the engagement of a champion or leader from the ED or hospital management team to keep the enthusiasm for Lean high for as long as possible—ideally, indefinitely—after the kickoff Kaizen event.

## RESULTS

We summarized our narrative about the 4 EDs in Table 1 and compiled the measurement dynamics in Table 2. In what follows, we briefly outline the relevant social characteristics of each hospital's working environment.

In Hospital A, the use of Lean in the ED was not viewed initially as a tool for total process improvement but only for improving the care of lower-acuity patients; this part of the care delivery was even given a name, rapid assessment and disposition, reflecting a specific local culture. Lean implementation was heavily driven by the hospital leadership, and an overemphasis was placed on frontline workers training. The latter were good followers but not the main drivers of the



changes, at least in the beginning. This caused a certain degree of deviation from the core Toyota Production System principles. Staff was reallocated and new operational standards were created under leadership supervision. There was a strong, long-term leadership commitment to pursue Lean at all levels of management, up to the hospital chief executive officer. One year post-Lean, all ED performance indicators have shown improvement except patient satisfaction. The latter remained a problem also during the months after the first post-Lean year reported here. The well-publicized success of Lean in-house has inspired other units to eagerly anticipate its implementation.

In Hospital B, Lean was entirely driven by the frontline workers. The hospital leadership is still not committed to the implementation but is informed about the developments throughout the post-Lean years. However, there are champions among the frontline workers who are instrumental in sustaining long-term Lean improvements. Thus, all caregivers have the sense of ownership of Lean and work relentlessly to add value in incremental ways. Employees mentor new employees during orientation. When audits show failure in following standard work, the team is invited to discuss ways of solving the issues. Toyota Production System principles are strictly observed at the level of the workforce, and this seems to compensate for the leadership disengagement. All the performance indicators have improved during the first post-Lean year, except patient satisfaction, and continued to improve 3 years post-Lean. Patient satisfaction improvement lagged behind but is steadily improving.

In Hospital C, frontline workers were not involved in the ED management's attempt to address crowding by cutting down the time "from ordering to reading radiograph." This attempt to improve throughput, as well as physician and patient satisfaction, was labeled "Lean" but did not begin with a Kaizen event. It was also not followed up by specific frontline workers' suggestions for process changes, once it was determined that the number of radiograph orders and the time from ordering to reading the radiograph did not offer opportunity for improvement. A similar attempt was later made to improve efficiencies in the laboratory turnaround times; it resulted in a 15% reduction in turnaround times and a reduction in hemolytic rates of approximately 45%. Hospital C's leadership had little ongoing contact during the implementation of Lean. During the first and second post-Lean years, not only was there no improvement in length of stay and patient satisfaction but also both showed a trend toward worsening while patient volume was increasing.

In Hospital D, Lean implementation is characterized by a typical Kaizen event kickoff, commitment of the department chairperson to the continuous Lean-driven process improvement, and permanent engagement of the frontline workers with ideas and suggestions from the beginning.<sup>18</sup> Given ownership of the Lean process, the local workforce demonstrated flexibility to change and responded positively to the chairperson, who was the ultimate champion of Lean

throughout the measured period. Not surprisingly, patient satisfaction began to improve from post-Lean year 1 and continues to improve during the months after the reported 2-year post-Lean period. All other performance indicators continue to improve. Staff satisfaction also is improving, as indirectly assessed by the steady increase in ranking of nurse and physician courtesy by patients.<sup>19</sup> The increased patient volume translated to a steady increase in admissions, another demonstration of improved throughput and growth beneficial for the entire hospital.

## LIMITATIONS

The main limitation to this study is that it attempts to evaluate a real process in an uncontrolled environment: an ED is a managed environment but cannot be rigorously controlled for the sake of an experiment. Moreover, patients arrive at a variable rate, with relatively unpredictable needs, creating a high amount of uncertainty. Yet, even if we cannot cut Lean clean of "noise," all 4 EDs attest that during the period of observation, Lean was the single paradigm for improvement.

We also recognize a selection bias: the EDs were included because they had decided to adopt Lean, that is, they were making a planned effort to fight crowding by using Lean. To our knowledge, this case series is the first to show negative results in a hospital that has attempted to implement Lean. Indeed, there is a current trend of reporting bias toward publishing positive—and more often than not immediate—results because hospitals who failed to achieve the intended behavioral changes do not come forward to openly analyze the reasons for their failure.

Relying on careful participant observation of the occurring changes, we also tried to account for a possible Hawthorne effect (a short-term improvement caused by observing worker performance). Such an effect might have limited the significance of the immediate post-Lean surge in positive performance outcomes. However, a 1- to 3-year follow-up of performance metrics and the changes in the ED working environment have lessened this limitation. Moreover, Lean drives improvement in patient flow slowly and incrementally.

We are aware of the difficulty in pinpointing improvement in patient flow by using length of stay alone while patient volume increases: length of stay may remain unchanged even if process has improved because the improvement will help increase throughput (patients per hour) but not necessarily length of stay. Unfortunately, none of the 4 EDs measured throughput. Thus, we can be reliably certain that length of stay reflected Lean-generated improvement in full only in Hospital B, where there was no patient volume increase. The longer Lean is pursued consistently, the more evident the changes become and the stronger the indicators of positive effect manifest the time savings resulting from the improved patient flow.

## DISCUSSION

Our Lean analysis takes the ED as a complex social system undergoing change. According to Berwick,<sup>21</sup> social changes are

multicomponent interventions of the social system that are often interpersonal and in all cases nonlinear. Therefore, these changes have to be evaluated in a model alternative to the classic linear model that says “observe—introduce a change to some participants but not others—and then observe again.” This new model, proposed by Pawson and Tilley,<sup>22</sup> is based on the formula “context + mechanism = outcome.” The EDs are the contexts in which Lean is the mechanism being introduced, and we measured the outcomes. In the EDs in which the outcomes were successful, Lean proved to be the appropriate mechanism for achieving the set goal. Our case series demonstrates that when the mechanism, Lean, was not implemented properly or the social context (for example, missing leadership support) was not the appropriate one, the outcomes were not successful or sustainable, and therefore the set goal was not achieved or took longer to be achieved.

Our observations support the view that when Lean is applied according to the Toyota Production System principles and is owned by the frontline workers who actually perform the work in the ED, it can produce care metric improvements. Lean is not a panacea, but rather a tool that may or may not succeed, according to the efforts surrounding its use.

Another factor with tremendous effect on the deployed processes and the outcomes is the local culture of emergency care. Leadership commitment and workforce’s flexibility to change are important components of this culture. The leadership commitment to Lean is a variable whose effects on Lean are hard to pinpoint. Frontline workers’ engagement alone produces improvement that comes more slowly but, given the presence of Lean champions, can be sustained. If both frontline workers’ engagement and leadership commitment to Lean are missing (our Hospital C), improvement fails to materialize. If leadership commitment exceeds the engagement of the frontline workers who, in addition, are not flexible enough to change (our hospital A), improvement of patient satisfaction seems uncertain, even though a 1-year decrease of length of stay and leaving without being seen by a physician could be achieved.

The EDs’ pre-Lean baseline conditions affect the extent to which Lean’s effects are reflected in the measurable outcomes. For example, the EDs with relatively short pre-Lean length of stay experienced little change on this outcome, whereas the ones with longer pre-Lean length of stay experienced a more profound change.

Patient satisfaction seemed to be the outcome most resistant to change. The reason for the postponed or slower increase may be that patient satisfaction requires more time to reflect the positive effects on patient perceptions. It is also likely that the decrease in patient satisfaction in some of the EDs may be due to the fact that the patients who were most dissatisfied pre-Lean (left without being seen by a physician) were now staying and being treated; hence, they are able to fill out a survey (those who leave without being seen by a physician do not receive a survey), in which they express their frustrations by giving the ED a low score.

The care metric changes and improvements outlined in this study persist during the current post-Lean year in Hospitals A, B, and D. What is common across the successful EDs is the strict adherence to Lean principles. What is different is that these principles translate into a variety of local process redesigns. In this sense, Lean must be regarded as an educational tool for both frontline workers and leadership because it introduces discipline and accountability when all concerned are motivated by an organizational strategy of better performance.

In conclusion, Lean is one tool to improve patient care metrics and satisfaction but depends on the degree of adherence to the Toyota Production System principles and the local culture of emergency care. Given a favorable combination of key factors—engaged frontline workers who come to own Lean, long-term leadership commitment, and workforce flexible to change—deployment of Lean could continuously improve patient flow, service, and growth in the ED.

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**Editor's Capsule Summary:** *What question this study addressed:*

Does a process improvement effort using Lean principles improve ED care? *What this study adds to our knowledge:* Three of 4 hospitals showed process and patient satisfaction improvements despite higher ED volumes 1 year after initial implementation. Qualitative analysis suggests that leadership and ED provider "buy in" were keys in the successful sites.