J Ambulatory Care Manage
Vol. 33, No. 4, pp. 296–306

New Directions in Emergency Service Operations and Planning

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Abstract: Emergency services continue to evolve new operational and facility concepts in response to increasing demand for care and pressures for efficient, and safe, patient management. This article describes new models for "intake" of patients and for responding to peak demand that are radically changing the traditional emergency service. Application of Six Sigma and "Lean" analysis techniques are demonstrating dramatic improvements in throughput times and in the utilization of treatment spaces. This article provides an overview of the application of Lean concepts to emergency services. Case studies of Mary Washington Hospital and Banner Health Corporation illustrate the result of application of these tools. Implication for the required patient care areas and design concepts are also discussed. **Key words:** *ambulatory care*, *design*, *emergency service*, *LEAN*, *Six Sigma*

THE CONTINUING SAGA OF EMERGENCY CARE

Emergency visit volume has increased nationally at a rate of almost 3% annually since the mid-1980s as a result of multiple factors: the increasing age of the general population; limitations in access to medical care by the general and indigent populations; and a general trend toward increasing utilization rates. The increase in volume is only one component of the pressure currently being experienced by emergency services in the United States. Over the same period of time, the rate of patients admitted from the emergency department (ED) has increased dramatically, frequently accounting for more than 50% of total admissions to acute hospitals. The "ripple" effect of high inpatient occupancies (particularly by day of week), and delays in discharges, has extended lengths of stays in the ED, frequently resulting in "grid lock" with few ED treatment stations available to maintain patient flow.

Although recently enacted health care reform could reduce some of the ED utilization, particularly for the currently uninsured, the shortage of primary care providers may limit the immediate shift in care. As hospitals struggle with pressures on financial margins, it is reasonable to assume that services showing negative contributions to the "bottom line" will be in jeopardy. One area that dramatically impacts emergency care delivery is behavioral care. As these impatient programs have been reduced over the past decade, the inability to find an available inpatient bed frequently results in extended stays in EDs.

Further complicating the provision of effective care is the uncontrolled variation in demand. Emergency departments must cope with a wide range of variation in arrival patterns, patient mix, and treatment regiments. With very limited exceptions, emergency services are required to assess and treat all presenting patients in a timely manner. The

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combination of variation in the arrival rates and service rates can generate swings in treatment bed census by multiples of 3 to 4 between early morning and midday.

A common strategy to address overcrowding is to increase the physical capacity without evaluating existing operations. All too frequently this has failed to resolve patient flow problems and has resulted in a larger facility, with increased staffing and minimal ability to improve the patient experience, particularly at peak periods with improved left without being seen (LWOBS) rates, by worsening length of stay (LOS) and patient satisfaction. This complex issue in emergency operations has stimulated renewed interest in operations research techniques, including Six Sigma, LEAN, and other operations improvement methodologies.

The ideal framework for ED operational improvement, particularly as it pertains to the "front end," can be described by the combination of several existing operations management theories. This framework is in evolution and many EDs may be in various depths of immersion in any or all of these operational approaches. While it is less important which formal operational approach is taken, it is vital that the underlying concepts are considered and integrated into the ED process redesign.

LEAN HEALTHCARE

Many of the best practices in emergency medicine have their origins in Lean. This is because Lean is intuitive. What most people are missing with respect to Lean thinking is the complete framework, toolset, mindset, and organizational commitment to have a completely Lean operation.

Lean is an operations management approach, which came to life after an intense study of why Toyota has been so successful for the last half century. What emerged was an entirely different way of running auto manufacturing in a resource-lite, customer-centric manner, focusing on processes and developing people. Lean Healthcare represents the evolution and diffusion of Lean applications from other industries (and in some instances, de novo innovations) into health care. It started in aspects of health care that were direct crossovers from manufacturing such as inventory management and other support areas. More recently, it has become more prevalent in clinical operations such as EDs and operating rooms. This delay in clinical applications has come from some major differences between service and manufacturing operations and the fact that health care is perhaps the most complex service operation that exists.

Lean Healthcare can be characterized by its following key components:

- Creating patient value
- Eliminating waste
- Promoting flow
- Continuous improvement
- Developing people

CREATING PATIENT VALUE

Lean Healthcare seeks to enhance patient value by creating and defining patient value streams, or groups of patients that follow the same basic steps throughout their visit. For example, all Emergency Severity Index (ESI) level 5 patients go through the exact same sequence of steps from beginning to end. This would represent 1 patient value stream. There are an endless number of potential patient value streams; the key is to have actionable groupings of streams that have unique pathways customized for that patient stream. In emergency medicine, there are 3 common streams—low acuity, mid acuity, and high acuity. Each of these substreams would have a well-defined process for each value stream with separate and distinct value-added steps.

ELIMINATION OF WASTE

All of the activities in a patient process can be classified as value-added or non–value-added. Value-added activities are those steps that move the patient closer to wellness, services that they desire that are done right the first time. Physician examination is a good example of a value-added step. This is actually the main reason a patient comes to the ED

in the first place. Other examples would be laboratory tests and radiographs, but only if they change the management of the patient or otherwise enhance the patient's well-being (psychological well-being of knowing they do not have a fracture). Non–value-added activities are those steps that do not create patient value and that they do not desire. "Traditional" triage is a classic example of what is viewed by many as a non–value-added activity.

One way to zero in on non–value-added activities is to describe them in terms of the classic Lean forms of waste. There are 8 forms of waste in any process. The goal is to eliminate as much waste as possible, fully knowing that you cannot eliminate it entirely.

- *Transportation*. This is the physical movement of patients, supplies, or equipment through the system. Transporting patients to ancillaries, or moving equipment back and forth through the ED, is an example of this form of waste because it represents a delay in care delivery.
- *Movement*. Staff movement is waste. Covering patients in remote areas of the ED or running around the ED looking for supplies or equipment is an example of the waste of movement.
- *Inventory*. Inventory in the form of supplies and equipment is waste. This essentially represents capital tied up in unfinished goods. As such, any inventory not in use is wasted money.
- *Waiting*. This is the most obvious form of waste in health care that permeates the entire patient experience in just about any health care setting.
- *Overprocessing*. Another prevalent form of waste. This is doing more than the patient needs, such as redundant questions from multiple different providers or triage protocols as opposed to getting the patient in front of the provider and ordering only what is necessary.
- *Overproduction*. This is producing more of something than is required. Generating reports that go unread is an example of this form of waste.
- *Defects*. Any activity not done right the first time is waste. Having to go back and ask the patient a question over again because you did not document the encounter in real time or ordering the wrong test or medication is a form of defect.
- *Human creativity*. Not using your human resources to actively engage in problem solving and process improvement is a serious form of waste that occurs all too often in the ED.

The goal of any Lean improvement effort is to create value and eliminate waste within processes, continually driving up the amount of value-added activity relative to the amount of non–value-added activity, increasing the "value-added ratio."

PROMOTING FLOW

One of the most important aspects of Lean Healthcare is the focus on flow. Because health care is a highly specialized service industry with high degrees of variation, flow must be managed much more intensely than in manufacturing. This is done by employing queuing theory and the theory of constraints (Goldratt, 1990). The former is used to properly establish service responsiveness within the context of the system's arrival and service rates, service capacity, and level of variation, the latter for targeting improvement efforts in the setting of linear flow.

QUEUING THEORY

Queuing theory is the mathematical study of waiting lines. It was developed to provide models to predict the behavior of systems that attempt to provide service for randomly arising arrivals—rather than constant or scheduled arrivals.

There are a few key ingredients necessary to describe queuing systems. Those most important to ED management are as follows:

- *The patient arrival rate and measure of variation around that arrival rate*. In the ED, this arrival rate is usually expressed in patients per hour.
- *The service rate and measure of variation around that service rate*. In the

ED, especially with the traditional ED operational design, the service rate is difficult to quantify because of the haphazard staffing scheme and flow patterns. The service rate is typically defined as the service rate of each of the individual servers in the system to process a single arrival.

- *Queue discipline*. This is the manner in which patients are prioritized after arrival. Most EDs use a priority queue discipline in which the patients with most acute conditions are seen first.

An important consideration when discussing queuing theory is the relationship between service responsiveness and server (space, equipment, and staff) utilization. The value in queuing theory is that it effectively explains the relationship between variation, server utilization, and service responsiveness. In general, in service operations, as variation and/or server utilization increase, so too do patient waiting times. In fact, waiting times increase in an exponential manner to increases in variation or server utilization. This is why things seem to go bad fast in most EDs.

New applications of queuing theory are just beginning to find their way into the health care literature. The following case studies illustrate the current use of these tools in the operations and planning of 2 emergency services.

CONTINUOUS IMPROVEMENT AND DEVELOPING PEOPLE

Perhaps, the most important aspect of Lean Healthcare is its relentless pursuit of perfection. This core principle permeates most Lean organizations and show in the way it approaches problem solving and the development of its people. Lean provides this framework in the form of a set of philosophies and corresponding tools to help front-line workers take action to realize their Lean vision.

Lean organizations place the front-line workers in control of improving the system because these people are the only ones who know the system the best and, in many cases, have the answers. There is almost a reversal of the traditional management roles. In Lean organizations, management supports improvement efforts by removing obstacles and providing resources in the so-called "servant leader" style. Lean organizations empower their staff members by teaching them tools to help them improve their workplace. These tools, as spokes with the hub, Plan-Do-Check-Act, create the wheel of continuous improvement.

CASE STUDY 1: MARY WASHINGTON HOSPITAL'S LEAN ED

Introduction

Mary Washington Hospital's ED, located in Fredericksburg, Virginia, reached its limits in the space that was available in 2003. That year, 75 000 patients were seen in a 25-bed ED, with a 6% walkout rate. Hallway beds were frequently utilized and there were frequent reports of patient dissatisfaction. In the summer of 2002, Mary Washington Hospital opened a 50-bed, 26 000-sq ft, state-of-the-art ED. The move to the new ED was problematic in many respects and did not solve the ED performance issues.

Shortly after the initial move, it became clear that process improvements were necessary. Basic steps were taken that facilitated patient care and communication. Treatment teams were created with discrete locations and bed assignments for nurses, physicians, technicians, and unit secretaries, including a separate lower-acuity area staffed by physician assistants, RNs, and licensed practical nurses in an area consisting of 16 total beds.

In 2003, the volume rebounded to 83 000 visits. By the summer of 2003, the increased volume coupled with constrained bed capacity and insufficient human resource capacity brought long waits. The inevitable hospital overcrowding ensued because of lack of inpatient capacity resulting in patients boarding in the ED waiting for beds on the inpatient wards. While there were plenty of ED beds, the admission holds further taxed the already oversaturated ED nursing staff. Winter came and brought with it a terrible season of

influenza and, predictably, the 25 additional beds were completely consumed, with holds resulting in a net increase of zero beds. Most problematic was the fact that 50% of the ED nursing resources were then consumed with treating inpatients. Subsequently, the walkout rate climbed to 10% to 14% from November to January resulting in more than 3000 walkouts over a 4-month period. Between 2001 and 2003, the ED LOS for treated and released patients was not measured consistently, but in 2004, the ED created a dashboard and the treated and released LOS was consistently 4 hours.

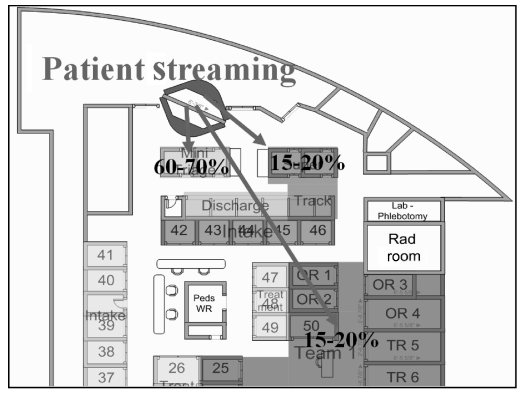

Figure 1. Pivot nurse streaming at Mary Washington Hospital.

Process changes in the ED at Mary Washington Hospital

In 2005-2006, the team in the ED at Mary Washington began by focusing on the lower-acuity patients (ESI levels 4 and 5). They realized that, despite having relatively straightforward problems (ear aches, sore throats), these patients were languishing in the ED for more than 2.5 hours. The team redesigned the process, creating what is now referred to as, "Super Track." This is a 2- to 3-bed team staffed by a mid-level provider, RN, and technicians. Lean principles were implemented in the form of standard work and discrete job responsibilities so that there was reliability on the service side of the encounter. The group refined the supplies needed to treat these patients, placing them all at the point of use. This required pulling them out of the Pyxis and creating charge sheets so that the providers could be more efficient and less time was spent running all over the ED. With this process, the team implemented a "results waiting" area for patients who do not need to remain in the treatment bed. This allowed the team to continue seeing patients, more efficiently utilizing their beds for value-added activities. After some refinement, this process was responsible for a 60% reduction in LOS for this patient population, from 2.5 hours to below 1 hour consistently.

In 2007, after implementing Super Track, the team soon realized that no longer were there long lines of ESI level 4 and 5 patients waiting to be seen. They then turned to the ESI level 3 patients implementing a system called "RATED: Rapid Assessment, Treatment, and Effective Disposition in the ED." This system employed a pivot nurse who would stream patients into different treatment pathways on the basis of their presenting chief complaint and whether or not they looked "good." From this position, patients would be streamed into the main ED (ESI levels 1, 2, and sick 3s), Super Track (ESI levels 4 and 5), and the new area, "Intake" (Figure 1). This area consisted of 2 equal teams of 5 beds, 1 physician, 1 mid-level, 2 RNS, a technician, and a unit coordinator. Each team had a corresponding 8-bed treatment team and could use an internal waiting area. The intake system (both teams combined) was designed to handle about 12 to 14 patients per hour, based on calculations utilizing Lean and queuing principles. Similar to Super Track, the intake teams were designed with Lean principles in mind. The supplies and treatment required for these patients was catered to these specific patients. For instance, a cart was created with everything needed to start an intravenous catheter and get a patient ready for computed tomography. Additional system improvements were made to enhance flow including I-stat and urine analysis capabilities, and pelvic examination carts were expressly allocated to these areas. The nursing team used these newly created intake teams as their operations testing staff to continuously improve the process, updating both the

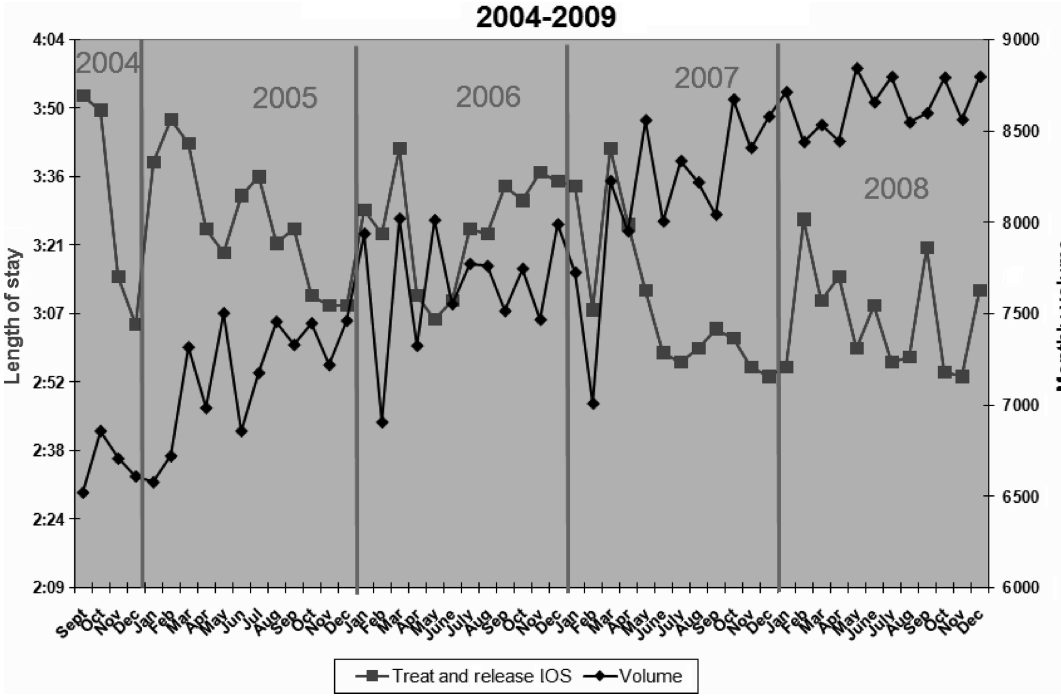

Figure 2. Volume versus treat-and-release length of stay (LOS) at Mary Washington emergency department.

carts and the job descriptions as the process evolved.

Results at Mary Washington Hospital

Because of these improvements, Mary Washington Hospital ED was able to dramatically reduce its LOS of treatment and release patients from almost 4 hours to below 3 hours, for a reduction of more than 25% from 2004 to 2009. The walkout rate has also been reduced from an average of 6% and a high of 13% to below 2% over the same time period. All of this has been accomplished with an increase in volume of more than 25% from 78 606 to a projected 100 000 visits from 2004 to the present, with no additional bed resources, few additional physician resources, and a stable, volume-based process of budgeting nurses (Figure 2).

As a result of becoming a learning organization, Mary Washington was able to spread this learning to other aspects of its organization. Lean is currently being deployed throughout the hospital and was critical in the design and implementation of its new facility, Stafford Hospital, which opened in February 2009 in Stafford Virginia as well as its new Free-Standing ED located in Spotsylvania County, Virginia. Both new EDs have state-of-the-art Lean layouts and have incorporated Lean into their process flow. In fact, the Stafford facility has consistently achieved door-to-doc times of less than 30 minutes and treated and released times of just over 2 hours, with walkout rates consistently below 0.5% despite having only 14 beds and seeing 36 000 visits annually, or about 100 patients per day.

CASE STUDY 2: DEVELOPING DOOR TO DOC AT BANNER HEALTH

In 2005, *USA Today* published a report from Press Ganey highlighting delays in receiving emergency care in the United States in which Arizona ranked last in the country with an average wait time approaching 300

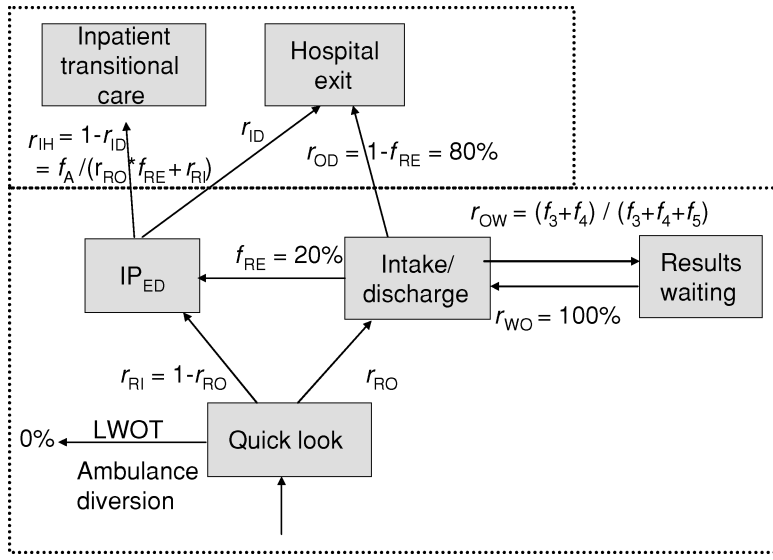

Figure 3. A high-level view of the Door to Doc model. LWOT indicates leaving without treatment.

minutes. Banner Health, a nonprofit hospital company based in the Phoenix area, was feeling pain in its EDs because of population growth, high seasonality, and a lack of inpatient bed capacity. It realized that risks to patient safety were too great and that fundamental changes had to be made to the way emergency care was currently being delivered. For more information on the effects of long door-to-doc times on patient safety, (Goodacre & Webster, 2005; Rowe et al., 2006).

Banner Health leveraged an existing partnership with Arizona State University to generate momentum to improve ED operations. A grant was written, with co-primary investigators from Banner Health and Arizona State University, and funding was obtained from the Agency for Healthcare Research and Quality to explore new ways to improve patient safety in the ED and develop a toolkit available to the public in order to help other hospitals increase ED efficiency.

The Door to Doc (D2D) toolkit helps to bridge ED operations with industrial engineering and operations research improvement techniques. With the toolkit, the user can employ concepts developed in other industries for operational improvement and increased patient safety realized by decreasing wait times. The goal of D2D is to minimize delays in getting the patient assessed by the physician. This was accomplished using a combination of Lean techniques and queuing theory.

Door to Doc Design

Door to Doc in the ED works by decomposing the traditional ED into separate areas, each with their own role in emergency care delivery. By separating the ED into functional areas, the entire ED can be viewed as a unified queuing network with probabilistic flows between network areas and service time and arrival rate distributions based on actual ED performance. Figure 3 shows a high-level view of the D2D ED design.

In this new ED design, the patient arrives and is registered into the ED electronic tracking board and subsequently receives a quick examination by a nurse to determine patient acuity and therefore patient flow. Patients deemed low acuity (ESI levels 4 and 5 and most ESI 3s) are routed to the Intake area. In Intake, the patient is assessed by the provider and nurse, who determine the care plan for the patient. The patient can then be immediately discharged, or sent for a procedure, specimen collection, imaging examination, or upgraded to an acute bed depending on the provider's assessment. The lower-acuity patients sent for imaging or procedures can

return from these activities and wait, not in a physical ED bed, but in a flexible Results Waiting/Continuing Care area. This area is a waiting room located internally in the ED where patients can sit in chairs or recliners as intravenous catheters are run and/or imaging/laboratory results are analyzed. When the results are in and the provider is ready to disposition the patient, they can be brought into a private area (many times the Intake rooms are used) for dispositioning and discharging from the ED.

Care delivery for patients deemed acute follows traditional ED standards where care is delivered at the bedside in what is referred to as the Inpatient ED. These patients can be downgraded to nonacute status, discharged from their bed, or transferred to an Inpatient Transitional Care status. The Inpatient Transitional Care area can be a location outside the department, internal to the ED, or simply a change in current bed status as the admitted patient awaits placement in the hospital's inpatient unit. All areas in the ED are staffed independently while charge nurses or team leaders coordinate patient handoffs between areas.

Process improvement with D2D

Queuing theory was employed to predict wait times and ensure ED capacity was adequate under the new model of care and resources were in the right locations. Further improvements were realized in the process via collaboration with caregivers. Lean techniques were used to eliminate non–value-added time before seeing a provider. Specifically, Banner Health made improvements in the following areas:

- *Initial registration*. Determining the minimum amount of information required to identify a patient and get him or her into the computerized patient tracking system with a process termed "Quick Reg." Full registration can be moved to later in the process as patients await test results, or prior to discharge.
- *Triage*. As a philosophy, Banner Health eliminated the use of traditional triage, replacing triage nurses and stations with "Quick Look." Caregivers, managers, and engineers worked together to determine what information obtained in a traditional triage is required to determine patient acuity using ESI and move the patient to the correct treatment area.
- *Initial assessment*. To improve efficiency in the initial provider contact with the patient, the doc/mid-level is paired with a nurse and a joint assessment is conducted. Much of the information obtained in the required nursing and provider assessments is duplicative, so the tasks were combined into a single, parallel process instead of the traditional sequential process.

Another Lean concept applied in the development of D2D is the reduction of variation achieved by having providers focus on a subset of patients, typically with more standard care processes. The providers are no longer splitting their attention between the highly acute cases requiring heavy intervention and inpatient admission and the lower acuity cases requiring, for example, an imaging study, a prescription, and a disposition. From a design standpoint, Banner Health has found improved efficiencies in reducing (and eliminating when possible) specialization in room equipment. Instead of having a single pelvic room in Intake that is set aside for patients requiring pelvic examinations thereby reducing overall efficiency and capacity, rooms are set up so that pelvic examinations can be performed in any room.

Implementation results at Banner Health

After designing the D2D model, Banner Health implemented the system in all Phoenix area EDs. Banner Health EDs range from inner-city level 1 trauma designated hospitals to suburban hospitals with heavily geriatric populations. All facilities saw immediate improvements in door-to-doc times, with associated decreases in patients leaving without treatment (LWOT). Figure 4 shows LWOT improvements after initial implementation.

Each facility continued working for improvements and refining the processes within the constraints of its physical space. Particular success has recently been realized at Banner

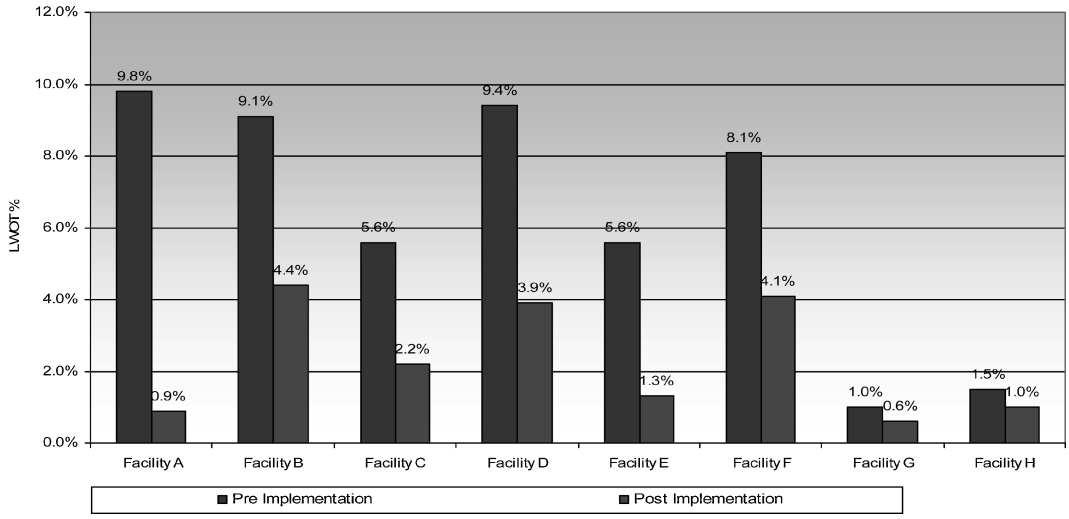

Figure 4. Leaving without treatment rates before and immediately after Door to Doc implementation.

Health's large inner-city hospital (facility D in Figure 4). A lack of capacity, misaligned processes within and outside the ED, and adherence to old methods, had historically hampered success. A change in leadership and a refocus on patient safety energized the staff members to want to improve their processes. Over the following months, staff roles were redefined, patient flow was redesigned, and the department processes were improved to match D2D principles. The results were impressive. Comparing January 2010 to years prior, volume had increased moderately from an average of 148 patients per day to 154. The rate of patients LWOT dropped from 8% to 9% to less than 1%, and improved processes resulted in overall treat-and-release patient LOS from close to 300 minutes to less than 200 minutes. Figure 5 shows treat-and-release LOS over the past 3+ years at this hospital. An uptick in LOS was observed in late 2009 because the facility switched to electronic medical record systems.

Similar success stories have been realized internally to Banner Health and to other external hospital systems using D2D. More

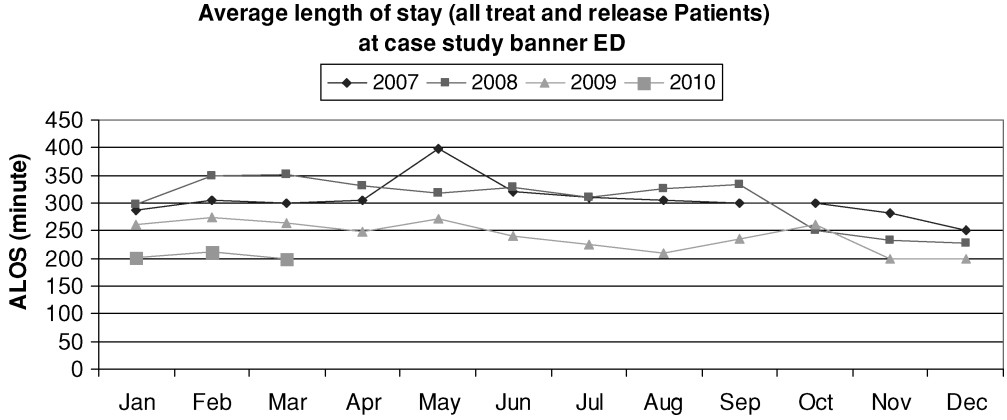

Figure 5. Decreases in treat-and-release length of stay realized. ALOS indicates average length of stay; ED, emergency department.

information about the D2D toolkit is available in Burdick et al. (2010) and the D2D toolkit is available for download at http://www.bannerhealthinnovations.org/DoortoDoc/About+D2D.htm.

Design implications

There is a natural lag in the translation of new operational models into design concepts. Pioneering initiatives frequently must adapt existing space to support their new processes and procedures. Planning for remodeling or new facilities should take full advantage of the opportunity to establish a design that serves their operational goals. Space guidelines and organizational models are well established for traditional emergency service organizational models. The design of facilities to respond to "intake" units, internal waiting, and observation can significantly alter common layout option.

Three design implications are emerging from initiatives to improve the patient flow and productivity of emergency services.

- Restructuring the triage/intake area
- Integration of internal waiting areas into the core of emergency treatment zones
- Provision of observation and holding services

Triage/intake

The design of intake areas must be framed within the overall plan concept of the emergency service. Fundamental guiding principles, such as patient/staff flow, safety consideration, and the long-term adaptability of the space, should be established in the early phases of space programming and planning.

Intake models discussed in this article can be accommodated in spaces smaller than standard examination rooms. Depending upon the space standards accepted by the state authority having jurisdiction, the space requirements for an intake space can vary between 80 and 120 net sq ft (clear floor area). Smaller open-bay intake areas can provide more intake stations in the same area, but risks of limited privacy, maintaining isolation from airborne infections, and long-term flexibility should be evaluated. A key characteristic emerging in the intake area is the use of recliners for patients rather than the traditional gurney.

Intake areas requirements should be determined by analysis of arrival patterns and LOS distribution assumptions in the intake area. As previously cited, utilization of queuing theory models or simulation tools can provide valuable methods for establishing an estimate of peak period requirements. If the demand for intake chairs during the peak period exceeds the available area, or budget, then utilization of internal waiting space is becoming an accepted option for results waiting or other low-risk selected patient population.

Support space adequate to accommodate a team approach is essential to new Intake model. This includes charting, medication, supply, and soiled utilities areas.

The impact of these new intake processes on traditional emergency service examination space needs should be considered when planning the main emergency service. Adjustment to the patient flow, excluding patients treated and released from the intake area, and the reductions in LOS resulting from the initiation of care in the intake area, will increase the annual capacity (visits/year) of each treatment space.

The decision to provide internal patient waiting areas within the main emergency service should be made on the basis of an overall concept of patient flow and management. Depending upon the overall physical organizational model of the department, the provision of internal waiting space can be centralized or decentralized. Critical to the decision to provide internal waiting are operational assumptions regarding observation and staffing of the internal waiting area.

SUMMARY

While EDs have a rich history of improvement and innovation, we have a long way to go with respect to developing our people and developing a robust set of tools that provide the framework for continuous improvement.

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