Statistical Quality Control in the Health Care Industry

A Senior Project

presented to

the Faculty of the Industrial And Manufacturing Engineering

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Industrial Engineering

by

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June, 2010

ABSTRACT

In recognition to the increased length of stay of discharge patients, deteriorating patient care and staff satisfaction in an emergency department (ED), this project was set to improve these measures without reducing staff, adding new workers, and without increasing the number of beds. Lean methods such as value stream mapping (VSM) formed the basis of the project. This tool helped identify the patient process flow through the (ED) as well as the valued added and non-value added steps of the process. This project describes value stream map development in the emergency department in a community hospital. A current-state value stream map was developed and reviewed by personnel in the ED. Lean methods were applied to develop a future-state VSM that will be reviewed for implementation.

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Introduction

Currently, there is a strong nationwide focus on the healthcare industry and its associated challenges. Providers, consumers and policy makers are seeking to improve the quality of health care therefore, there is a need for accessible and reliable indicators of quality to flag potential problems or successes, follow trends over time, and identify disparities across regions, communities, and providers.

The United States has the highest per capita spending on health care of any industrialized nation. Yet despite unprecedented levels of spending, harmful medical errors abound, uncoordinated care continues to frustrate patients and providers, and U.S. healthcare costs continue to increase. These findings are summarized in the 2000 Institute of Medicine study, *To Err Is Human Building a Safer Health System Report*.

In the face of rising healthcare costs, various initiatives have begun to increase the operational efficiency and cost effectiveness of the healthcare delivery process. In particular, the ED (Emergency Department) which plays a vital role in providing care to patients in the community and are recognized for their contribution to society. Also, the ED patient service delivery system represents one of the most visible sectors of the health care system in which improper procedures might lead to severe consequences. Poor service delivery can often make a difference between life and death. The legal consequences of failed services are immense in the U.S (On Committee. I.O.M, 2000).

Poor delivery of service indicators such as decrease throughput, delays and bottlenecks, growing complaints, climbing rates of patients leaving without being seen, and medication errors all signal that the operations of the Emergency Department are

faulty. Lean production methods also called lean manufacturing is increasingly being implemented as a potential solution for health care inadequate service delivery.

The following report focuses on the application Industrial Engineering concepts to make healthcare delivery safer and easier. Healthcare providers can use quality improvement techniques from Lean methods and tools like value-stream mapping (VSM) to reduce medical errors and help ensure patient safety. Eliminating waste (rework), patient-handling capacity and flow, decrease wait times and potentially harmful delays in care. The result is a safer, more efficient, cost-effective system that better satisfies patients and healthcare workers (Zidel, 2006).

The scope of the project involved improving patient flow and identifying sources of medical errors in ED at a medical facility in San Obispo California. The Medical Facility is one of four major hospitals in the county with an emergency department. The ED at sees about 1500 patients per month in a facility equipped with 13 beds, 5 nurses, 1 admitting clerk and 2 emergency physicians most of the time. In the ED, approximately 84% of patients are treated and discharged therefore, this particular group of patients, or product family, became the target for Lean improvement methods. The project focused on measuring and improving efficiency, productivity, medical errors with the ultimate goal of reducing ED wait times and improving patient satisfaction.

Background

Lean Methods

"Lean" is a term related to philosophies derived from the Toyota Production System. The main goals of the Lean Method are to create standardized work in order to smooth out the workflow and to eliminate wasteful steps in a process. The Lean system concentrates on attaining continuous flow through a system by identifying value in each step of a process. If a step fails to add value or results in a redundancy to the next user in the process, it impedes quality and flow, and is eliminated. Furthermore, reducing wait times between steps, and providing exactly what the next user in the process requires results in quality and productivity improvements. Lean thinking emphasizes identifying the root cause of a delay or problem by going to the worker and workplace to understand the demands of the work. Front-line workers are taught to identify waste, improve and standardize their step in the process (Chalice, 2007).

Definition of a Process

A process is a set of actions or steps, each of which must be accomplished properly in the proper sequence at the proper time to create value for a customer or patient. Primary processes serve the external customer (in health care, patients and their families). Internal processes serve internal customers/staff in support of the primary process. Primary processes are easier to see, but internal processes are necessary to create value in the primary process.

Compared to other industries, health care has been slow to identify who the customer really is. Because of the complexity of the health care system, internal customers — physicians, hospitals, insurers, government, payers— have often driven processes. It is critically important that value be defined by the primary customer: the patient (Sharkar, 2009).

A perfect process creates precisely the right value for the customer. In a perfect process, every step is valuable (creates value for the customer), capable (produces a good result every time), available (produces the desired output, not just the desired quality, every time), adequate (does not cause delay), flexible, and linked by continuous flow. Failure in any of these dimensions produces some type of waste. The Toyota Production System (TPS) identifies seven categories of waste: overproduction, waiting, transporting, processing, inventory, motion, and correction (Liker, 2004). A perfect process not only creates value, but it is also satisfying for people to perform, managers to manage, and customers to experience.

Value Stream Mapping

Value Stream Mapping is a structured approach for improving a value stream (Rother, 1999). A value stream is defined as all the actions (both value added and non value added) required to bring a specific product, services or a combination of products and services, to a costumer .VSM is an enterprise wide improvement technique that helps visualize the entire process, representing material and information flow, to improve production or service processes by identifying waste and its sources. VSM presents a big picture that encompasses the entire set of processes from start to finish that a product

goes through in the manufacturing process or the customer experiences in a service delivery operation.

The first step in VSM is to identify relevant product families and select one as a target. The second step is to construct a current state map for the product value stream, using information gathered from the actual production process. The third step in the VSM process is to map a future state. It is important to bear in mind the steps and the icons are product specific that are more in tune with the manufacturing systems, nevertheless , authors believe that concepts can be employed in the service industry as swell (McDonald et. Al 2002). The abundance of success stories available in research and practitioner based papers and texts are directed towards the manufacturing process but authors believe that with minor changes and using the framework that has been suggested by Rother & Shook the success stories can be replicated in the service industry specifically the healthcare industry.

Design

The design for the project began with a scoping of the ED overall process to determine the parameters, participants and goals. Those participating were emergency physicians, nurses, clerks, cleaning staff, lab technicians and the ED administrator. It was agreed that the key process to be measured would be the flow of discharged patients and its sources for potential or existing medical errors. Additionally, one of the primary goals of this project was to help the ED staff see the tremendous potential in examining patient flow from an operations improvement stand point.

After performing preliminary time studies to develop appropriate time study data collection methods based on observations and guidance from the ED staff, a current VSM was created for the ED health care service delivery process. The ED service delivery process can be represented by the following set of core activities. These activities usually occur in a sequential manner however; some of the steps are either rearranged or omitted for different patient types:

1. Arrival

2. Triage/Registration

3. Registered Nurse (RN) Vitals check

4. Doctor of Medicine (MD) assessment

5. Initial diagnosis and treatment

6. Diagnostic testing

7. Assessment of test results

8. Follow up/treatment planning

9. Discharge

Triage and Registration

Arriving patients check in with a clerk and present their ID and are asked to sign consent for treatment. At the same time the patient waits to be triaged by a nurse in the waiting room. Once the nurse arrives the patient is called back to the check in desk if he or she had to wait. Then the nurse documents their chief complaint, past medical history and assigns an Emergency Severity Index (ESI) level (1 through 5) depending on both the acuity of the case and predicted resources needed for the care of that particular patient.

After the initial assessment by the triage nurse the patient waits (typically in the waiting room) for an available bed. In theory the ESI level governs the routing of the patient to one of the care delivery units, the main ED room or the *Fast Track,* for low level acuity patients.

Diagnostic Testing

Patients from the ED may undergo diagnostic tests. The diagnostic testing unit might be viewed as a set of sub-systems within a larger system. Diagnostic tests were classified in four broad categories. The phlebotomy section performs multiple types of blood and urine assays on patient samples. If the patient needs an IV line blood will be drawn for sampling at that instant. If the patient does not require or already has an IV line a lab technician will be called to draw the blood from the patient. The imaging section was divided in two, the first group being EKGs, Ultrasounds and some X-rays which can be preformed in the ED that is, with out having to transport the patient to the radiology lab. The second group of imaging tests constitute of CAT scans and MRI for which the patient needs to be transported to the radiology lab. The last section is medication which can be obtained by a nurse from the onsite ED medication inventory (Omni Cel). If a particular medication is not available on site then an order is made to the pharmacy for delivery. These tests help diagnose the nature of the clinical case and permit follow up remedial clinical steps.

<u>Assessment of Lab Results</u>

The delivery of the results of the diagnostic tests varies depending on the type of assay performed. EKGs and Ultrasounds are delivered to the MDs in person due to their immediate importance; X-rays will be delivered electronically to the MD computers; phlebotomy results arrive at the main printer and are randomly picked up by nurses and placed on the corresponding patient chart.

<u>Discharge</u>

Following any diagnostics tests, the patient is reviewed by the MD. The review process will result in a recommendation for admission to the hospital or discharge from the ED. In the case were the patient is going to be discharged a dictation of the clinical case must be made by the MD. Following the discharge request by the MD a nurse will print the discharge papers that include follow up procedures and clinical information regarding the patient's case; this will be explained by a nurse in detail to the patient as he or she prepares to leave the ED. Before the patient leaves the ED he or she must go to the check-in desk to verify information concerning insurance and payment issues are properly recorded.

Data Collection Methods

Fidelity of any process improvement study depends upon the quality of the data. The medical facility under study is a forward looking institution that has extensive data collection systems in place. Some of these data proved invaluable to the development of the current-state VSM service delivery process. The data compromised of key service

times including patients arrival times, length of stay, and number of patients seen; times are collected electronically using computer log information. Although very useful these data fell short to the requirements of the VSM for the clinical service process. The automated data collection system does not collect key time indicators such as wait time for triage, wait time for an open bed, wait time to be first seen by the MD among others and accurate length of stay.

Interviews with emergency physicians, nurses, nurse administrators, and lab technicians were conducted to gain valuable insights into the process of ED service delivery. Direct observation and the and the judgment of directly involved staff (front-line staff) in the service delivery operations were used to justify meaningful data collection methods for the key time indicators not provided by the computerized automated log systems. After several iterations of the data collection system and 10 trial patients, data used for the final analysis of the current process consisted of 30 dischargeable patients excluding ambulance arrivals and psychiatric patients. This data lead into the creation of a current-state value stream map.

Methodology

For the key process identified, (flow of discharge patients) a current-state VSM map was created based on how it actually operates (not how it is supposed to operate), specifying value from the standpoint of the customer (the patient), as well as waste in steps or between steps. Physically walking through the process steps — following the route of a patient through the ED was the first vital step.

The current state VSM created a view of the actual process steps involved in patient care for dischargeable patients. The overall discharge patient process was divided into three separate sections: Check-In (Appendix A), Testing (Appendix B) and Discharge Process (Appendix C). Blue boxes indicate the event that triggers the start and end of each section. Each VSM depicted major process blocks or "chunks" of activities that occurred before a handoff or a major stop in the time line of the process. The associated staff represents the number of nurses, MDs or clerks providing service to the patient in that step. Cycle time and wait time were indicated below each step of the process; these values were obtained from the time studies for 30 patients. It should be noted that the median time was utilized when the data proved not to be symmetrical as shown by the histogram in Figure 1 for the process time of a patient preparing to leave the bed. When the data was proven to be symmetrical the mean time was utilized instead.
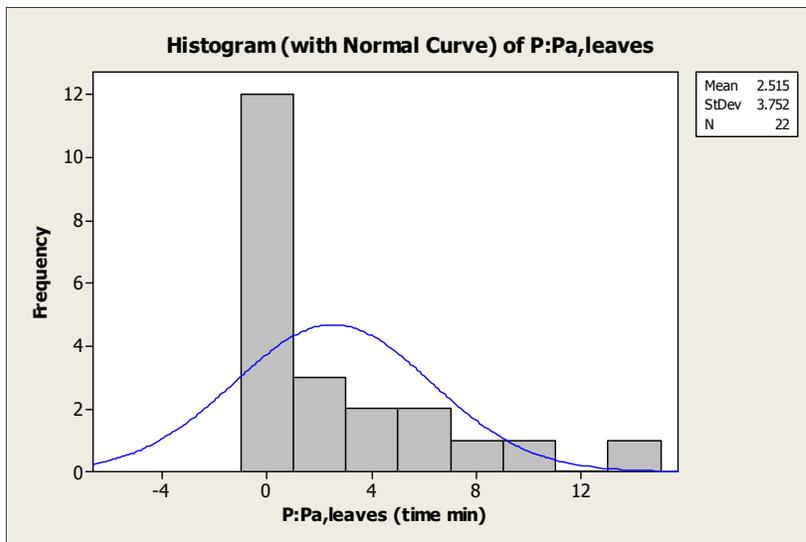

Figure 1: Histogram for a Patient Preparing to Leave the Bed

Below the process flow stream a time line shows the value added time and non-value time throughout the process. At the end of each process flow a summary box indicates the total lead time, total value added time, and percentage of value added of the entire process. A Takt time was calculated by using average demand on Thursdays throughout the month of May 2010 during the shift from 2:00pm to 8:00pm. This particular shift was suggested by the ED staff as a good representation of peak patient care demand in the ED.

Rework was identified as occurring when process steps were repeated because of a change of information, medical errors or incomplete or inaccurate prior steps. Red arrows on the map connected the points of rework, the form rework loops(waste). Once the current-state map was drawn out and approved by the ED staff, it was possible to visualize the complexity of processing a patient through the ED.

With all the steps of patient flow mapped out, the ED staff was asked to identify three key bottlenecks in the entire value stream from registration to when the patient leaves the ED. In addition, when the data collection was culminated and the current-state value stream was updated to include key time indicators and percentage occurrence of medical errors; the current –state VSM's results and metrics were presented to a decision panel, which included senior administrators, the emergency physician administrator and the nurse administrator within the hospital. The group answered questions, accepted criticisms and obtained approval to proceed to the design of the future-state VSM.

The Future-State Value-Stream Map

The creation of the future-state value-stream map (Appendices D,E,F) consisted of reviewing the current-state VSM, in this procedure repetitive process and work steps within each section were either eliminated or combined. Before major handovers in the process, suppliers and customers were identified, as well as inputs and outputs to ensure the process steps within each a preceded seamlessly, an agreement among ED staff was established regarding what inputs were required to begin each step, and what outputs were required at the end of each step. The review of the current process identified the necessary changes required to meet the demands of the customer at each section as standard work. Finally, the integrants of the review process agreed on an ideal target times for the value added time to complete each process.

During the final planning phase PDSA projects were suggested around the "check-in," "testing" and "discharge" sections of the future-state VSM. Three general priorities were established: workplace organization to improve placement of equipment and charts, a creation of standard work that every worker was expected to do consistently, level loading and communication of lean concepts and projects to the ED staff.

The key to implementing a lean system depends on the involvement of the front-line workers in creating plans and projects to improve their work, to run the projects as trials and to gather feedback to refine the project. This method executing and sustaining the future state of a process involves Plan-Do-Study-Act (PDSA) cycles in which small tests of change are carried out, the results assessed and analyzed, adjustments made, and successes spread. The aim is trying to create a perfect process, teams should design small

tests of change ("Plan"); implement the tests on a small scale ("Do"); measure the

performance compared with the current state and reflect on how it could be better

("Study"); introduce the necessary changes to adjust the process ("Act");and determine

whether the adjusted process is stable and sustainable (Cladwell, 2005).

Results

The current-state VSM (Appendices A,B,C) identified 26 process steps of which

12 are waiting steps (delays) involving the care of the dischargeable patients.

Furthermore, the VSM identified 13 rework loops in the entire process with the

respective percentage of occurrence denoted in the current state value stream maps. The

total process time ranged from 29 minutes to 263 minutes. The total wait time for the

discharge section of the process ranged from 0.2 minutes to 37min, and 12.2 minutes for

the total lead time. The check-in total wait time ranged from 1.1 minutes to 45.3 minutes

for a total lead time of 18.4 minutes. A Takt time of 12.8 minutes was calculated in both

processes. A complete time analysis was not done for the testing section since it the root

sources of delay were outside the ED department in the radiology and phlebotomy labs

which fall outside the scope of the project. However rework looks were identified with

their respective percentages of occurrences shown in the current-state map.

The future-state VSM (Appendices D,E,F) were designed to increase the

percentage of value added time from 59.6% to 78% in the check in section. This goal

could be achieved by reducing the wait time for triage from 0.7 min to 0.3 min, similarly

decreasing the wait for vitals from 1.7 min to 0.83 min. The wait time for the MDs' first

assessment should be cut in half to 2 min and the wait time for a bed should approach 0

min 90% of the time. Correspondingly the percentage of value added time in the discharge process should be increased from 56.32% to 85.5%. This might be attained reducing the wait time before an order is requested from 3 min to 1 min, eliminating both the wait time for discharge delivery of 1.25 min and the wait time for a patient to be free to leave. A discharge should not be given while medication or observation is still pending. To achieve these goals the following PDSA projects were recommended.

To illustrate, an initial suggested project derived from the VSM exercise involves sorting patients into admitted or dischargeable streams, based on the assumption that the charge nurses can predict which patients would be discharged from the ED. Charge nurses would be asked to assign the category of "discharge," "admit" or "uncertain" to each patient at triage, excluding patients who arrived by ambulance or have primarily psychiatric complaints. The accuracy of this decision system should be measured to statistically demonstrate accuracy. Charge nurses should also assign patients to the respective areas with to goal of not having a nurse with more than three patients (level loading) at the time. A charge nurse should also be allowed to discharge any patient when possible.

Closely related to the last project another recommends the reorganization of the ED into a probable admission area, a dischargeable area and a complex dischargeable area (i.e., for those uncertain patients requiring lengthier testing and care within the ED; e.g., renal colic, abdominal pain, atypical chest pain and asthma). All of these areas should be located within the ED and represented, simply, by a label attached to existing beds.

The third suggested project is the creation of a floating staff that during light periods of patient flow a group of nurses should focus on *5s* and lean implementation in the ED. New project implementation regarding lean principles should have an assigned day when the ED staff is required to try the change and then provide feedback directly to team leaders, the lean facilitator or an information white board.

Economic Analysis

Even not-for-profit medical facilities like French Hospital need to have a surplus to remain financially viable and to drive future growth. Hospitals are becoming less able to demand "cost plus" pricing that pays them for their efforts as opposed to being paid flat rates based on patient diagnoses. Compounding the pricing pressures, the U.S. government, through Medicare and Medicaid, has proposed new rules under which hospitals would no longer be paid for care required to treat a range of preventable errors (Nakahi, 2009). Hospitals will be left to absorb the cost of poor quality themselves, which should provide incentives for improvement such is the lean project.

Since this project had not yet been implemented a quantitative economic analysis was illusionary to compile. Nonetheless there is a cost to train front line workers in lean methods and it is estimated to require about 80 hours of training for a jump start workshop. Online courses on Lean Methods and Six Sigma degrees and certificates from the University of Villanova range from $2,000 to $3,000 dollars a small price to pay when compared to a the medical error penalties ranging from $4,225 million to $ 75000 dollars issued the by the CDHP in April of this year (Lundeen,2010). Errors are

becoming more costly for hospitals, but patients and their loved ones have long felt the effects of the patient safety and quality problems in the industry.

DISCUSSION

This project focused on the flow of discharge patients in the ED. By reducing wasted steps and better coordinating the medical care for these patients, the hope is to improve the productivity of the ED by a prioritized organization of the workplace, standardization of the work, and established continuous communication of lean concepts to the department.

While discussing and creating the value-stream maps, the staff was able to see how inefficiently the ED operated. Efforts like increasing ED processing at the point of triage for example, medical directives for blood tests and full nursing assessments implemented at triage because of an inability of the MD attend the patient were identified as waste. These directives often resulted in unnecessary or incomplete testing (Lean waste). Delays at the first assessment by the MD were exacerbated by the need to reassess patients with extended waits for lab results (an example of rework). A single charge nurse was also responsible for responding to calls from the emergency medical service, delivering printed laboratory results to the paper charts and escorting non-ambulance patients into the ED.

The incorrect use of the ED information system and a central visual signal made it difficult to identify empty beds in the department, the current status of patients and the nurses assigned to each patient. By using a system of directing patients to the next

available bed, a nurse could be asked to care for patients of varying complexity, delaying the care of the patients requiring less intensive care. Nurses wasted time looking for equipment that was misplaced, in disrepair, inappropriately stocked or in the wrong location. Often-used materials such as intravenous (IV) solutions were stocked in central locations to ease the work for the hospital supply staff and pharmacy, but not for the main users of the material, namely the nurses.

There are no visual signals on the charts to indicate when investigations were complete or when lab results arrived. Physicians, nurses and lab technicians wasted time searching for charts, laboratory results and hospital records, causing unnecessary delay and frustration. On discharge, patients could linger in their beds for up to 45 minutes waiting for a nurse to deliver a prescription, to remove an IV lock, find a wheelchair or organize transport home. The entire flow of work within the ED is uneven, and staggers from those waiting for things to be done to those having too many tasks to do. The chaos precluded staff finding time to institute workplace improvements. The VSM mapping exercise revealed much waste of effort and material in the ED.

The value stream exercise allowed a series of bottleneck reduction projects to be identified concurrently. Workplace organization projects should have an immediate impact on efficiency. The front-line staff must be asked to reconfigure these areas with the appropriate stock and ergonomics. Projects should include stocking all physician required material to the patient's right, organizing stock carts such that 90% of the most used stock were within steps of the patient, negotiating with pharmacy to deliver stock to required areas in the required amounts, foot printing or marking the ED floor with

designated locations for necessary equipment to be placed after use (such as the wandering EKG machine). A red tag exercise project is strongly recommended to identify improperly placed equipment in the ED.

The staff should correctly use the FX room as an area for dischargeable patients. All patients in the department should be classified as "admitted," "uncertain" or "dischargeable" on presenting to the ED, and their charts would be placed in these respective boxes. Incorrectly assigned patients could be reassigned at any time during their visit to the appropriate value-streams. The nurses assigned to the dischargeable area should be responsible for filling their own beds based on the visual cue of the charts in the inbox. This signal is parallel to the Kanban box, which is used to signal work in a Toyota factory, allowing the worker to "pull" their work at a steady pace. Having a predictable workload created steady flow through the ED with an aim toward "just-in-time" delivery of care.

Furthermore, a great emphasis should be placed on reducing the time that a discharged patient stayed in a bed or chair. Nurses should be encouraged to complete discharge procedures on patients before receiving the next patient or ambulance stretcher. Patients requiring home care were identified at triage and not on discharge. Physicians should be encouraged to provide complete prescription and discharge instructions to the patient in order to minimize delay of bed turnover. Re-routing of laboratory results to the printer for the appropriate stream should improve information flow.

Improving efficiency for the dischargeable stream should have a positive benefit for the rest of the ED. By increasing the throughput of patients through a limited but pre-

allocated number of ED beds, remaining beds should be freed for ambulance offload and boarding admitted patients. Workplace organization projects, such as streamlining stockrooms and standardizing (IV) carts should have universal benefits in the ED. Placing dischargeable patients in a geographically distinct area of the ED could open other beds in the department for higher acuity patients likely to need admission. Also, the improvement in ED patient discharge turnaround time should reduce the small but existing number of patients who leave without being seen. Finally, as a result of improving ED process and wait times, careful attention should be given to the patient satisfaction surveys.

A major paradigm shift will be required to think of patient flow in terms of work involved rather than diagnosis. By standardizing work based on worker consensus, medical error and miscommunication should be reduced while increasing the acceptance and sustainability of the change. The challenge of the lean system is to train the workers to identify waste and to think in terms of the overall system and not just their own work step. Each step in a process has a potential impact down the line, and what may be convenient for one worker may cause great inefficiency for the rest of the process. For example, physicians piling charts can be a personal desire, but impede the nurses' efficiency, which can result in overall delay for the patient.

In the ED, a project should be implemented and trialed, feedback collected, and the project revised and re-implemented. Many projects, such as IV cart organization required repeated refinements, until the staff felt satisfied with their effectiveness. Other projects, such as the labeling of chart boxes to indicate what results were pending, should

be attempted. Furthermore, By using the tools of VSM and Lean problem-solving, the ED should also create side projects outside of the initial value-stream maps, such as reducing the turnaround time for urine tests and projects around mental health and admitted patients in the ED.

The greatest challenge in implementing the Lean system involves creating and sustaining the ongoing projects, which requires leadership and support from ED and senior hospital management. There is cost to hiring a Lean consultant, developing in-house Lean expertise and paying for staff to participate in kaizen workshops. Individual projects are often done during clinical hours by front-line staff.

Increased ED efficiency also requires affiliated downstream improvement in information flow from laboratory, diagnostic imaging and physician consultation services. Hospital overall flow is an issue beyond the scope of the ED and requires a more comprehensive hospital-wide strategy to improve patient flow. Based on the success of introducing the Lean system in the ED, it could become the role model department at the medical facility to create future Lean projects in radiology, internal medicine, and other departments.

Conclusion

This project applied Lean manufacturing techniques to improve the flow within the ED. The study suggested a dischargeable patient group, which represents the majority of the patients. By eliminating waste from our internal ED processes, improving workplace organization, focusing on reducing interruptions and internal waits, and continuously refining improvements, wait times, length of stay and patient satisfaction should all improve with no additional staff or beds. The lean system provides an approach to analyzing process flow and improving efficiency by focusing on the ideas of frontline workers and providing maximum value to the customer. These principles represent a change in how participants think about problems rather than a prescription for how to solve problems.

Glossary of terms[1]

5-S: Sort, Simplify, Sweep, Standardize, Self-Discipline: a visually-oriented system for organizing the workplace to minimize the waste of time.

Adequate: In value stream mapping, the capacity for any given step in a process is adequate if the process is not delayed at that step.

Available: In value stream mapping, a step in a process is available if it produces the desired output, not just the desired quality, every time.

Batch-and-queue: The mass-production practice of making large lots of a part then sending the batch to wait in the queue before the next operation in the production process. Contrast with single-piece flow.

Capable: In value stream mapping, a step in a process is capable if it produces a good result every time.

Cycle time: The time required for completing one step of a process.

Flow: The progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery, and raw materials into the hands of the customer with no stoppages, scrap, or backflows.

Just-in-Time: A system for producing and delivering the right items at the right time in the right amounts. Just-in-Time approaches just-on-time when upstream activities occur

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minutes or seconds before downstream activities, so single-piece flow is possible. The key elements of Justin- Time are flow, pull, standard work (with standard in-process inventories), and takt time.

Kaizen: Continuous, incremental improvement of an activity to create more value with less muda.

Kanban: A signal, often a card attached to supplies or equipment that regulates pull by signaling upstream production and delivery.

Lead time: The total time a customer must wait to receive a product after requesting the product or service. In service sectors, it is the time from the beginning of the process to the end (e.g., from when a patient arrives until he or she leaves the hospital).

Pull: A system of cascading production and delivery instructions from downstream to upstream activities in which nothing is produced by the upstream supplier until the downstream customer signals a need; the opposite of push.

Set-up time: All time spent getting ready to add value (e.g., time preparing a bed for an patient).

Standard work: A precise description of each work activity specifying cycle time, takt time, the work
sequence of specific tasks for each team member, and the minimum inventory of parts on hand needed to conduct the activity.

Takt time: The available production time divided by the rate of customer demand. For example, if customers demand 240 widgets per day and the factory operates 480 minutes per day, takt time is two minutes. Takt time sets the pace of production to match the rate of customer demand and becomes the heartbeat of any lean system.

Value: A capability provided to the customer at the right time at an appropriate price, as defined in each case by the customer.

Value stream: The specific activities required to design, order, and provide a specific product (or service) — from concept launch to order to delivery into the hands of the customer.

Value stream mapping VSM: Identification of all the specific activities occurring along a value stream for a product or product family (or service).

Valuable: In value stream mapping, a step in a process is valuable if it creates value for the customer.

Waste: Anything that does not add value to the final product or service, in the eyes of the customer; an activity the customer wouldn't want to pay for if they knew it was happening.

Appendix A

Current State Value Stream Map: Check-In Section

Day		
28		
Item		

Day	Hr	Min
6	60	60
Hr	Min	Sec

Patient Arrives To Waiting Room

Charge Nurse not available

A010
Wait Triage
Wait 0.7 Min

A020
Triage Process/ Check-In
	Min
Cycle Time	3.4
Associates	2
Batch Size	1

Sign Consent
Present ID – Photocopy
Dr. On Duty
Chief Complaint
Medical Background

A030
Wait For Bed
Wait 1 Min

Nurse checks for bed availability

Patients are asked to switch beds

Switch 30% beds

Patient Has a Bed

Bed not clean
13%

A040
Wait For Vital
Wait 1.7 Min

Busy Nurse

Nurse not aware about assigned patient

A050
Vitals Process
	Min
Cycle Time	3.1
Associates	1
Batch Size	1

Equipment Misplaced

A060
Wait For MD
Wait 4 Min

A070
MD 1st Assesment
	Min
Cycle Time	4.5
Associates	1
Batch Size	1

End

Z010
Summary		
Lead Time	18.40	Min
Total Value Added	11.00	Min
Value Added Percent	59.78	%
Takt Time	12.86	Min

0.70 Min   3.40 Min   1.00 Min   1.70 Min   3.10 Min   4.00 Min   4.50 Min

Created By: Roberto Arce
May 2010

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Appendix B

Current State Value Stream Map: Testing Process (Lab Orders)

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May 2010

Appendix C

Current State Value Stream Map: Discharge Process

Appendix D

Future State Value Stream Map: Check-In Section

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Appendix E

Future State Value Stream Map: Testing (Lab Orders)

Results examined by MD

Signal for X-ray arrival

Medical Record Lost 23%

Wrong chart 13%

Do not allow MD To pile up charts

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Wait for MD | Wait | 12 | Min

Results Charted

Light signal for printer

Specific med delivery Mail box

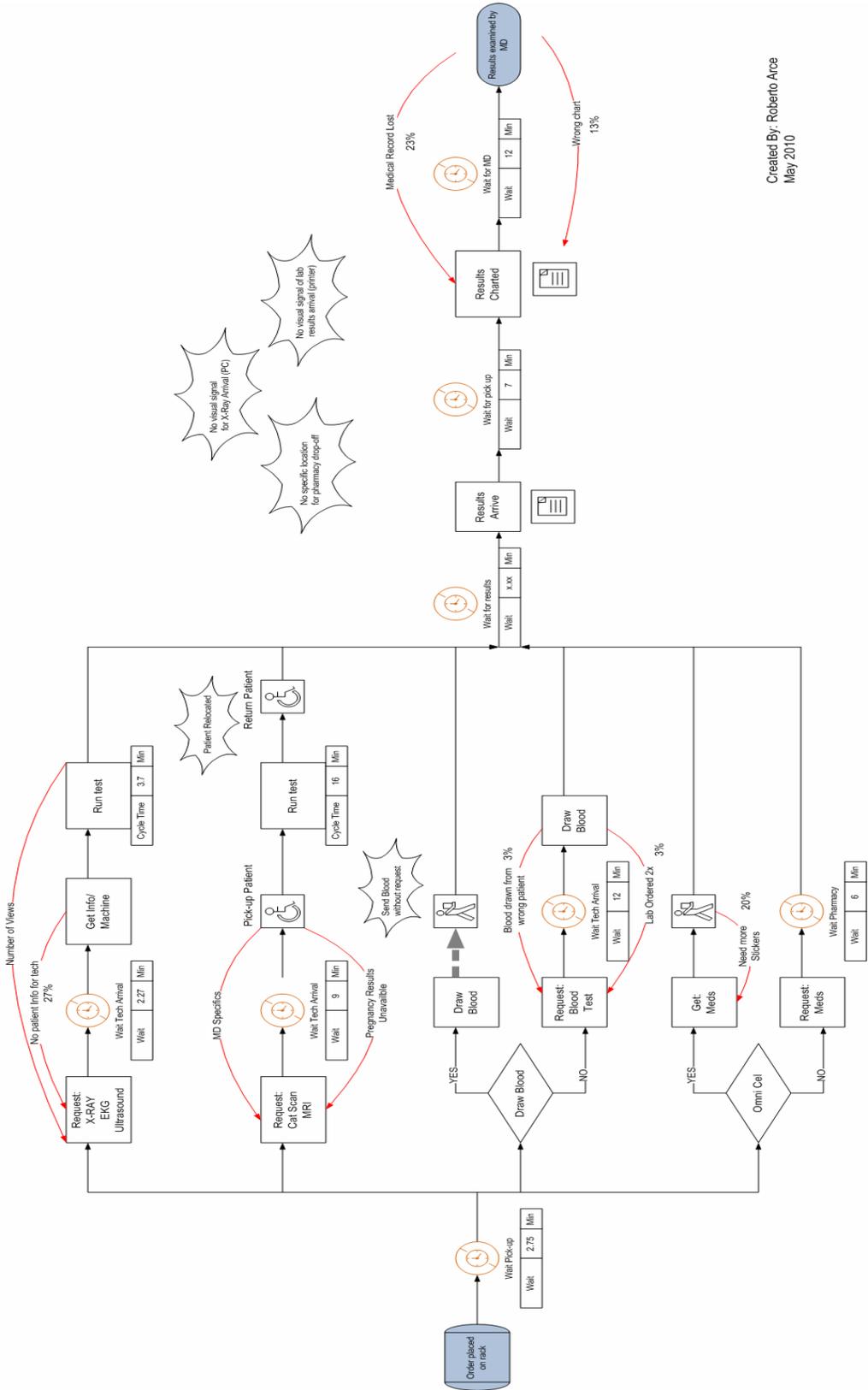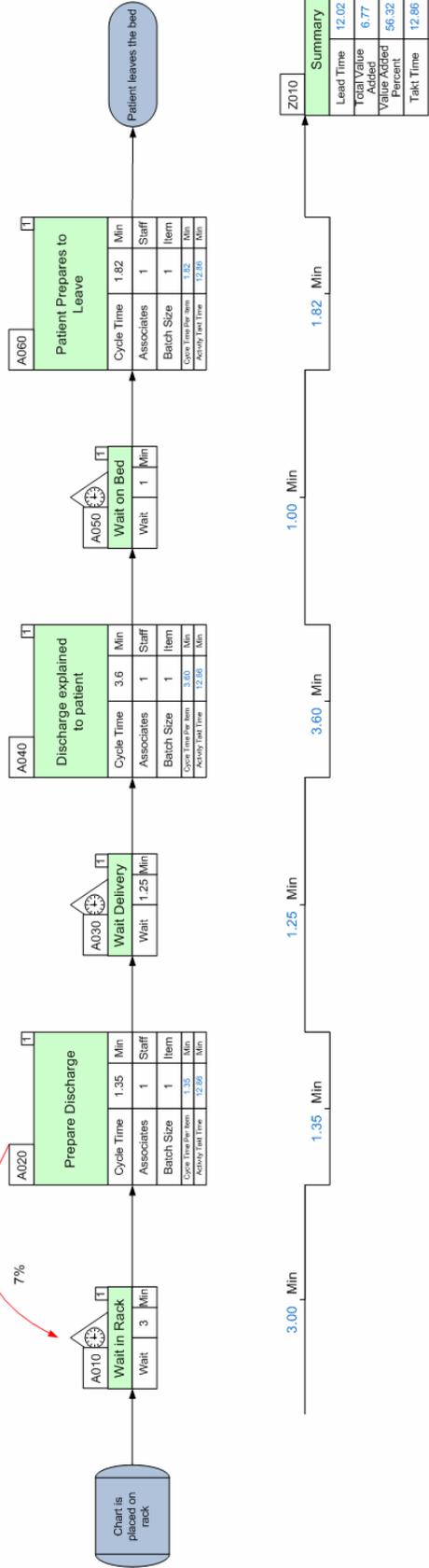Wait for pick up | Wait | 3 | Min

Results Arrive

Excludes EKGS

Wait for results | Wait | 20 | Min

Standard work: # views

Number of Views

No patient Info for tech 27%

Run test | Cycle Time | 3.7 | Min

Patient Relocated

Return Patient

Get Info/ Machine

Eliminate paper order, use board

Run test | Cycle Time | 16 | Min

Pick-up Patient

Request: X-RAY EKG Ultrasound

Wait Tech Arrival | Wait | 2.27 | Min

Standard Work: Order Labs when pre-test Is completed

MD Specifics

Request: Cat Scan MRI

Wait Tech Arrival | Wait | 9 | Min

Standard Work: Use cell phone not Pc to order during weekends

Pregnancy Results Unavailble 27%

Draw Blood

Blood drawn from wrong patient 3%

Draw Blood

Request: Blood Test

Wait Tech Arrival | Wait | 12 | Min

Lab Ordered 2x 3%

Draw Blood

YES

NO

Get: Meds

Need more Stickers 20%

Omni Cel

YES

NO

Request: Meds

Wait Pharmacy | Wait | 6 | Min

Order placed on rack

Wait Pick-up | Wait | 2.75 | Min

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Appendix F

Future State Value Stream Map: Discharge Process

Day	Hr	Min
6	60	60
Hr	Min	Sec

Day
28
Item

Standard Work Discharge then dictate

Chart is placed on rack

A010 Wait in Rack

Wait	1	Min

Exit Writer Crashes

7%

Work Balance

A020 Prepare Discharge

Cycle Time	1.35	Min
Associates	2	Staff
Batch Size	1	Item
Cycle Time Per Item	1.35	Min
Activity Takt Time	12.86	Min

Allow charge nurse To discharge

A030 Wait Delivery

Wait	0	Min

Discharge patients before crunch time

A040 Discharge explained to patient

Cycle Time	3.6	Min
Associates	2	Staff
Batch Size	1	Item
Cycle Time Per Item	3.60	Min
Activity Takt Time	12.86	Min

Eliminate Discharge interruptions

A050 Wait on Bed

Wait	0	Min

Visual Work Place Throughput

A060 Patient Prepares to Leave

Cycle Time	1	Min
Associates	1	Staff
Batch Size	1	Item
Cycle Time Per Item	1.00	Min
Activity Takt Time	12.86	Min

Patient leaves the bed

Z010

1.00 Min   1.35 Min   0.00 Min   3.60 Min   0.00 Min   1.00 Min

Summary		
Lead Time	6.95	Min
Total Value Added	5.95	Min
Value Added Percent	85.61	%
Takt Time	12.86	Min

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