# Efficiency and Satisfaction

# Quality of the Health Care Delivery System

Muhammad AlEnzy, Jason Harris, Rebecca Mantecon

**Abstract**—The focus of our project revolved around staffing efficiency and prediction. Multiple case studies were reviewed, allowing us to develop a deeper understanding of how various industrial and systems engineering tools can be utilized to improve healthcare efficiency. The case studies used gradually build upon each other, showcasing how more sophisticated tools can allow a hospital to build to a point where the staffing needs can be modeled and predicted.
By increasing staffing efficiency, a hospital is able to reduce non-value added tasks, which within this summary will refer to situations that are not customer-focused or customer-facing. By streamlining and optimizing the processes that distract from patient care, hospitals are able to achieve higher employee satisfaction and engagement. Improved satisfaction and engagement lead to a better patient experience and outcome as the employees are able to focus on the tasks on the tasks that they are most passionate about—the patients. This improved patient focus ultimately leads to a higher quality of healthcare delivery.

**Index Terms**— Quality, Healthcare, Management, Simulation, Triple Aim, Qulaity Measurement, Systems Engineering

## 1 Introduction

The focus of our project revolved around staffing efficiency and prediction. Multiple case studies were reviewed, allowing us to develop a deeper understanding of how various industrial and systems engineering tools can be utilized to improve healthcare efficiency. The case studies used gradually build upon each other, showcasing how more sophisticated tools can allow a hospital to build to a point where the staffing needs can be modeled and predicted.
By increasing staffing efficiency, a hospital is able to reduce non-value added tasks, which within this summary will refer to situations that are not customer-focused or customer-facing. By streamlining and optimizing the processes that distract from patient care, hospitals are able to achieve higher employee satisfaction and engagement. Improved satisfaction and engagement lead to a better patient experience and outcome as the employees are able to focus on the tasks on the tasks that they are most passionate about—the patients. This improved patient focus ultimately leads to a higher quality of healthcare delivery.

## 2 Quality Assessment and Performance Improvement

The lean Triple Aim Statement
Within the context of the case studies to follow, the main aim from the Triple Aim that is heavily emphasized is patient experience. Population health and cost are almost byproducts of the first aim, with only patient care being the sole focus. By streamlining processes that ultimately resulted in improved employee satisfaction and engagement, the hospitals were also able improve the patient experience through actual face-to-face attention.
Through streamlining processes, wastes were eliminated, providing staff the time to complete value added tasks that focus on the patients. Rather than needing to perform extremely manual tasks that present many opportunities for error, unnecessary steps were eliminated, cycle time reduced, and more patients could be accommodated, directly contributing to the hospital's bottom line.
With respect to improving the health of a population, the case studies did not cite specific evidence to support this aim, but with process improvements made, existing systems were able to increase capacity due to the elimination of non-value added actions. As for reduced cost, the same conclusion could be made that by eliminating waste, costs were lowered.
Quality Defined
The case studies reviewed for this report define quality as the ability to focus on the patient by eliminating non-patient focused activities that ultimately distract from the desired goal - patient care. As improvements are made to the operational workflow process, hospitals can reduce the time required for non-value added activities and implement new technologies and tools. Once the operational efficiency has been reduced to levels that a hospital is comfortable with, there is also the ability to create operational models that can allow a hospital to predict staffing requirements and guarantee that the necessary personnel is available to support the needs of the patients.
Quality Measurement
The following case studies measure quality primarily through reductions of non-value added tasks. These measurements are discussed in detail in subsequent sections that review each case study in detail.
Current Challenges
Each case below highlights the challenges medical centers face in providing high quality healthcare. A few key areas are made obvious about where certain challenges lie, they are as follows:

- Incompatible IT systems
- Data collection
- Misaligned incentives to aid in improvement projects
- Change management

Incompatible IT systems provide a barrier in allowing effective and efficient communication between different areas of the hospital. This barrier ends up creating extremely manual processes where the staff are required to work around the shortcomings of the system, creating more work that distracts from patient centered care and introduces potential for errors.
As in many industries these days, making informed decisions comes from having the appropriate information available. For many hospitals, the challenge may be that the right data is not readily available, not being collected properly or is not easy to be collected, or that there simply is not enough of it.
A very large problem in process improvement projects is the motivation to participate in the change because of monetary incentives. With a new project, there are many uncertainties about changes especially if there will be any advantages. Because of the possibility of no positive changes made, most organizations are hesitant to adopt such projects and changes. Without changes, organizations will still get paid for inefficient practices, making it hard to want to change.
Change management is difficult when systems are inefficient, making it difficult to predict what work is necessary and what resources will be needed. Organizations need programs to be well defined before change is to take place otherwise it may not be received well by staff. Similar to some of the challenges already discussed, when IT systems within a hospital do not communicate with one another and the appropriate data is not being collected, trying to create accurate models for staffing, healthcare, and inventory management can be challenging, if possible at all. Also, adapting to new processes such as a change in workflow, can be hard to implement if employees are not willing or able to follow changes.

## 3 Application of Systems Engineering

Systems engineering involves looking into systems and processes currently in place and how human users interact with these systems in their daily work. Systems engineering in healthcare is used to improve systems that all providers use while interacting with patients or preparing to provide a service to a patient. For healthcare, a systems engineering application could be reformatting a current system to follow the same workflow a provider would follow, limit options for order entry, or even pull up surgeon specific case lists for surgery. There are many applications in healthcare, as will be detailed in the Case Studies section of the report. From the three cases, the following methods have been demonstrated:

- Value Stream Mapping to aid in system redesign (including process standardization)
- Resource utilization (including staffing analysis and scheduling techniques)
- Forecasting for predicting the potential use of the ED
- Simulation to analyze different variables (such as capacity)
- Lean Sigma (including Rapid Process Improvement Workshops, U-shaped work cells, one-piece flow, JIT, and Kanban)

Value Stream Mapping was used to identify the current process by steps and locations of work. Value Stream Mapping also identifies wastes and inefficient processes that can be reorganized or redesigned to fit the situation and save time and money. Also, VSM can segue into process standardization where multiple processes were being performed, creating delay or mistakes in other areas.
Resource utilization focuses on the usage of any resource from providers, to rooms, to surgical instruments. Staff utilization was a big focus in many of our cases because staffing is seen as a bottleneck and a costly resource. Another costly resource includes the operating room which typically accounting for a significant amount of supplies consumed by a hospital. The OR is one of the largest contributors of profit and inefficiencies from the OR have significant impact on general day to day operations of a health care organization.
Forecasting and simulation are used to analyze unknown circumstances and put them into a more predictive model. Forecast can help to find trends from the past and be used in the future. This could be finding patient arrival rate trends to help staff correctly. Simulation helps to show different scenarios that may arise and how to allocate resources based on outputs of the model.
Lean Sigma implements two industrial engineering techniques for quicker process improvements. Lean is implemented to make processes more efficient and eliminate wastes while Six Sigma is used to analyze and control processes with statistics. Combined, the two methods create a quicker but well-rounded process improvement.

## 4 Case Studies

Case 1: Quality Improvement through Lean Sigma at Virginia Mason Medical Center
Goal
Virginia Mason Medical Center (VMMC) is a not-for-profit health care center in Seattle. Due to rising costs of health care delivery, VMMC realized it had to do something to change their processes in order keep providing health care services to its current customers. This change focused on quality improvements and used Lean as its basis for efficiently redesigning their system. With this problem they hoped to resolve the level of quality on five characteristics: 1. patient satisfaction; 2. evidenced-based care; 3. prompt access to care; 4. quick recovery; and 5. cost (Blackmore, et al.). Another main goal was for VMMC to be able to keep patients as their principal goal, with all efforts surrounding patient care granting more time for providers to interact with their patients rather than "non-value added" tasks. Overall, VMMC wanted to provide service that was efficient and focused and at a reasonable cost.
Methodology
Achieving the goal of a well-rounded, high-quality service was made possible by applying Lean Sigma techniques, a combination of Lean methodology and the Six Sigma approach, to create a system that is very efficient, with minimal wastes, and monitored through data analysis (Huang, et al.). Using this technique, VMMC had to keep their definition of quality in the forefront then chose their main problem areas, and focused their efforts on appointments due to headaches, lumbar pain, joint pain, and upper respiratory infection with implementation in many units throughout the hospital.

The beginning of the improvement project started with evidence-based care in which Value Stream Mapping was done to find the proper treatment route for each condition or reason for patient visit. With the design suggested by best practices already in place, clinics were able to adopt more efficient methods. Once practice included the use of phone appointments before physically seeing or meeting with the provider. This method would essentially screen patients before their visit to ensure that they needed to keep the appointment rather than completing a complex, costly and timely process that was unnecessary. Through reviewing the value stream map, providers and processes in place were examined. Unnecessary tests, as well as some ED visits and other appointments were eliminated; nurses or physical therapists were used instead of physicians, where possible; and because of these changes, more patients were able to be accommodated.

Another main technique was the implementation of a Rapid Process Improvement Workshop (RPIW) for one week (with about eight weeks of preparation and monthly follow-up intervals) that aimed to create a standard process through elimination of wastes, leaving only value added work to limit the variation between providers and patient cases. In preparation for the RPIW, the team of executive and care providers realized that delivery and quality of care and interaction with the patients was the biggest. All improvements were based around caring for the patient rather than pure systematic changes that would benefit the users only. Some of the methods to achieving standardization and a Lean system are listed below:

- Standard work: all providers will provide the same kind and same level of care
- U-shaped cells for a more efficient work layout: providers work in a centralized area in their unit or clinic to avoid non-value added time travelling to get supplies
- One-piece flow to complete necessary tasks for one patient before moving to the next: nurses would know all value added steps for patient care so that they did not need to leave and come back if a patient needed other actions to be completed
- Just-in-Time: timely delivery of supplies to units
- Kanban notification system: monitor inventory levels
- Systems approach: system redesign to prompt users to common treatments rather than costly, unnecessary alternatives (Nelson-Peterson, et al.).

Results

With simple modifications and process improvements, VMMC realized many positive results that led to greater patient and employee satisfaction. Improvements were noticed in headache and back pain appointment scheduling, reduce usages of unnecessary MRIs for headaches and lumbar pain, less steps taken in the Telemetry Unit, time spent per patient (through reducing non-value added time), less call lights used by patients, and preparation time reduction. Details of the results are listed below:

- 95% increase in same or next day appointments for headaches
- 23% reduction (each) in the usage of MRIs for headache and back pain
- 39% increase in new patients in the system for back pain appointments (per year)
- 85.5% reduction in steps taken by staff in the Telemetry Unit
- 47.5% reduction in time spent with patients from standardized work
- No call lights used compared to 5.5% usage in a four-hour shift previously; nurses completed all tasks before leaving the patient's room
- 85% reduction in non-value added tasks such as searching for supplies
- 85% reduction in preparation time to ensure instruments and supplies were ready and available (Nelson-Peterson, et al.).

Through closely examining current processes and finding wasteful actions and methods, VMMC was able to use systems engineering in the form of Lean Sigma methodology to improve their health care delivery system. Many changes were made to transform their clinics and hospitals to help create a more efficient work flow for providers and a better patient experience overall.

Case 2: A IT Integration in the OR: A Case Study for Improve Efficiency and Quality of Patient Care

Goal

For many hospitals in today's healthcare environment, continuous improvement is becoming more and more important. Many hospitals are focused on improving operational efficiency, clinician workflow, patient safety, and quality of care. The staff at Beaufort Memorial Hospital are no different, and this case study chose to focus their efforts on their operating room (OR). Since an operating room accounts for a large percentage of a hospital's operating revenue and supply costs, it is an ideal location to optimize process efficiency to increase profits. The stakeholders at Beaufort Memorial Hospital identified several areas of improvement which include:

- Charge capture
- Supply chain management
- Medical device standardization
- Supply standardization
- Physician and nurse staffing efficiency
- Patient safety

While developing these goals, the stakeholders realized that the ability to optimize the operating room process was severely limited by the lack of interoperability between the supply management systems and the clinical documentation systems. This lack of communication between the different systems creates a tremendous amount of non-value added time to manually bridge the gap between the two systems by documenting the surgical procedures and any supplies used in multiple places, reconciling the supplies used, adjusting procedural supplies to accommodate surgeon preference, and obtaining or returning the actual supplies. As a result, the stakeholders focused on being able to bridge the gap between the documentation systems while simultaneously working to optimize workflow efficiency.

Methodology

The staff at Beaufort Memorial Hospital worked over the course of two years to complete the IT integration project. The team

consisted of representatives from various groups within the hospital including physicians, nurses, and IT personnel. One of the main tools and methodologies that the team used were Value Stream Maps (VSMs). The team used an iterative Value Stream Mapping process through a Plan-Do-Check-Act methodology. This technique allowed them to create an initial process flow map, understand where the bottlenecks were, optimize the process, and then adjust the value stream map to see where to focus next.

Results

Within only 60 days of implementing the IT integration, Beaufort Memorial was able to achieve tremendous results. Some of the highlights include:

- 62% reduction in overall process time for a supply item to be obtained and documented (reduction from 42 minutes to 18 minutes)
- 33% reduction in implant procedure time which includes the surgical time and the time to document the supplies (reduction from 39 minutes to 26 minutes per case)
- An average savings of 10.9 minutes per implant case that nurses spend documenting the implant and supply usage
  - As Beaufort Memorial Hospital performs over 6,000 procedures annually, this results in saving over 1,000 clinician hours
- 50% reduction in back-end supply reconciliation of products used during surgery (reduction from 40 minutes to 20 minutes)

As can be seen from the statistics listed above, the IT integration between the different documentation systems in Beaufort Memorial Hospital dramatically reduced the time nurses spend documenting the various aspects of supply procurement, documentation, and reconciliation. As a result, the case study mentions that the saved time was used to spend more time with the patients or with their peers discussing patient care.

One of the potential benefits not directly mentioned in the case study is employee engagement. Many of the staff reported that tasks that are not directly focused on the patient feel like a distraction. As a result, employees are able to spend less time on non-value added tasks and more time with patients, ultimately improving employee engagement. In addition to a happier employee, decreased turnover would result, leading to improved familiarity and teamwork among the entire staff.

The high-level summary of the results are that staff can spend less time in the operating room per procedure, achieve lower supply returns, easily generate an accurate estimate of product inventory, and support a larger number of surgeries which improves the bottom line for the hospital.

Case 3: The Use of Arena Simulation to Improve Processes at Iowa Health – Des Moines (IHDM)

Goal 1

Iowa Methodist Medical Center is the state's largest private hospital. Some of Iowa Methodist's areas of specialization include:

- Cancer
- Cardiovascular
- Maternity
- Emergency and trauma (Life Flight)
- Surgery
- Orthopedics

IHDM has different medical centers with different capacities and they established a set of goals for every center belongs to it as follows. Iowa Methodist Medical Center (IMMC) has the following goal to accomplish to improve some of their processes: "Provide a method to quickly adjust volumes and determine if changes to staffing would be necessary." However, the IHDM have assigned 4 team members with engineering background to work on achieving this goal. And the team has decided to use Arena software to define all decision points, complex situations and to make the process improvement.

The IMMC wanted to predict the demand for ED with more accuracy levels taking into account variables like patient preferences and other sister hospitals capacities.

Methodology 1

The team has decided to use Arena software to define all decision points, complex situations and to make the process improvement. In addition, they chose Arena so they can change the volume with little effort and also to try different scenarios of queuing configuration like fast track for example.

The input data were from a Read-in Excel sheet with patients' arrival per hour for a week. A volume factor was also added for trial purposes. Regarding seasonality, an assumption was made to have it consistent.

The logic was that when patients arrive they would be assigned an acuity level from 1-5. Less acute patients will be assigned designated rooms and will be seen by mid-level provider. Resources for this model will include: rooms, providers, and patients.

Results 1

Ironically, the volume was less than what was expected, and the use of minimal staffing was deployed. Because of this, they tried a similar approach to another medical center that belongs also to IHDM, the Blank Children's Health Center.

Goal 2

The general pediatric providers felt thought that the number of rooms is a constraint to the patient flow. And additional room can become available in case of some movement of specialty providers.

The goal that they set was to "Determine the optimal number of rooms per provider with and without a resident physician."

Methodology 2

The team in charge was also interested in using Arena to easily determine the impact of room utilization on both the center resources plus the patients. The input data were including patient inter-arrival data plus the delay due to seizing or finding a resource (e.g. nurse, provider, bed, resident, etc.).

The model logic was built in a way that the patient first seizes a room then is seen by a resident then by a provider then the patient can leave the clinic.

Results 2

From the simulation, the output data includes:

- Provider utilization
- Resident utilization
- Room utilization
- Total time of patient in the system

With 2-7 rooms per provider were considered.
Eventually, a new schedule was developed including the optimal number of rooms to be assigned to each provider.

## 5 Conclusion

Through the use of systems engineering and process improvement techniques based on industrial engineering methods, many benefits can be achieved. These methods aim to make any process more efficient while also looking into how users interact with the system. In using the Triple Aim statement as a guide, the systems approach is also applied in the sense that patient experience, cost and population health are all intertwined and part of the same system.

## 8 Impact of Systems Engineering

Industrial Engineering has proven its usability and cutting edge efficiency tools in the manufacturing industry and that is what is needed to be done in the healthcare industry. It starts with hospital design, which takes the tool and methods of facility planning and it goes all the way to staff utilization, operational efficiency and patient safety and satisfaction, while maintaining a reduced and overall costs (Linenberger, 2014).
"Engineering methodologies… such as Lean and Six Sigma… have radically improved manufacturing in the last few decades; there is no comparison to what manufacturing was like before they were developed. As our economy spends more money on healthcare, both in absolute terms and relative terms, it is becoming extremely important to streamline our health systems and delivery utilizing these methods," says Hari Srihari, PhD., Chairman of Systems Science and Industrial Engineering, State University of New York at Binghamton.
The use of industrial engineering methods and tools can help healthcare organization decoding the dilemma of reducing costs while achieving operational excellence. This can be seen in many cases were millions of dollars were saved or even tons of wasted time were eliminated.
One area in which Six Sigma has already provided cost-saving benefits is the emergency department (ED) billing process in Virtua's existing facilities. System-wide, the EDs were losing $1.5 million annually due to incorrectly assigned levels of acuity for patients at the time of registration. An improved process was initiated including standard definitions and continuing staff education. That improvement will be carried over to the completed Greenfield facility.
One of the areas that industrial engineering were doing a big help is the use of 6 Sigma. For example, a billing process in an ED department in Virtua's existing facilities was causing a waste of $1.5 million every year due to incorrect assignment levels of acuity for patients at the time of admission. However, that waste has been eliminated after the proper implementation of 6 Sigma.
"The transition of industrial engineering from the manufacturing sector to service industries and healthcare is accelerating," says Hari Srihari. "Day-to-day cost cutting is a reality of modern healthcare. Management engineering must be a part of the existing healthcare building process to provide better results for everyone."
In conclusion, Industrial Engineering is becoming a must for healthcare to achieve both service quality and operational excellence.

## References

[1]: Arena healthcare simulation, http://www.arenasimulation.com/Solutions_Health_Care.aspx. Retrieved on April 3, 2014.

[2]: Blackmore, C. C., Mecklenburg, R. S., & Kaplan, G. S. At Virginia Mason, Collaboration Among Providers, Employers, And Health Plans To Transform Care Cut Costs And Improved Quality. *Health Affairs*, *30*, 1680-1687. Retrieved April 13, 2014.

[3]: Huang, Y., Li, X., Wilck, J., & Berg, T. Cost Reduction in Healthcare via Lean Six Sigma. Proceedings of the 2012 Industrial and Systems Engineering Research Conference. Retrieved April 1, 2014, from http://www.xcdtech.com/iie/index.cfm

[4]: Linenberger, PhD, RN, Harriett. Hammes Company Senior Operational Planner, Industrial engineering principles enhance hospital design. Hammes Company – news and events. Retrieved on April 3, 2014.

[5]: Nelson-Peterson, MN, RN, D. L., & Leppa, PhD, RN, C. J. Creating an Environment for Caring Using Lean Principles of the Virginia Mason Production System. *JONA: The Journal of Nursing Administration*, *37*, 287-294. Retrieved April 7, 2014.

[6]: Work, Mitch, (2009, June 11). *A IT integration in the OR: A case study for improved efficiency and quality of patient care*. Retrieved from http://www.psqh.com/septemberoctober-2009/241-it-integration-in-the-or.html#.UztYzFEUasw.email