Project Number: SAJVA

An Analysis of Work Flow in the Phlebotomy, Chemistry, Hematology, and Urinalysis Laboratories at the Edith Nourse Rogers Memorial Veterans Hospital in Bedford, MA

An Interactive Qualifying Project

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By

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Abstract

The goal of this project was to reduce lead times for sample processing caused by the increased sample volume received by a laboratory with limited technician capacity. Cluttered work space, distractions, and lack of a technology-based tracking system all affected the time for sample processing at the Edith Nourse Rogers Memorial Hospital laboratory, Bedford. Observing and measuring the pre-analytical work-flow enabled the team to use lean methods to suggest changes, develop plans for evaluating results, and outline actions for sustainability.

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Mari Ann Amador - Laboratory Supervisor

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James Taylor - Phlebotomist

Melissa Williams – Phlebotomist

Authorship

Darcy Del Dotto
Worked mainly on becoming an expert of the processes in the laboratory and reflected her observations in the background section. Worked on mapping the processes of the four areas in the laboratory, phlebotomy, chemistry, urine, and hematology. Also spent time at all four of these areas learning about the employees' profiles, including their roles, responsibilities, and interactions. Uncovered many opportunities for improvement by focusing on sample flow. Formatting and spelling check of the final proposal was also conducted. Edited and formatted first draft of final report.

Michelangela Yusif

Worked mainly on the methodology and the VA-TAMMCS and DMAIC within the literature review. Described the 5S system within the report. Observed process of samples within the laboratory as well as collecting data such as incoming and outgoing phone calls, and steps towards completing accession and producing results. In addition multiple questions directed towards the employees were asked during observation. Recorded observations of the work area within the laboratory. Uncovered many opportunities for improvement by focusing on telephone log and work space. Formatting and spelling check of the final proposal was also conducted. Edited and formatted first, second, and final drafts of final report.

We would also like to acknowledge work done by our partner:

Burak Birand
Worked mainly on the introduction and processes within the literature review. Observed process of samples within the laboratory as well as collecting data such as incoming and outgoing phone calls, and steps towards completing accession and producing results. In addition multiple questions directed towards the employees were asked during observation. Formatting and spelling check of the final proposal was also conducted.

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Chapter 1: Introduction

The Veterans Health Administration (VHA) is part of the United States Department of Veterans Affairs (VA), directed by the Under Secretary of Veterans Affairs for Health, which implements the medical assistance program of the VA through the administration and operation of numerous VA outpatient clinics, hospitals, and medical centers [12]. The Edith Nourse Rogers Memorial Veterans Hospital is located in Bedford, Massachusetts and is part of the VA New England Healthcare System [2]. Many patients are treated every day in Bedford, and the hospital is committed to provide high quality, innovative, comprehensive and compassionate care [2]. Some departments within the facility are experiencing long lead times with the increasing demand. The blood laboratory in building two is one of them.

Ideally, the laboratory should be able to process samples from inpatients and nearby Community-Based Outpatient Clinic's (CBOC) and have results ready in a reasonable time. However, currently the times required for the tests can be slower than desired due to the large number of samples being tested.

The foremost cause of this problem is the increased quantity of samples that need to be processed by a small number of lab workers. This is a common problem in operations where meeting demand with capacity becomes problematic. In order to understand the problem thoroughly, the project team observed the procedure meticulously. Factors that were examined were whether tasks and work-flows are value-added, so the work force can operate more efficiently, and if the samples coming in from different clinics were on time for the

process to be initiated. The work flow was broken down in three steps as shown in Figure 1. Our main focus was the pre-analytical step of the process which mainly includes collection of samples and the accession process.

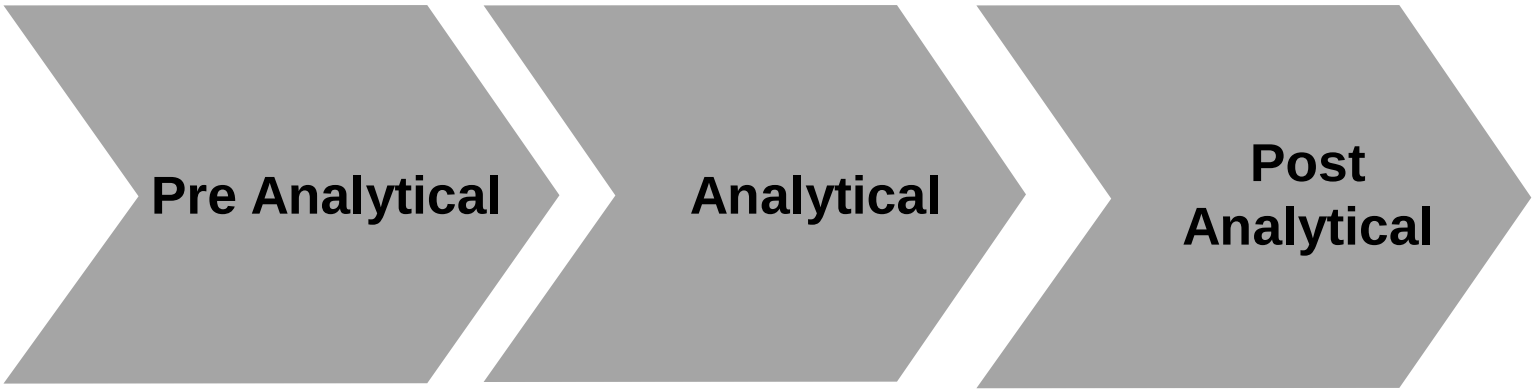

Figure 1: Breakdown of work flow

The goal of this project was to understand the problems the blood laboratory is having and to optimize their pre-analytical work flow and operations to provide better care for the customers. The major questions we had to answer was what change was needed in the process to improve the lead time, and the elapsed time required from when a sample was received until testing results were entered in the computer. We approached the issue by observing the work flow at different times and drawing out the points that were believed to cause the delays. The VA-TAMMCS process improvement method was used to guide our methodology. The remainder of this report describes our background research and process observations, our methodology, and our results and conclusions.

Chapter 2: Background

To become knowledgeable of the areas for improvement in the laboratory, it was first necessary to observe and learn the current flow of work as well as the job requirements of the employees. Each of these categories involved further breakdown to ensure complete understanding of the laboratory, and also to develop an insider's perspective for current issues.

Accession Process

The Veterans Administration hospital in Bedford, MA has a small scale laboratory that services both in patients and outpatients as well as supports four CBOCs. Three classifications of test are performed in the laboratory: hematology, chemistry, and urine. Staffed with six medical technicians and three phlebotomists, the laboratory processes hundreds of samples daily which can be grouped by the type of patient, as shown in Figure 2.

Every sample is accounted for by a process of accession, conducted in one manner for in-patients and out-patients, and another for the CBOCs. The in-patients' and out-patients' samples are both accessioned by the phlebotomist. When patients initially enter the front area of the laboratory they are required to provide their military identification number, which the phlebotomist enters into a computer program called Vista and checks to confirm which tests patients' doctors have ordered. After the samples are drawn the accession labels are then printed and placed on the sample tube. For the in-patient procedure, when the phlebotomists arrive in the morning at 6:30AM and log into the Vista program, they are presented with a list of patients in the adjacent hospital for whom they need to draw samples as well as the tests

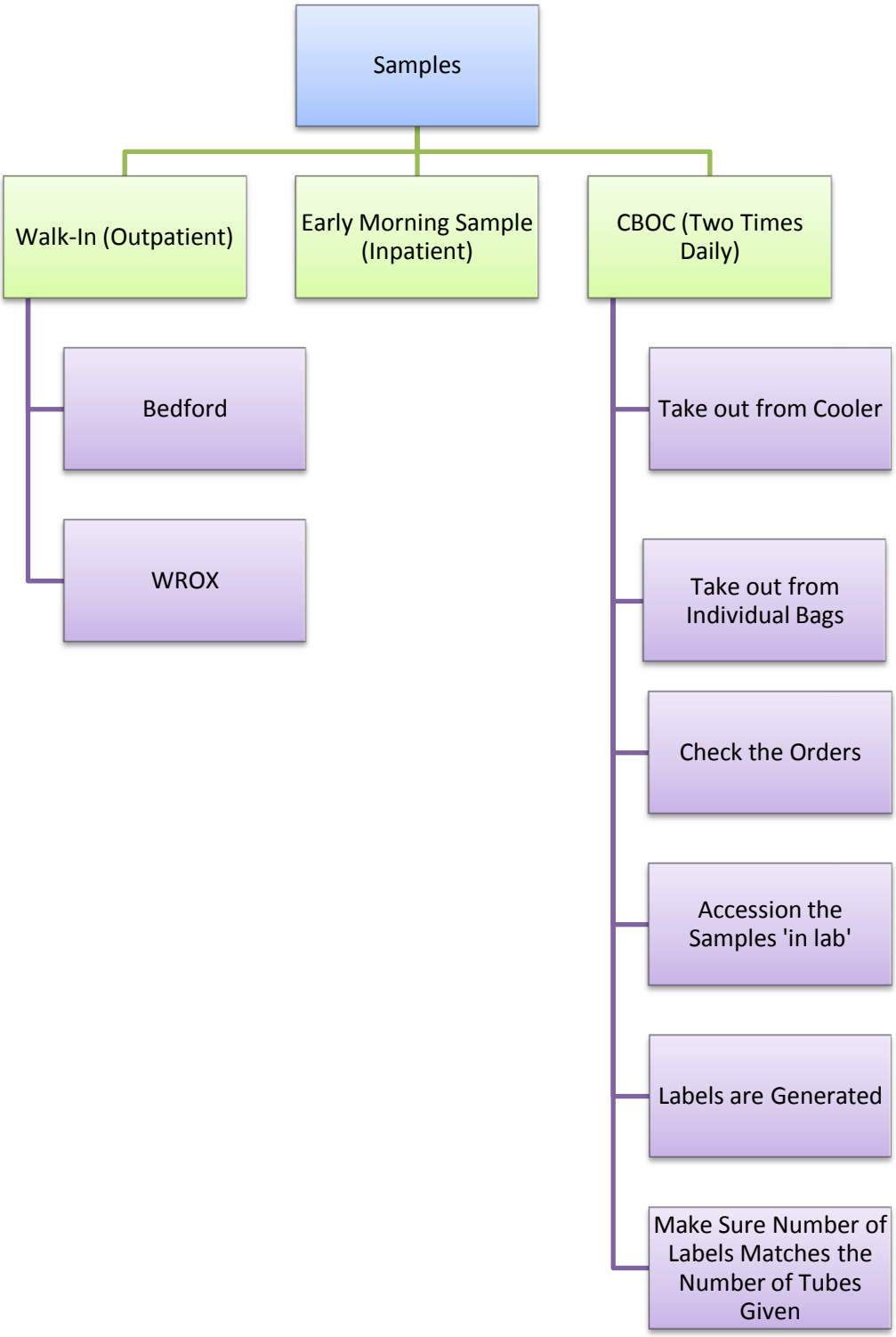

Figure 2: Flow of the three types of samples through the laboratory (emphasis is how the CBOC samples are followed)

that will need to be conducted. The number of in-patients varies from five to thirty, with an average of approximately fifteen. The phlebotomists are then able to take the samples and attach the accessioned labels.

The accession process for the CBOC samples is quite different, as shown in Figure 3, and is conducted by the medical technologists in the laboratory. In the morning when the technologists arrive they are able to log into the Vista program and receive via fax the tracking sheets for the CBOCs. These tracking sheets report each patient's name and how many samples of each color tube (the different colored tubes correspond to different types of testing) to expect. When the CBOC bags arrive, the technologists remove the plastic boxes from the bags. These boxes contain biohazard bags, one per patient with the exception of urine which is usually packaged in its own bag, and the manifest which is a detailed paper that includes the patient's order number as well as the various tests their samples will need. Upon removal of the samples from the biohazard bags, they are placed in the test tube racks and the technologist confirms that the orders match both the tracking sheet and the manifest. After this step has been completed, the accession process on Vista begins by confirming all the samples have arrived and their collection times are entered. An unaccounted for sample, if present, also has to be entered into the computer. The labels are then printed and placed on the samples carefully to avoid covering up the previous labels on the tubes. Once again the sample tubes are cross checked with the tracking form and manifest before both are saved and stored for a specified time to ensure patient confidentiality.

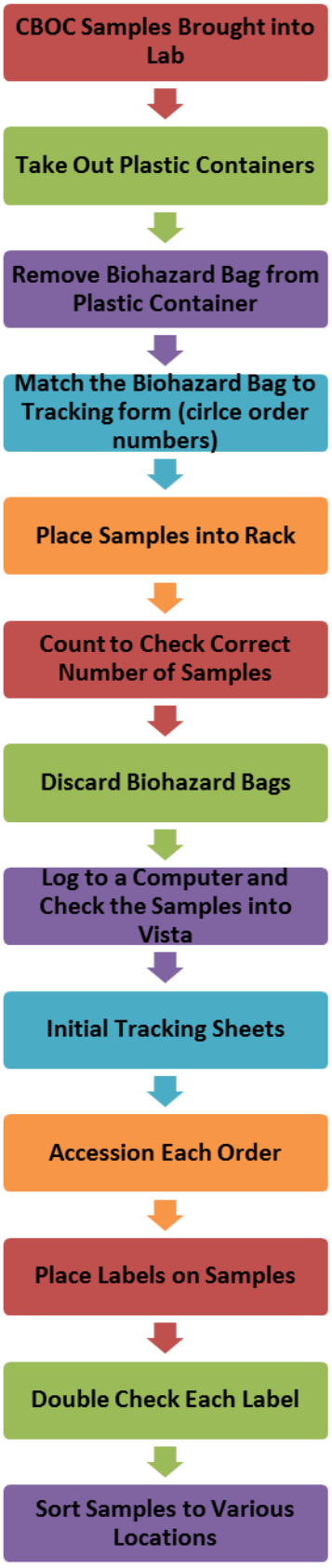

Figure 3: CBOC accession process

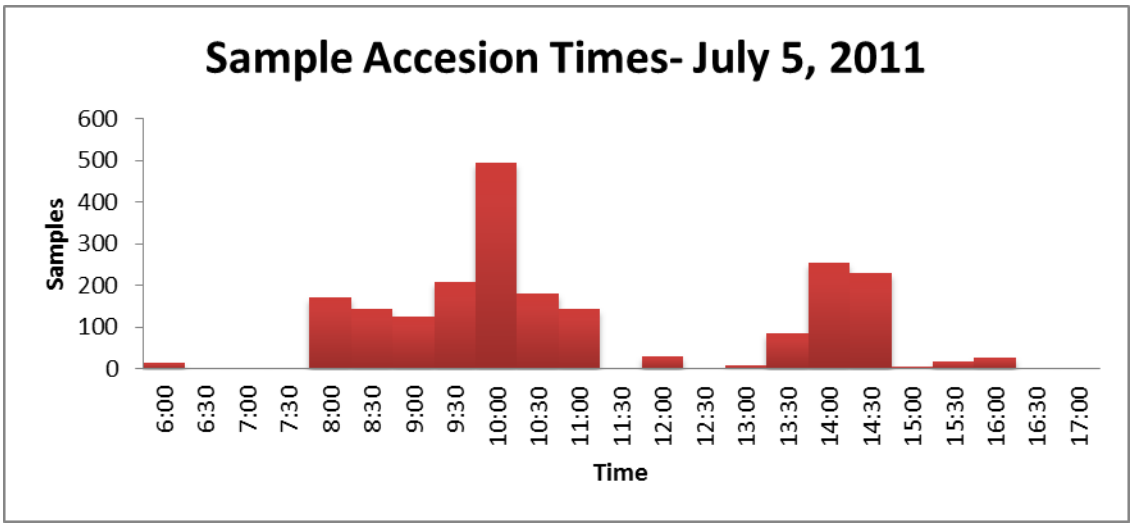

Figure 4: The number of samples accessioned per half hour on July 5, 2011, an average day at the laboratory at the Bedford Veteran's Association

Figure 4 is an example of the number of samples accessioned during a typical day in the laboratory. There are a few samples immediately ready when the lab opens at six o'clock in the morning, but the first peak is at eight o'clock when the samples from the in-patients and outpatients arrive. Also in the morning, samples that were not able to be processed in the late afternoon, due to their late CBOC delivery, are tested. The lab becomes very busy at approximately ten o'clock when the first deliveries from the CBOC's are delivered; this is the heaviest flow of the samples for the length of the day. After these orders are accessioned, the demand dies down between eleven and one due to the lunch hour and the pick-up from West Roxbury at 12:00 noon. At around one thirty the second high demand time of the day begins; typically this is when the afternoon CBOCs begin to arrive. The laboratory remains busy until 3:00PM when the second West Roxbury pick-up occurs. From this time of the day until the laboratory closes at 6:00PM there are only a small number of samples accessioned.

Chemistry

Like the accession types, there are three categories of samples serviced by the laboratory including urine, hematology, and those to be processed through chemistry. Each category of sample follows a particular flow through the laboratory and is processed in a unique manner. Of the three types of samples, chemistry is the most abundant in the Bedford laboratory. After the accession process has been completed, chemistry samples follow three paths based on their final destination whether it is to stay in the lab or transported out to West Roxbury, Quest, or West Haven. All three paths begin with the centrifuging of the blood samples, as shown in Figure 5.

Urine

The Urinalysis department of the laboratory is located in the same room as the chemistry department, in an enclosed area. The procedure involved only one machine, an AX 4280, followed by manual observation under a microscope, but the IQ 200 machine was purchased, in addition to the previous machine, and this eliminated the need for analysis under a microscope. Upon training of the usage of the IQ 200 machine, the technicians now use the procedure depicted in Figure 6. Once the samples have arrived in the urinalysis department, they are placed in racks located near the AX 4280 machine. After the caps of the sample tubes are removed, the samples are placed on Iris racks which are specifically designed to work with both the AX 4280 and IQ 200 machines. The Iris racks are then loaded onto the AX 4280 machine and upon completion of testing results are printed. A technician is now required to use the Vista computer system to print labels to place on the result paper because currently the

results do not have patient information. Upon labeling of the papers containing the results, they are then entered into the computer system.

Figure 5: The chemistry flow chart from the time of centrifuging to the sample's final destination, whether it is staying at the lab or being shipped to another location

If the results are normal, the papers are placed into a folder and the samples are recapped and stored in the refrigerator. When the results are not within normal ranges the result papers are placed in a designated bin and a technologist has to order a microscopic analysis into the computer system. The samples are then poured into smaller test tubes and run through the coagulation machine. Once the samples have been spun down, small amounts are pipetted into the cavities on microscope slides. The sample are then manually analyzed under a microscope and observations are recorded on the original results paper printed from the AX 4280 machine, and entered into the Vista system.

As can be seen in Figure 7, the addition of the IQ 200 machine eliminated many of the steps in the current process. The initial steps of the process are the same until analysis of the samples in the AX 4280 machine is complete. With the new machine, samples are sent over to the IQ 200 machine using a connecting bridge compatible with both machines. The IQ 200 machine then does a microanalysis test with illuminated the need for manually microscopic observation to be conducted. The monitor of the IQ 200 machine then displays images of the sample which are manually examined for review. All results are printed from this machine include patient information eliminated the need for technologist to manually print and add labels. Any results which are flagged are unusual can then be manually checked under the microscope. Now results in the computer can be confirmed and samples put in the refrigerator for storage.

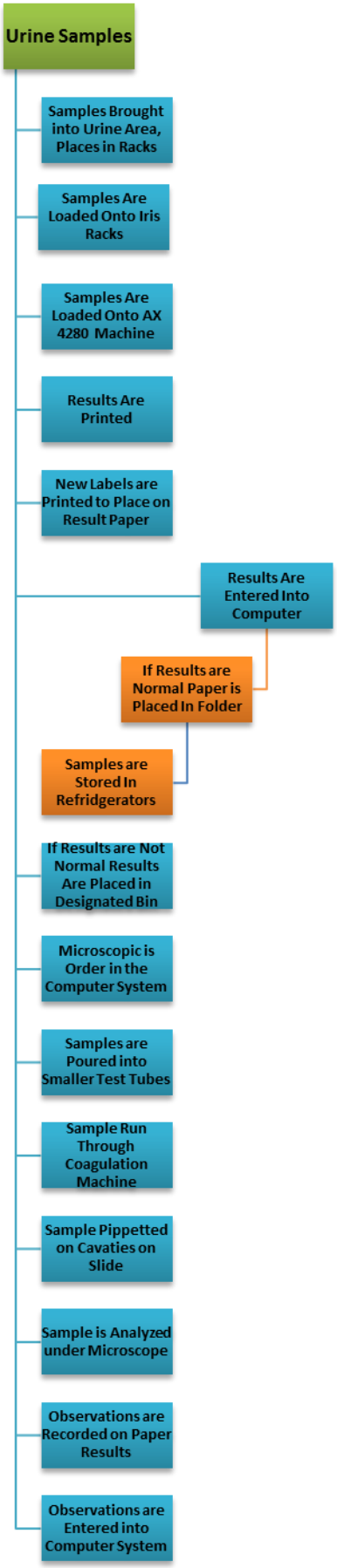

Figure 6: Current urinalysis flow chart

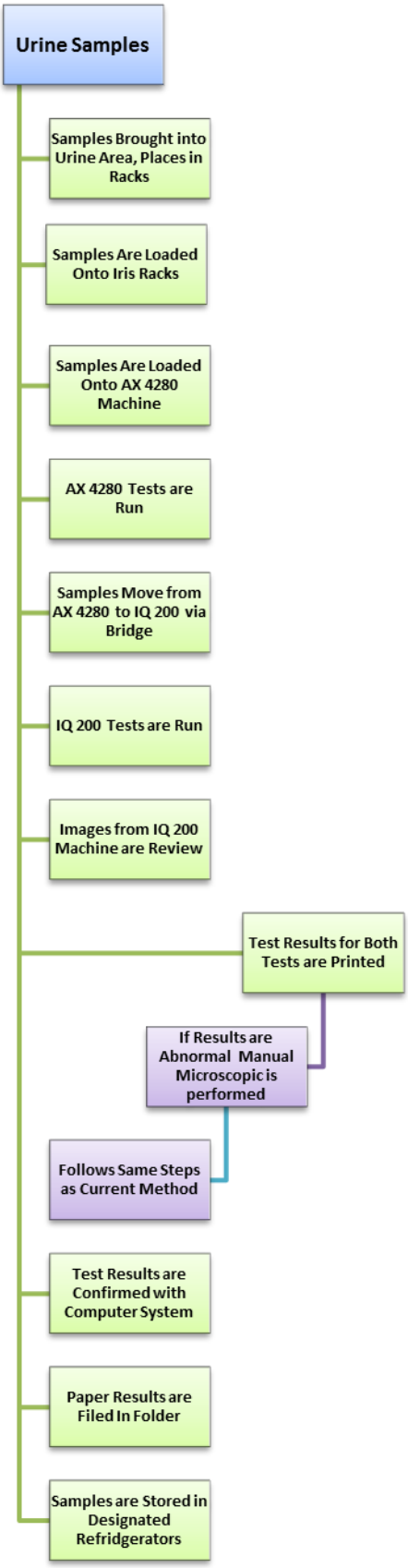

Figure 7: Flow chart for urinalysis process with the addition of the IQ 200 machine

Hematology

The hematology laboratory is located in the furthest back room of the laboratory. During most of the day, two technologists work in this area, but during less demanding times only one technologist is required to do the testing. One of the technologists typically works in this room, with others rotating through during the week. As shown in Figure 8, currently four types of tests are conducted in the hematology laboratory; CBC's, Coagulations, Sediment Rates, and D-dimers.

Each of these categories requires its own unique process through the laboratory. On an average day seventy to eighty hematology samples are tested in the laboratory, but on busier days more than one hundred and thirty samples may have to be accessed, the bulk of these samples are designated for either CBC or Coagulation testing.

Samples to be processed by the CBC machine are dropped off in the front of the hematology laboratory either by a phlebotomist bringing the sample directly from the front of the laboratory, or by another technologist who has recently accessed samples delivered from CBOCs. When the technologist is ready to run the CBC machine, they gather all the samples, all having purple caps, intended to be run through the CBC machine. Before loading the test tubes on to the uniquely designed test tube racks specific to the CBC machine, the technologist must check to confirm that both name labels are showing on the samples from the received CBOCs. After loading the samples into the test tube racks, they are loaded into the machine and the test is run. Upon completion of the test, the results are printed from a printer attached to the CBC machine. The samples are then loaded in numerical order in a test tube rack designated for

Figure 8: Flow chart of the four processes conducted in the hematology laboratory

storage. After printing, the test results are confirmed along with the negative results, which only need a brief check, to ensure the printed test results mirror the results the computer displays by a technologist logging into the Vista computer program. These test result print outs can then be placed in the CBC test results rack on the filing system. Any test results that are shown as positive require additional steps. First the blood samples have to be made into smears to view under the microscope. During a calm time of the day, the smears can be made, analyzed under the microscope by a technologist, and observations of the morphology can be recorded on the test result paper; these are then entered into the Vista program. These smear slides are kept for a month, in the event they are needed for future referencing.

The other type of test that is a large fraction of the hematology work load is the Coagulation test. Samples that require this test have blue caps and are dropped off in the hematology lab in the same manner as the CBC samples. Upon arrival in the hematology laboratory the samples are loaded into a centrifuging machine that runs for fifteen minutes. At the end of the process a buzzer sounds to inform the technologist that the samples are ready. Before loading the test tubes into the uniquely designed test tube racks for the Coagulation machine, the technologist must examine the test tube to ensure the content reaches a certain height. After this inspection, the samples are loaded onto the test tube rack and put into the machine. The Coagulation machine display depicts blue circles to show that the samples are loaded into the machine properly, and then turns purple to mark its acceptance of the sample. Finally when the test is complete the display changes to green. After five samples have been successfully tested the machine's attached printer sends out results; these results are used to cross check with the results displayed on the Vista program when the technologist signs into

the software. Not only do both sources have to match, but the results need to be checked to make sure they fall into a health range. If the test has been requested by a pharmacist, the results must be between zero and fifteen because the pharmacist is required to confirm the patient is within a certain range to prescribe particular medications; the latter rule does not apply to doctor's orders. After each of the samples has been confirmed in the Vista program the printed out results are then placed in their designated filing rack.

A much less frequently conducted test is the sediment rate test, typically completed two to three times daily. When samples that require this test are brought to the hematology laboratory, the technologist present is informed of the arrival of this type of sample because the sample is inside a test tube with a purple cap that could easily be mistaken for a CBC sample. The technologist must first log on to the Vista program and print the work load in order to print a new accession label for the new test tube required to conduct the test. To process this order the technologist obtains a long, thin test tube with a black cap, and pours the contents of the original sample up to a marker on the black capped tube. The accession label is placed onto the test tube and the original sample and any remaining contents are then discarded in a biohazard waster container. A barcode scanner is then used to read the accession label and now the sample can be loaded into the sediment rate measure and the test can be run. When the test has been completed the results print on a small receipt-like paper. The results then have to be manually entered into the computer program because the sediment rate machine is not directly connected with the computer. Upon completion of the test, the tubes are discarded in a biohazard waste container.

D-dimer is the final type of sample processed in the hematology laboratory. Technically it is a chemistry sample, but the centrifuge in the chemistry department runs at too low a rate to properly prepare the sample for testing. The D-dimer samples arrive in the hematology laboratory in the same manner as the sediment rate samples; the technologist is informed of the type of sample since it could easily be mistaken for a coagulation sample due to its blue cap. After arrival the sample is then loaded into the centrifuge, which runs at a higher speed and for a longer time than the unit in the chemistry laboratory. When the machine buzzer sounds, the sample is ready to be brought back to the chemistry laboratory where it is placed in a freezer in preparation for its packaging to be sent out to West Roxbury.

Staffing and Employee Roles

Currently the laboratory is staffed to the department's maximum budget with six medical technologists and three phlebotomists. Of the nine staff members, all are full time with the exception of one medical technologist who is only part-time. On a typical day at the laboratory when the entire staff is present, completing the work demand is not problematic, as expressed by the opinions of the employees. Normally the front of the laboratory (phlebotomy), and the back, (chemistry and hematology rooms), operate separately, with the exception of delivery or pick up of samples from the front rooms to the back rooms.

Phlebotomists

In the phlebotomy rooms, there are a total of three stations for drawing blood, which allows for three of the four phlebotomists to be working at all times between the hours of eight and two-thirty. Currently three of the four phlebotomists work from 6:00AM to 2:30PM, while

the fourth works from 8:00AM until 4:30PM. The employees' hours are divided in such a way to account for work flow. In the morning when the phlebotomists arrive they are required to draw blood from the inpatients of the adjacent hospital upstairs, but at seven a.m. one needs to return to the phlebotomy rooms to begin drawing blood for the outpatients who may arrive. The number of patients who come in for blood work drops off steeply in the afternoon which is why only one phlebotomist works after two-thirty. The phlebotomist who remains in the laboratory alone has a unique set of job requirements though, including cross checking all of the orders sent out to CBOCs with the computer data base. Outside of the laboratory this phlebotomist also has responsibilities in other departments of the hospital involving machinery.

In addition to drawing blood and accessing samples, the phlebotomists have other routine daily responsibilities. Each day they are required to record the temperature of their work areas, and record a log of difficulties with miscommunications with doctors and nurses. When there are discrepancies between the information patients are giving them and what doctors have ordered via the computer system, the phlebotomist are required to make the necessary phone calls to rectify the situation. One phlebotomist is also in charge of re-ordering inventory and making sure the supply room is fully stocked.

Medical Technologists

In the back section of the laboratory there are three departments divided over two rooms, chemistry and urine in the larger room, and hematology a few yards down the hallway. In these two rooms the six medical technicians process hundreds of orders. Although each technologist is expected to be skilled in each area of the laboratory, each has their particular area in which they typically work. Currently there are two technologists focused primarily on

hematology, one who manages all of the urine samples and three who process the chemistry orders. On days that the laboratory is fully staffed, it is the chemists who are responsible for unloading the CBOCS and accessing the samples. There is also one chemist who is primarily responsible for managing the laboratory phone. There is only one technologist, who works part time from nine a.m. to two p.m., whose focus is on the urine samples because the number of urine samples is rather small in comparison to the blood samples. The medical technologists' hours are designed to correspond with the demand for processing samples. During the busiest hours of the day, all three chemists and both hematologists are present, while in both the morning and afternoon only one representative from each department is present.

Each of the medical technologists is responsible for keeping the laboratory operating as smoothly as possible. This includes simple office tasks such as loading printers, restocking supplies, and keeping up to date with paper work. They are also required to store and dispose of old samples in three of the laboratory's five refrigerators. Periodically during the day, the technologists collect samples from the phlebotomy rooms. On days where the phlebotomists are understaffed, the technologists are required to assist in the phlebotomy rooms to help draw blood. To be hired as a medical technologist, phlebotomy skills are required.

Employee Interactions

From observation, it is noted that both the phlebotomist and medical technologist work very efficiently together. Both areas of the laboratory work cohesively among themselves and with each other. In the back of the laboratory, the medical technologists communicate to continuously keep up to date with each other on their current area of work. This allows for

everyone in the laboratory to be aware of which tasks have been completed and which remain unfinished. For example, when the CBOCs arrive one technologist will share with the others they are going to unload the samples. Also, technologists inform one another when they plan to run a machine, which allows the other technologists to input their samples as well, if they are ready for processing, making the use of the machinery more efficient.

Chapter 3: Literature Review

To complete a project involving both the Department of Veterans Affairs and a system redesign, or improvement, knowledge of processes and methodology is necessary. Information about processes includes methods to collect, analyze, and map data. Because of the specificity of the laboratory's affiliation using not only the standard DMAIC methodology, but the Department of Veterans Affair exclusive version VA-TAMMCS is required.

Processes

Healthcare is a field where optimal operations can not only save money, but also lives. Patients expect to receive the best service possible when they are in hospitals, clinics or medical centers [8]. The VA Hospital in Bedford, MA has a very busy schedule and it provides hundreds of patients with healthcare and medical assistance every day, including the blood laboratory in building two. This laboratory collects samples from walk-ins, inpatients or Community-Based Outpatient Clinics (CBOC) as shown in Figure 2. In order for them to offer the best service, they must have a very efficient process. If we were to define a process, it would be "a part of an organization that takes input and transforms it to output of greater value to the organization", which in this case it would be the blood laboratory [6]. To be able to properly do the latter, questions should be asked to help define the problem and comprehend if the process currently in use is suitable for future operations including:

- How many customers can the process handle in an hour?
- How long will it take to serve the patient?
- What change is needed in the process to expand capacity?
- What is the output?
- Is it a single or multiple stage process?

Flowcharts are an easy way to understand the operations of an organization, in this case, the blood laboratory. Different types of charts exist for diverse operations; value stream mapping is one of them [3]. Value stream mapping is a picture of the process steps from beginning to end that provides the result for the customer. Some activities add value to the result, some do not and sometimes the process stops with no activity at all. There are a few key principles of value stream mapping:

1. Keep the value stream moving at maximum velocity
2. Eliminate waste that stops, slows down, or diverts the value stream
3. Concentrate on removing waste rather than speeding up value-adding operations
4. Look for waste in the procedure and technical operations

As an example of process mapping, Figure 9 illustrates the basic operations of the pre-analytical process of the lab with the samples coming from walk-ins, CBOC's and another medical clinic.

Common characteristics of processes that are often calculated to optimize the work flow include:

- **TAKT:** particular type of cycle time, defined by customer demand. The process should be designed so that cycle time meets the TAKT time.
- **Utilization:** $utilization = \frac{time\ resource\ is\ activated}{time\ available}$
- **Productivity:** $productivity = \frac{output}{input}$

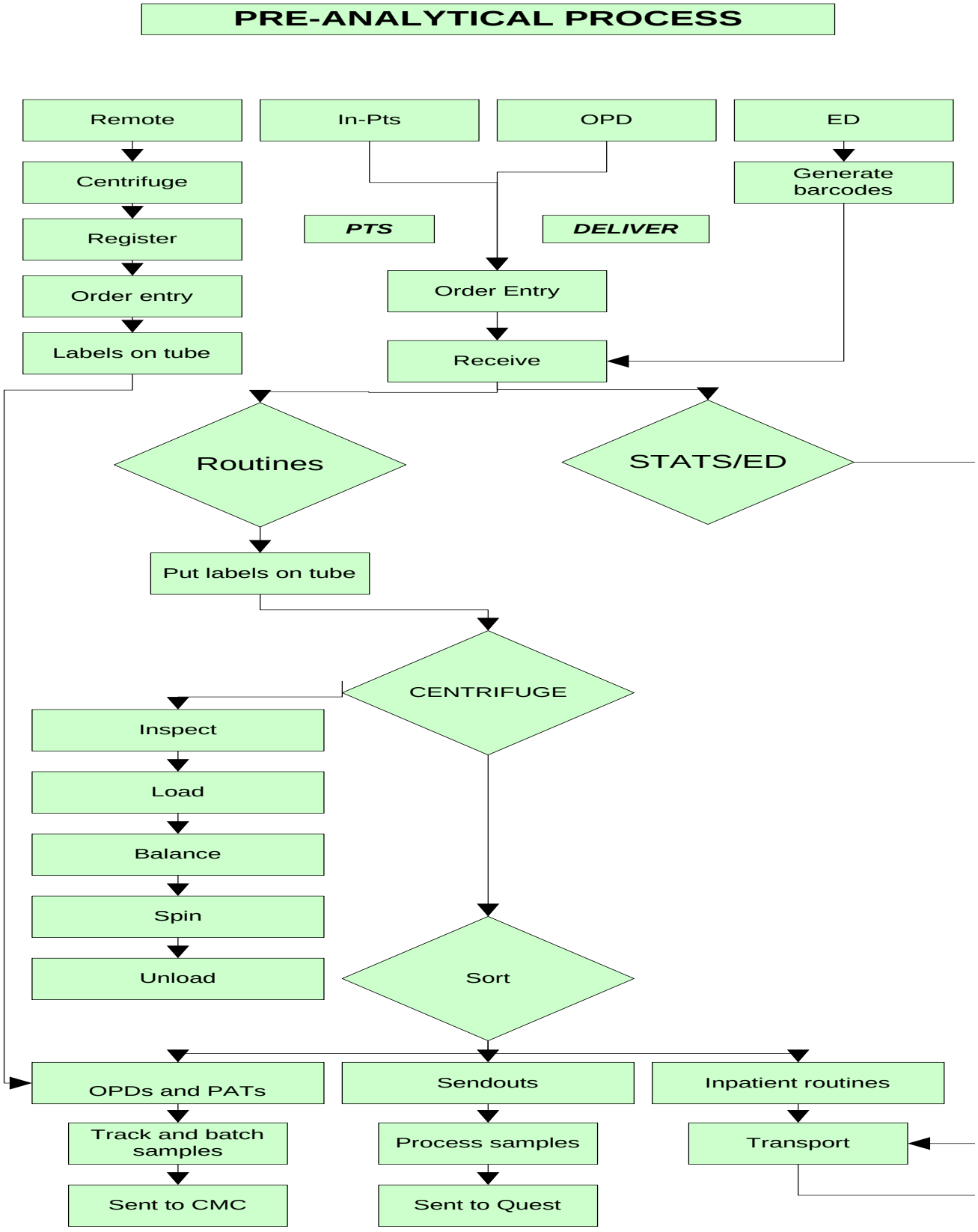

Figure 9: Example of a pre-analytical flowchart for a laboratory

- **Efficiency:** $efficiency = \frac{actual\ output}{input}$
- **Run-time:** Time required to produce a batch of parts→$time\ for\ 1\ unit * batch\ size$
- **Setup time:** Time to prepare a machine for use
- **Operation time:** $operation\ time = run\ time + setup\ time$
- **Throughput time:** $throughput\ time = time\ work\ done + waiting\ time$
- **Throughput rate:** output rate the process is expected to use over a period of time
  $throughput\ rate = \frac{output\ rate}{time}$
- **Value added time:** Time where useful work is actually done on a unit
- **Process velocity:** $process\ velocity = \frac{total\ throughput\ time}{value\ added\ time}$
- **Little's Law:** $throughput\ time = \frac{work\ in\ process}{throughput\ rate}$

Using and analyzing these concepts with data from the lab can help to understand the problem and to design to improvement.

VA-TAMMCS and DMAIC

In trying to improve a company's products and services, people turn to strategies and methods that target the improvement of processes. Confusion about what the problem is and how to solve it bring about methods which guide a company toward better understanding of the problem and how to find a solution. This leads to motivation to consistently use improved solutions without deviation and returning to the old ways of process production and delivery. The Six Sigma DMAIC process, a generic methodology, and VA-TAMMCS, a methodology specifically used for Veterans Affairs, are two different examples of process improvement methods.

Six Sigma is an organized improvement process widely used by large and small businesses. One aspect of Six Sigma is a measurement which reveals how much products and/ or services deviate from being perfect and having zero defects. In an ideal world it could be possible to achieve such perfection, but in real life situations, mistakes are bound to happen. Six Sigma tools help businesses reduce the number of defects in their processes. When zero defects are mentioned in Six Sigma, it statistically means the goal of defects per million opportunities should be 3.4. The main objective of Six Sigma is to realize that if a business can measure its number of imperfections then those imperfections can methodically be eliminated[11] .

Within the core of Six Sigma is DMAIC, which is a five step breakthrough strategy used to improve processes [11]. The acronym DMAIC stands for Define, Measure, Analyze, Improve, and Control. A business cannot start an improvement process without defining the process of the work flow from when customers request services to when the services are provided. The business must know what the most important features are for the customer, and where the defects are found in delivering the results. The process of the business must be measured in order to record data of services and products. Data analysis proceeds as soon as data is collected in order to formulate an educated assumption as to what causes the imperfections in the process. Once a business knows what the problem is and what causes those problems, an improvement plan is generated where changes to the original process are made. The new changes to the process are also measured in order to observe whether the defects have been removed. If the new changes did not improve or eliminate the defects, new changes can be

brought about. When the number of defects decreases or vanishes completely, the new improved process is monitored in order to assure that no changes occur. [11]

Another example of an improvement methodology is VA-TAMMCS, which was specifically developed for improving Veteran Affairs products and services [1]. The main goal for the existence of VA-TAMMCS is to improve services provided to customers. In order to provide such services, the environment (hospitals and laboratories) must be safe for Veterans to feel secure and for better care to be provided. Before a new process is made to upgrade the facility's services, the old process has to be examined to find which specific parts of the process cause disadvantages to providing better care for the Veterans. The professionals within the system have to be willing to try out new processes to examine which new processes provide the best outcome. This involves engaging professionals in their work, and discipline. In order for change to come about, VA-TAMMCS must be involved because it is the road to success and it makes sure that a new process will indeed be successfully implemented and be used throughout. [1]

The acronym of VA-TAMMCS stands for Vision, Analysis, Team, Aim, Map, Measure, Change, Sustain, and Spread [1]. In the vision step, the supervisor tries to target places in the process where an improvement of the services provided can be made. Analysis consists of closer observation as to which specific part of the process has to be changed and which part is priority. Upon completion of these two steps by the supervisor, a team of people within the system tries to formulate an improvement option. The team has to know its final goal. A mapping of the plan has to be laid out by the team in order to be aware of the necessary steps needed to arrive to the main goal. A measurement of the importance of the change has to be

made to determine whether the change will improve or worsen the process. Different changes will generate different outcomes; therefore the specific changes that result in improvements must be somewhat known. In order to see the improvements made, the changes must be sustained. Finally, the new improved changes need to be shared (or spread). By changing small portions of the system and guaranteeing its success before changes are administered, others are provided with what they need to know in order to improve services given. Supervisors cannot implement changes at once when a defect in the process is seen. The changes made have to be transformational and gradual. [1]

In comparing and contrasting DMAIC and VA-TAMMCS, both are used to target improvement of work flow within a company but they also have differences. VA-TAMMCS has four more additional steps than DMAIC which include team, aim, mapping, and spreading which are described above. This shows how specific VA-TAMMCS is in comparison to DMAIC. Both methodologies have initial steps; define (DMAIC) and vision (VA-TAMMCS), where an observation of the entire process has to be conducted in order to target holes within the process where problems originate. Analysis of both steps consists of narrowing down exactly where in the process the problem that is preventing the deliverance of either excellent products or customer service lays. The measurement steps explain the magnitude of knowing how heavily the new changes being made will impact both the providers and customers. The main goal of both methodologies is to improve work flow by eliminating waste steps not positively contributing to the results; therefore an improvement step, where ideas of how to efficiently and successfully deliver services, has to be present. Not only must the changes be

made, but they must be sustained or controlled to prevent employees from returning to the usage of old procedures.

In comparison, DMAIC is a general improvement methodology that is wide spread whereas VA-TAMMCS was specifically designed for use by the Veterans Affairs. If a company had a choice between choosing VA-TAMMCS and DMAIC, it should choose DMAIC because their work flow and services probably will not correspond to those of the Veterans Hospitals. The Veterans Affairs Department is dedicated to providing different types of services to both veterans and their families; therefore even though both methodologies target improvement, VA-TAMMCS is specifically designed to improve services provided to Veterans while any company may use DMAIC because it does not target a particular group of people.

Case Studies

Case Study 1

Because the technological and medical fields are constantly expanding and growing, there is frequent need for medical laboratories to be analyzed and methods of work flow modified to meet new demands and engage new technology. An analysis of how another laboratory updated their work space and increased their productivity provides a guideline or material for comparison for the proposed methodology for the laboratory is Bedford [10]. The location and identity of the laboratory improved upon were kept confidential, but the information shared was unedited.

The proposed plan for work flow improvement began with a statement of the main goals and the initial steps to begin identifying methods to achieve them. First was process

improvement, which was analyzed beginning by determining the current state, observing the factors that cause process delays, and suggesting changes for improvement. The second goal was instrument replacement, which required first identification of “bottlenecks”, a method to determine needs, and suggestion of which equipment would best meet the needs. Third was the consideration of automation, which involved a proposal of the best configuration of machines to optimize work flow.

To begin identifying both problems and solutions the team that worked on this project began with interviews and observations, analyzed the information, and then proposed solutions. They considered the laboratory was a system, and broke it down into three sections, pre-analytical, analytical, and post-analytical, the floor plan of the laboratory was considered as well. The pre-analytical section of the systems encompasses the collection, transportation, and processing of samples, while the analytical section involves the test menus, instruments, and locations of the instrument. Post-analytical processes include review, release, storage, and retrieval.

Next the group looked at laboratory as a system, but from the lean perspective, meaning that the current state of the laboratory was viewed strictly to find methods to increase workflow and do less work while still preserving the value of the work or results. A plan to identify and decrease NVAs (non-value added activities) and therefore eliminate waste was then developed. NVAs are activities that are not valued by the customer and absorb resources including labor, time, and materials. Some common laboratory NVAs are calibrations and maintenance of instruments, reagent preparation, sample proliferation (dividing one sample to

be used for multiple tests), and other activities such as de-capping, recapping, storing, retrieving, centrifuging, and sorting samples.

A breakdown of the percentage of time spent on sample collection, transport, pre-analytical processes, analytical processes, and post-analytical processes was then conducted. Table 1 shows the percentage of time a sample is involved in each process of the total processing time.

Table 1: Percent of total processing time each sample takes through each process

Process	Percent of Total Processing Time
Sample Collection	13%
Transport	13%
Pre-Analytical	27%
Analytical	20
Post-Analytical	27%

Observations noted from the pre-analytical process illustrated opportunities for improvement. Each process that impacted work flow had a proposed solution; examples include problems with waited states, shared printers, and high traffic areas or barriers. Waited states are cause by batching samples, and favored centrifuges, suggestions to improve these processes were implementing a policy to run the samples after only six were collected, and to

utilize the second centrifuge. A simple solution to the issue of shared printers was to purchase additional printers to give different areas easier access. The favored centrifuge issue was addressed by a suggestion to dedicate one centrifuge to a particular department to reduce demand.

The same process was used for the analytical processes, observations and improvements for each area of work flow impact were made. A few of the main areas of concern were high NVAs, workload imbalance, and loading samples one-at-a-time. The high NVAs were being caused by constant need for maintenance and calibrations, so a new machine with fewer calibrations was suggested for purchase. To determine whether the new instrument would indeed increase work flow, data for the amount of samples currently being processed in the laboratory per hour was collected, and graphs comparing the output from the new machine compared to the old machine were created.

For the most part, each of the opportunities of improvement for the analytical process involved purchasing new machinery because this work flow analysis project was also centered on selling new equipment for the laboratory. Diagrams mapping the current steps involved in the analytical process work flow were drafted and steps the new equipment would eliminate or condense were highlighted. Also a floor map was drawn up to show current wasted transportation time and a second was made to depict how the new set of machinery could reduce sample movement times.

The final component of the laboratory work flow breakdown was then addressed, the post-analytical processes. This part was also improved upon by suggesting a new machine that would eliminate the time wasted manually re-capping samples and locating samples.

Case Study 2

System redesign can be used on a larger scale, as described in this case summary. The Denver Health organization, which provides care for the majority of the city, embarked on a hospital wide system redesign project. Through Denver Health's thorough documentation of their processes, a multitude of information on wide scale system transformation is available. [10]

The report on Denver Health describes the components of the integrated system, the demographic of populations served, organizational aspects of the system, and information technology structure. For the Bedford Laboratory, the description would be considerably smaller, and considerations of demographics served would not be necessary because the interaction with patients is straightforward and health insurance is provided by the Department of Veterans Affairs.

Next the forces which lead to the need for system redesign were highlighted [10]. Many of these forces are related to this project being for an entire hospital, but some overlap with issues seen at the Bedford Laboratory include workforce shortages, employee dissatisfaction, continue rise in hospital costs, work hour limitations, and redundancies in care delivery process. The article then highlighted the key factors the transformation was designed to focus on.

The basic outline of Denver Health plan was as follows: assess readiness for major redesign, establish perspectives for redesign, create structure for redesign, gather external

(literature review, form committee, visit site) and internal data (observations, interviews, present data), and finally chose tools to enable redesign (tools to facilitate change in processes as well as environment). These steps are similar to the VA-TAMMCS model that will be used for the Bedford Laboratory, but are broader.

Following brief explanations of each of the steps for system redesign, the majority of the paper includes detailed discussion of each step beginning with assessing readiness. Before beginning a redesign process, it is important to determine if the facility is ready to commit to a transformation program. Denver Health considered the questions below in their assessment:

- What other redesign projects have been completed?
- What were the lessons learned from these projects?
- Does the workforce believe that there were benefits from implementing these projects?
- Is there a compelling reason(s) for redesign?
- Are top administrative, physician, and nursing leadership committed to redesign?
- Can champions be identified and developed?
- Is the culture committed to data and information sharing?
- Does the workforce have the needed skills and tools to accomplish redesign?
- Does the system have the resources to undertake the redesign process?

All of these questions are relevant to the Bedford Laboratory because they are broad and not project specific. For a redesign project to be successful all questions would need to be answered with yes, excluding the first two which would need to highlight the reason for failure of previous projects. The VA-TAMMCS model asks an almost identical set of questions.

Once readiness to begin the transformation is confirmed, the perspectives from which the redesign process will be viewed must be determined. The areas Denver Health decided to include were: quality, safety, customer services, efficient, physical environment, and workforce

development. The main focuses of the Bedford Laboratory vary considerably from these because of the smaller scale of the project. Currently at the laboratory, quality of results and safety are not of concern or the lab achieves high levels of both.

The Denver Health project looked to many other institutions for examples of successfully implemented system redesign/transformation and the processes used. Models they found included: Lean, Six Sigma, Institute for Healthcare Improvement's Pursuing Perfection, Baldrige Criteria, and Clinical Microsystems approaches.

This section also highlighted the importance of establishing an organization "culture" committed to the redesign program. To begin this they gave the project an identity, entitling it "Getting it Right: Perfecting the Patient Experience". Also an effort to continuously communicate the progress of the redesign and actively engage the workforce in the process was made.

Once perspectives were identified a structure for the redesign process was created using the three steps of establishing a leader, developing a team to oversee the planning approach, and developing a group of leaders and champions. This step on the process was quite similar to the Team component of the VA-TAMMCS. For the Bedford Laboratory the team was developed immediately but was much smaller considering the size of the project, and did not have a leader per say, but instead a group of leaders being the students.

Upon development of the structure, the gathering of external data began. First a literature review was conducted, focusing on redesign efforts. Next the formation of an external steering committee was completed. The large scale of the project allowed for a

committee which encompassed leaders from all perspectives of the hospital. This group was scheduled to meet quarterly to provide insight from all perspectives. Again because of the size of the Bedford Laboratory project, no such group is possible, but could still be beneficial if resources allowed it. Finally site visits were conducted, not to Denver Health, but to other types of industry to learn from their unique processes and methods. Other hospitals that were renowned or awarded were also observed.

The next step involved gathering internal data which was done by observation of current process, focus groups for employees and patients, and a presentation of the data. Denver Health is a large scale facility so focus groups were held within each department and each job title. Learning what issues employees encounter on a daily basis helps in prioritizing areas for redesign. Some of the cross-cutting issues identified included a need for streamlining of processes, need for more effective communication across departments, and desire for respect. Again because of the size of the Bedford Laboratory project there is not a need for focus groups, but talking with the workforce during observations to ensure their input is a priority. The patient focus groups' uncovered issues faced from the opposite side of the spectrum as well as confirmed that the patients desired to become active participants in their care. Limitation on the clearance for the Bedford Laboratory prevents patient questioning, but currently patient satisfaction has not been an issue at the laboratory.

It is essential to not only hear how the processes are currently being conducted from the patients and workforce, but to also observe the processes and map them. At Denver Health each observation included collection of the following data

- Name of process
- Process owner
- Process output/product
- Who is involved in delivering the process
- Who cares about the process
- Extent of the process to be mapped
- Activities that define the process
- Start point
- End point

Following observation it is important to create process-flow maps, which can be done in a multitude of ways. By documenting events it becomes easy to identify non-value-added times, bottlenecks, redundancies, points of dissatisfaction, and inefficient use of workforce skills.

The next portion of the Denver Health document focuses on different ways to present data to show the current problems. First the data collection tool used to gather information for describing processes was shown. This chart shows the process a particular staff member completed with start and end times, as well as how long the process took to complete. It also includes who the staff member interacted with, the category of the activity, and notes on the activity.

Time and type of activity are the main methods to measure processes, therefore there are many way to depict these types of data including: pie charts, pareto diagrams, value stream mapping, area diagrams, and top down formatting. Pie charts are allow simple depiction of how much time, as a percentage of one shift, are spent on each activity. There are also many other percentage break downs that can be shown through pie graphs in relation to the Bedford

Laboratory, such as which department has the bulk of the workload or which time of the day traffics the most samples. Pareto diagrams are bar graphs that display the activities arranged in order from largest to smallest, from a time perspective. These diagrams can show the components of each bar broken down as individual activities that in total make up the entire bar. This creates an illustration of the total number of activities and total number of interruptions.

When focusing on the staff movement through a facility, an area diagram is useful for depicting the unnecessary travel. The geographic area is shown on the diagram and lines represent the distances traveled by a worker, with start locations indicated by circles. Top-down format maps are similar to area diagrams but show all the workers involved in a process. It depicts the different activities and people involved in completing a process. This diagram shows the number of handoff and how many types of staff members are involved in the process, identifying inefficient use of the workforce. One of the issues the Bedford Laboratory encounters is confusion on who's responsibility it is to complete certain tasks, creating maps such as the area diagram and top-down format could be used to show who would create the most efficient work flow regarding certain tasks.

After both external and internal data have been collected and key areas for improvement have been identified, the next step of the redesign process is to choose the tool to enable redesign implementation. Identifying the tools to be used is helpful and can be categorized into tools that facilitate process change and tools that facilitate change in the workforce.

One of the simplest models for testing ideas in rapid cycles to create improvement is the Plan, Do, Study, Act (PDSA) model [10]. Before attempting to make improvements though, it is important to ask these preliminary questions:

- What are we trying to accomplish?
- How will we know that a change is an improvement?
- What changes can we make that will result in improvement?

Once these questions have been addressed the first step in the model is plan. This step involves determining who will be completing what work and by when, what training will they need, how will the information for assessing success be collected, and when will the process be reviewed. It is crucial to check that the predicted improvement has actually happened. After creating a plan the next step is to do the plan. Next, the study step dictates that the information be collected and be analyzed to determine if the desired outcome occurred, and if not what the actual outcome was. The final step is then to act, determining what action needs to happen as to whether to continue using the change, stop using the change, or make adjustments and begin the cycle again. All these steps can be linked back to the VA-TAMMCS and the DMAIC methodologies which use a similar approach.[10]

Another common model for determining change is Lean production which is a method focusing mainly on working more efficiently and effectively while providing for customers, or in this project, patients. When fully utilized, lean provides a set of tools that aim to eliminate waste from processes; it also centers on the parts of the processes that add value, from the customers' perspective. The ten rules of Lean production are:

1. Removed Waste
2. Reduce Inventory
3. Increase Flow
4. Pull production from customer demand
5. Meet customers' needs
6. Complete task correctly the first time
7. Empower workers
8. Designs have rapid changeover
9. Work closely with suppliers
10. Create environment for continuous improvement

Lean tools produce outcomes that maximize efficiency, quality, and customer service. For these tools to be used successfully, the entire workforce within an organization must be required to become involved and stay committed to the changes.

Upon completing initial changes in processes, tools to facilitate change in environment, culture and workforces must be implemented in order to ensure continuation. One program commonly used to provide a business framework as well as the tools to help improve performance is the Baldrige Criteria for Performance Excellence. With a main focus of delivering better value to customers, the program is customer and process based for it works to improve organizational processes. Core values include visionary leadership, patient-focused excellence, organization, personal learning, valuing staff, focus on the future, focus on results, and creating value from all perspectives.

A second program for continuation of improvements is the work developed by Dartmouth College, called Clinical Microsystems. This approach centers on the smallest replicable unit that actually conducts work, the unit includes the people, information systems, clients, space, and work design. Clinical Microsystems are the small frontline units that provide

the majority of the health care to the patients and together these smaller units form the larger healthcare system. The principle behind this is the larger system can only be as efficient as the small units it is composed of. The toolset used in these systems is called the “5Ps” (Purpose, Patients, Processes, Professionals, and Patterns).

A unique approach for improvement focuses not on the processes but the workers completing the processes. Talent profiling focuses on matching the right person with the right job, based on the talent characteristics of each person and the necessary characteristics needed to fulfill a role.

The final section of the Denver Health document summarizes system metrics which are crucial in determining if the processes changes implemented during redesign have actually improved the system. From the initial perspectives that were chosen at the beginning of the process, metrics can be developed for the system. It is important for the system measures to be defined before the project is started for this enables the accurate determination of whether the measurement truly reflects the desired outcomes and if the data available is able to be measured. Baseline data, pre-project, is also needed to evaluate the effectiveness of the change.

Chapter 4: Methodology

The goal of this project was to maximize work flow by observing the overall process adding to lead time in the laboratory at the Veteran's Hospital in Bedford and to eliminate issues that negatively impacted the efficiency of the work flow. The VA-TAMMCS methodology was used to optimize the process in order to efficiently provide services. This methodology was used because it is extremely specific as to what steps need to be completed in order to observe improvement, and with the type of regulations and confidentiality required within the laboratory, VA-TAMMCS was the best solution for exploring the issue being faced by the laboratory. Before observations of the process were gathered, and before attempting to determine the root of the problem, objectives were developed to guide us through the project. After defining objectives which guided where the team wanted to go with the project, the VA-TAMMCS methodology was then followed.

Objectives

The specific objectives defined for the project were to:

- Determine the issues within the process which are preventing the delivery of better customer service, such as producing test results in a timely manner
    a. Most of the problems lie within the pre-analytical portion of the process
- Calculate:
    a. number of incoming samples
    b. type of samples (urine, chemistry, or hematology)
    c. arrival time for the samples
- Explore tools that support different analyses, including:
    a. Efficiency
    b. operation time
    c. value added time
    d. Microsoft Visio
    e. Microsoft Excel

- Develop recommendations to show how to improve the process and work flow in the laboratory

In developing ideas for improvement, multiple problems within the process of producing laboratory results and providing excellent customer service were brainstormed.

Vision

In the first step of the methodology, we focused on defining a vision. A visual observation of the complete process was conducted and the team determined to focus on the pre-analytical portion of the process. Processes of incoming samples from CBOC's, inpatients and outpatients were observed in the pre-analytical portion of the process. In the process, the different urine and blood samples coming into the laboratory have to be identified to make sure the correct tests are being conducted on the appropriate sample. Labels informing the employees of whom the patient is and the tests that have to be conducted are made for each sample that comes into the laboratory. This process of accession is needed in order for the machines to read the "barcode" and perform the specific test needed for that particular patient. With the help of the Laboratory Supervisor, Mari Ann Amador, and the Improvement Advisor, Abigail Krinsky, we were able to observe the complete process and gain knowledge about which steps belong to each stage of the process.

Analysis

Analysis of the observed process was conducted in order to identify where the main problems within the three different components of the process - pre-analytical, analytical, and post-analytical- lay. The pre-analytical portion of the process was/is where most problems lie. After accession (pre-analytical work) takes place, samples are placed in racks, waiting to be put into the machines to produce results. A brainstorm of the different problems, all falling under the pre-analytical stage, being faced by the laboratory can be found in Table 2:

Table 2: Problems within the Veteran's Hospital in Bedford

PROBLEMS
Disrupting incoming and outgoing phone calls
Increased number of samples being received but constant number of employees
Delayed arrival of CBOC'S samples
Duplicate orders
Incorrect samples being tested or incorrect test being conducted on samples
Increase number of pick up from phlebotomists or chemists
Tools or supply search
Extra processing of paperwork
Lost or misplaced sample
Non retrievable samples due to spillage/ leakage
Unacceptable sample due to incorrect labeling

Team

The third step in the VA-TAMMCS process is to develop a team. Our team included the Laboratory Supervisor, Mari Ann Amador, the Improvement Advisor, Abigail Krinsky, and the IQP students (Burak Birand, Darcy DelDotto, and Michelangela Yusif). Both the Laboratory Supervisor, Mari Ann Amador, and the Improvement Advisor, Abigail Krinsky provided us with necessary information regarding improvement methods, number of incoming samples, statistics on samples, and power point slides showing examples of ways to optimize work flow. The IQP students had to review all the information given and the data being collected in order to generate possible changes or suggestions that would help the Bedford Laboratory maximize their work flow.

Aim

The team developed the following overall aim for the project: providing a larger work area, decreasing the number of distractions, and providing reliable system that could potentially eliminate some steps involving accession of samples from CBOCs. To improve work flow, in order to provide better customer service, by specifically targeting one or more of the problems listed in Table 3 was the ultimate goal. We determined **w**hat happens between accession, last pre-analytical step, and the analytical procedure for the three different types of samples. We focused on incoming and outgoing telephone calls, space limitations, and sample flow because these three issues were stressed by the employees and the Laboratory Supervisor. They were seen as the most significant problems faced within the pre-analytical stage of the process, and

through thorough observations and analysis of the issues we were able to suggest possible changes.

Mapping

The entire process was mapped, as shown in Figures 2 (Pg. 4), 3(Pg. 6) , 5(Pg. 9), 6(Pg. 11), 7 (Pg. 12), and 8(Pg. 14). The different stages (pre-analytical, analytical, and post-analytical) within the process were established along with problems within the pre-analytical phase of the process.

Measure

A measurement of value added time for the sample flow was conducted by calculating the amount of time each sample, depending on where it came from, spends in the tube racks before they are examined, and how many samples are examined by each employee within an hour. A chart analysis was developed in order to observe where the wait time occurred. In addition to the sample flow measurement, a log of incoming and outgoing telephone calls was kept. The telephone log consisted of the type of phone call (incoming or outgoing), time the call was made or received, the duration of the call, and the amount of time it took the technologist, who answered the call, to regain the same attention level as before he/she was interrupted. Microsoft Excel was then used to produce bar graphs correlating the work load for the sample accession time with the number of incoming and outgoing phone calls. In terms of space limitations, no measurements were conducted but observations of the work area were

made. Through the observations made, possible suggestions were made and portrayed through the use of Microsoft Visio.

Change

During the course of the project many changes were made in the laboratory which brought this project closer to its main goal of maximizing work flow. The purchase of a new analyzer was made in addition to a larger refrigerator, and a faster centrifuge. All these new purchases increased the efficiency of the process because through the purchase of the new analyzer, more tests were conducted at within the Laboratory as opposed to having to send the sample out to a different destination. This of course allows for the technologist to focus on producing results for these samples as opposed to preparing them for delivery in a different facility. The purchase of the refrigerator eliminated the usage of two separated fridges in the lab, which adds to the limitation of space, yet still providing enough storage for samples. With the purchase of the new centrifuge, samples are spun in a decreased amount of time which gives more time for the technologist to effectively produce results. Suggestions and possible changes were suggested for each area (telephone call interruptions, limitation of space, and sample flow) focused on, which can be found in the upcoming sections on pg. 50, 55, and 63.

Sustain and Spread

Once the changes are made and implemented, they must be followed in order to prevent the technologists form retracting to the old ways of following the procedure. Technologists should be informed of the benefits the changes made will bring for this allows for the technologists to easily adopt the new changes. Upon implementation of the new changes, results of the changes should be made in order to observe whether the changes made positively or negatively impacted the work flow. When the latter step is determined, the knowledge learnt from the changes made should be spread whether they were a positive or negative impact. If they did positively impact the work flow another facility or company might want to use the same or similar changes and if a negative impact was identified, it would prevent another facility or company to make the same changes.

Chapter 4: Results

Within the following chapter, the three main focuses of telephone log, space limitations, and sample flow are discussed in terms of mapping, measuring, possible changes, and sustaining the changes made which will aid in accomplishing the goal of efficiently maximizing the work flow at the Bedford Laboratory; the latter was done by recommending possible suggestions for improvements. After becoming familiar with the various processes at the laboratory, CBOCs, chemistry, urine, hematology, and phlebotomy, a goal was set to streamline these processes as much as possible. Decreasing the amount of phone call interruptions, increasing the amount of space within the work area, and minimizing the number of steps in the processes were ultimately the final goal.

Telephone Log

Aim and Map

The number of incoming and outgoing phone calls in the chemistry in the laboratory is the aim or focus for this section. The latter is considered a problem due to its possible negative impact on the work flow. Mapping of the accession process can be found in Figure 3 (pg. 6) which is the portion of the pre-analytical stage where the most incoming phone calls are received and outgoing calls are made.

Measure

In trying to confirm how incoming and outgoing phone calls affect the pre-analytical part of the process, a phone log was recorded. By recording the data, we were able to determine approximately how many phone calls were received or made during the busiest times as opposed to the down times. Tables 3 and 4 below show the phone logs collected from the chemistry lab starting from September 5, 2011. Both incoming and outgoing calls were collected in addition to the duration of the phone call, time call was made or received, and the amount of time it takes the employee to regain the attention they had prior to the interruption. It has been documented that it takes approximately 20 to 25 minutes to regain the same amount of concentration after being interrupted [2]. Table 4 shows the total amount of time spent on the phone and total time to regain attention, only for November 30, 2011. The data do not suggest that a significant amount of is being spent on the phone, which suggests phone calls are not the main issue in work flow. This is not to state that phone call interruptions are beneficial to the work flow but it does not severely impact the work flow since it all depends on the amount of incoming calls received or outgoing calls made. In order to see the effects phone calls make on the work flow, a graph correlating the sample accession time of August 22, 2011 with the amount of outgoing and incoming phone calls received over a five month period is shown in Figures 10 and Figure 11, respectively. Data from Tables 3 and 4 were used for the bar graph and a line graph was produced from data provided to us by the Laboratory Supervisor, Mari Ann Amador; all the times recorded were converted into seconds.

Change

Improvements in terms of phone call interruptions are difficult to make as stated because most outgoing phone calls are essential since they are usually made to ask clarification questions about a specific sample. Because they are focused on the work being done, when looking at the time spent to regain attention, it does not take the employees a long time to regain attention. What also affects work flow is having a delayed response from another party in regards to the specific sample being worked on. If, for example, a nurse has to return a phone call to the employee at the lab in order to give requested information, it leads to a prolonged and inefficient work process. Due to its uncontrollable nature, there is not much that can be done to decrease the amount of incoming calls. A possible option would be to try and manage the conversation since the incoming phone calls cannot be controlled but the content of the conversation can.

Table 3: Data collected on incoming and outgoing phone calls

Date:9/21/2011	Start time: 10:20AM		End Time: 11:50AM
Call Number	Call Direction	Call Duration	Call time (AM)
1	-	30 sec	10:23
2	-	4 sec	10:32
3	+	1 min 25 sec	10:46
4	-	1 min 5 sec	10:49
5	-	1 min	10:56
6	-	36 sec	11:09
7	+	20 sec	11:14
8	-	10 sec	11:39
9	-	15 sec	11:42
10	+	45 sec	11:45
Total time spent: 6 minutes 10 secs			

Date:10/5/2011	Start time: 1:20PM		End Time: 2:50PM
Call Number	Call Direction	Call Duration	Call time (PM)
1	-	45 sec	1:27
2	-	50 sec	1:45
3	+	3 min 15 sec	2:25
4	-	2 min 40 sec	2:36
5	-	1 min 35 sec	2:41
6	-	40 sec	2:44
7	-	55 sec	2:46
8	-	1 min 55 sec	2:47
Total time spent: 12 minutes 35 secs			

Table 4: Data collected on incoming and outgoing phone calls including time spent to regain previous attention level by employee

Date:11/30/2011		Start time: 1:04PM	End Time: 2:50PM	
Call Number	Call Direction	Call Duration	Call time (PM)	Regaining previous level of attention
1	-	40 sec	1:16	15sec
2	-	2min	1:42	30sec
3	+	15min	1:55	10sec
4	+	1min	2:01	30sec
5	-	30sec	2:27	5sec
6	-	25sec	2:36	2sec
Total time spent: 19 minutes 35 secs			Total time in regaining attention: 1min 32 sec	
Date:12/7/2011		Start time: 12:07PM	End Time: 2:50PM	
Call Number	Call Direction	Call Duration	Call time (PM)	Regaining previous level of attention
1	-	1 min 25 sec	12:10	10sec
2	+	30 sec	1:07	5sec
3	+	30 sec	1:15	5sec
4	+	1min 15 sec	1:23	3sec
5	-	50sec	2:07	15sec
6	+	40sec	2:09	30sec
7	-	35 sec	2:16	4sec
8	+	1 min	2:21	7sec
9	-	37sec	2:25	3sec
10	-	1 min	2:34	4sec
11	+	45 sec	2:38	2sec
Total time spent: 9 minutes 7 secs			Total time in regaining attention: 1min 28 sec	
Date:01/19/2012		Start time: 11:15AM	End Time: 11:58AM	
Call Number	Call Direction	Call Duration	Call time (AM)	Regaining previous level of attention
1	-	7 min 15 sec	11:26	5sec
2	+	2min 6 sec	11:41	21sec
Total time spent: 9 minutes 21 seconds			Total time in regaining attention: 26 sec	
Date: 01/24/2012		Start time: 11:10AM	End Time: 11:55AM	
Call Number	Call Direction	Call Duration	Call time (AM)	Regaining previous level of attention
1	-	55 sec	11:17	3sec
2	-	30 sec	11:18	3sec
3	-	10 sec	11:20	5sec
4	+	45 sec	11:24	4sec
5	+	1 min 10 sec	11:54	15sec
Total time spent: 3 minutes 30 sec			Total time in regaining attention: 1min 32 sec	

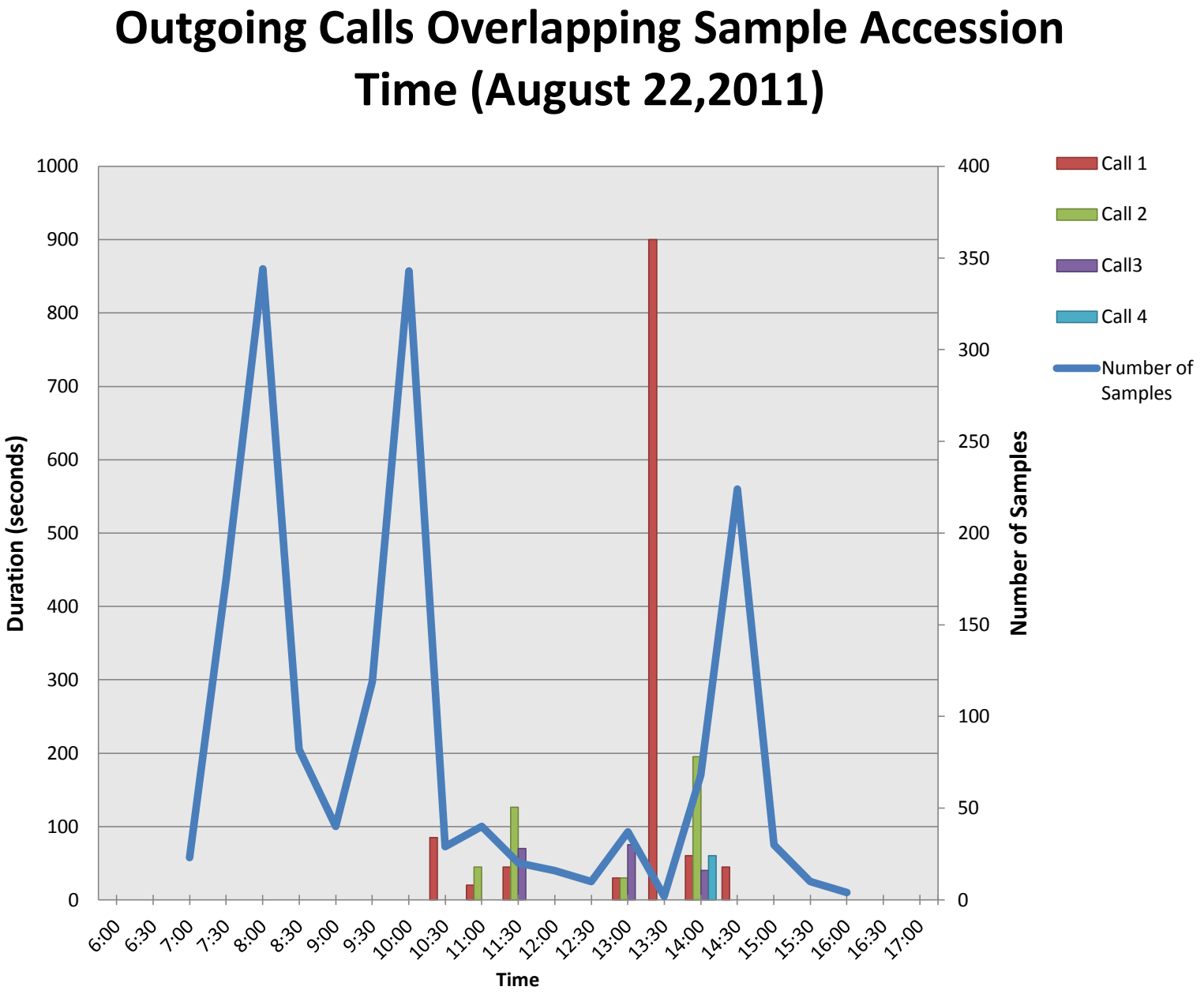

Figure 10: Bar graph of the outgoing phone calls overlapping sample accession time of August 22, 2011

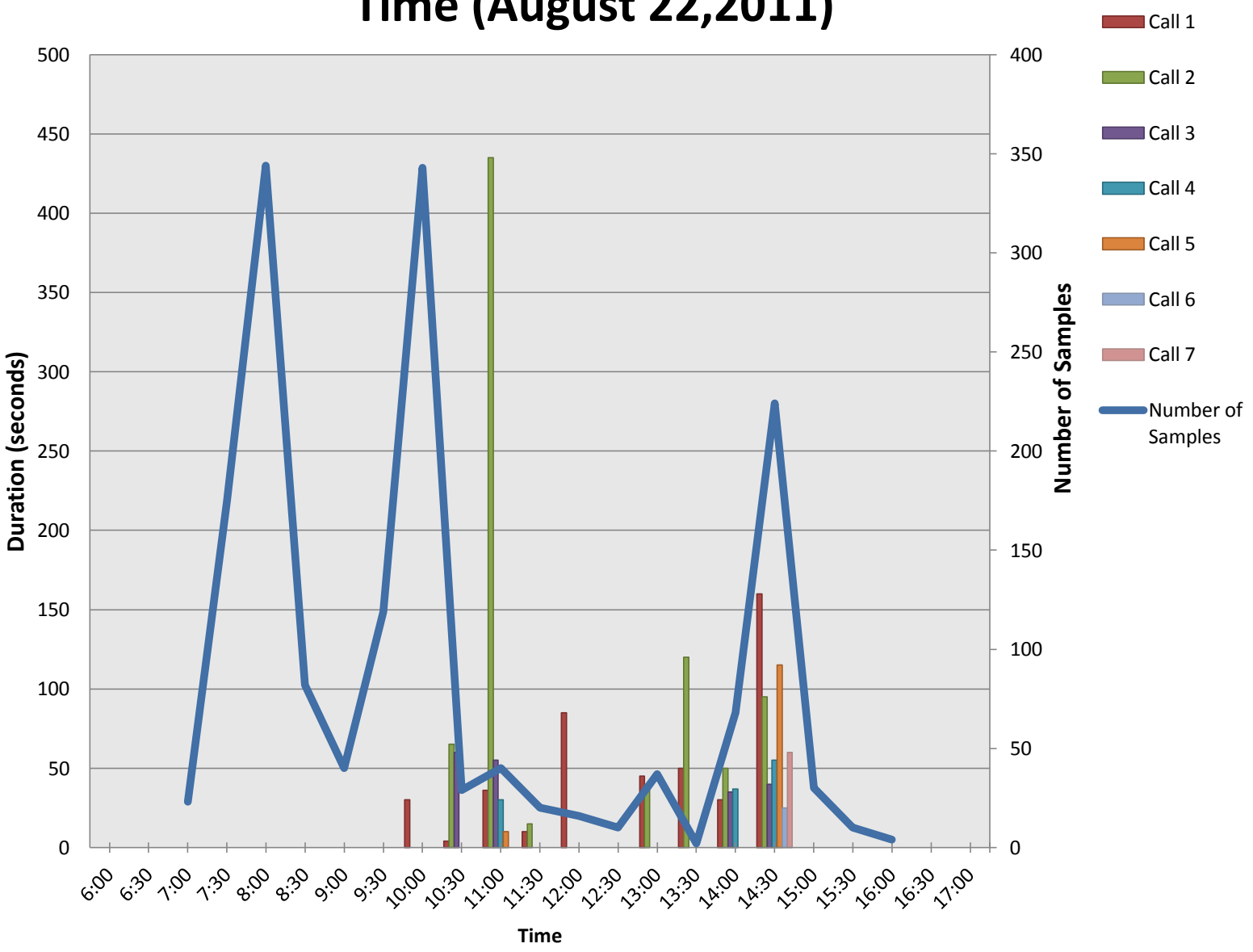

Figure 11: Bar graph of the incoming phone calls overlapping sample accession time of August 22, 2011

Work Space

Aim

The limited amount of space within the laboratory is the aim or focus for this section. The latter is considered a problem due to its possible negative impact on the work flow.

Map

Based on observations, the amount of space within the laboratory also proved to be a problem, mostly affecting the pre-analytical portion of the process. The limited amount of laboratory space is both an advantage and a disadvantage for process flow. From an advantage point of view, there is less of area to cover, therefore transporting a sample from the chemistry lab to the urinalysis lab takes a shorter amount of time. From a disadvantage point of view, with a limited amount of work area for the employees, there is a decrease in work flow. For example, not all the employees can work on the benches because there are only two benches where samples can be placed, and this in effect decreases the amount of samples that can potentially be examined if there were a larger work area.

A system which is more likely to solve the clutter in the laboratory is the 5S System, which is a methodology used to better-organize and clean a working environment for a company. This system was used to inform what can be changed after observations were made in terms of space. The latter system comes from the following five Japanese words which include Seiri, Seiton, Seiso, Seiketsu, and Shitsuke which mean sort, set in order, shiny clean, standardized clean up, and sustain, respectively [9]. The first step for a better-organized work environment is sorting. This step requires the team to remove unnecessary objects in the work area in order to reduce wastes. This allows for additional space and less clutter [5]. If there is

uncertainty about whether something should or should not be discarded, a red tag should be placed on the object in order to note the amount of usage. If the red-tagged item is not used within a month or a designated period, it subsequently is not needed in the work area and therefore needs to be discarded. In removing objects from the work place some simple items such as broken tools that will not be repaired, outdated spare parts, and documentation should be the aim.

In setting things in order, each item must be placed in their adequate spaces with the most used items in close proximity over the items which are slightly used. All working tools should be kept close to their corresponding work related stations, along with minimally used items stored in an easy accessible area.

Third, “shiny cleaning” has to come into effect. The two main goals involved in this stage include establishing a certain level of cleanliness and discovering innovative methods to follow in order to keep order in the workplace. Some ideas to keep in mind are safety, easy utilization of items, and maintenance issues that have been ignored for an extended amount of time. The main question that should be thought about in this stage is how the better-organized workplace will improve the services provided. [10]

In the “standardized clean-up” stage, the team should focus on ways to make the first three steps easily followed [5]. A technique to remind employees to use the new methods to keep organized is by posting up signs, labels, or banners in the workplace or a bulletin board [5]. An agenda or a binder should be kept with descriptions on how each work area should be cleaned, and a checklist of all the things that need to cleaned in that area within a specific

period. The latter will make each employee have a responsibility to maintain a certain level of organization in their work space.

The last step, sustain, involves an implementation and a regular check up from the supervisor in order to assure the constant use of the checklist and the upkeep of the reorganized workplace [10]. Through this last step employees will be able to learn the beneficial results acquired from the improved workplace [7].

Change

Because of the limited amount of space in the lab, several recommendations as to possible changes to re-organize the place using 5S are mentioned below with description of designated hallways.

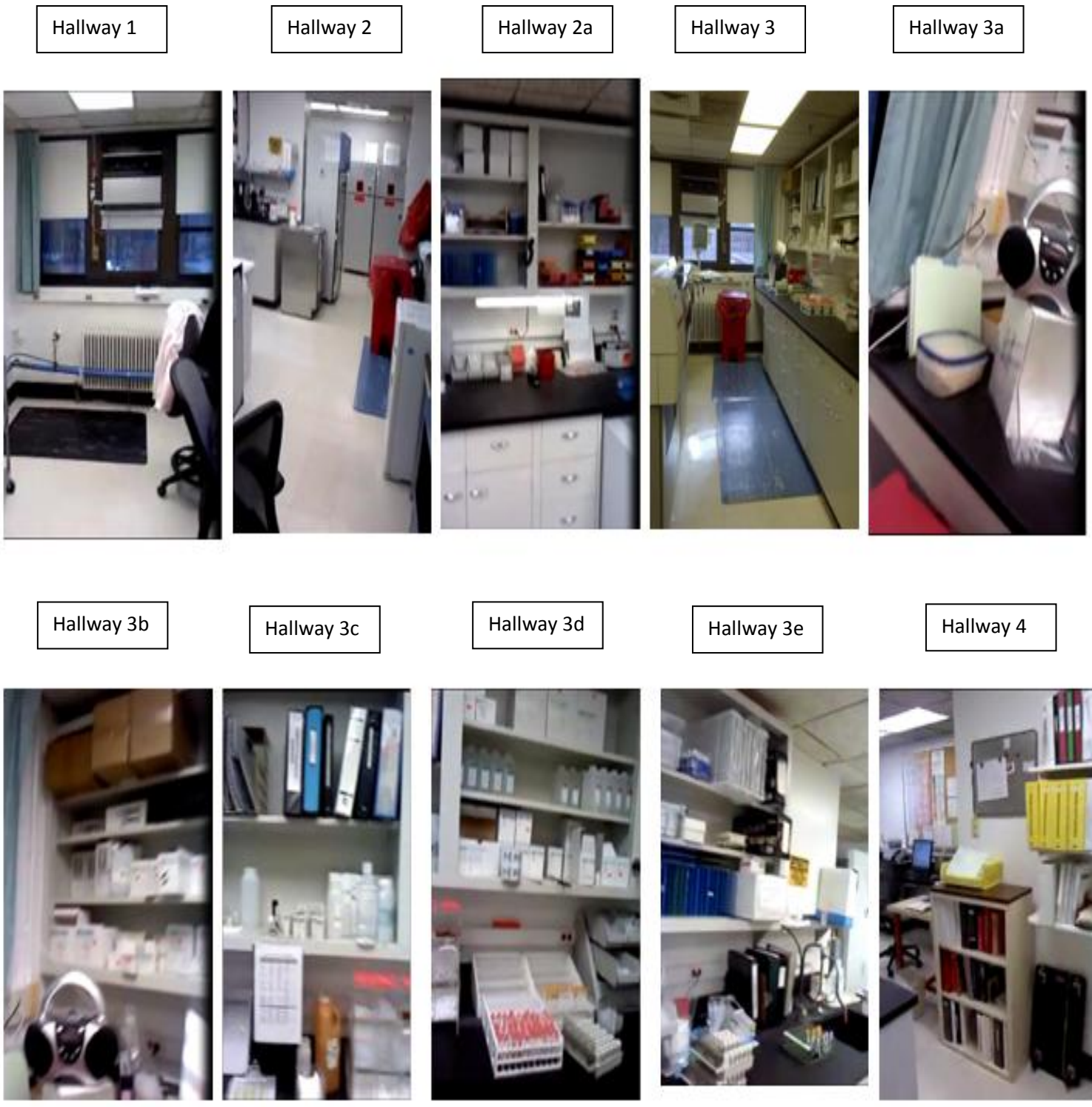

Figure 12: Pictures of the designated hallways in the laboratory

In order to clearly understand the suggestions mentioned through the 5S system, a Microsoft Visio picture of the laboratory was made.

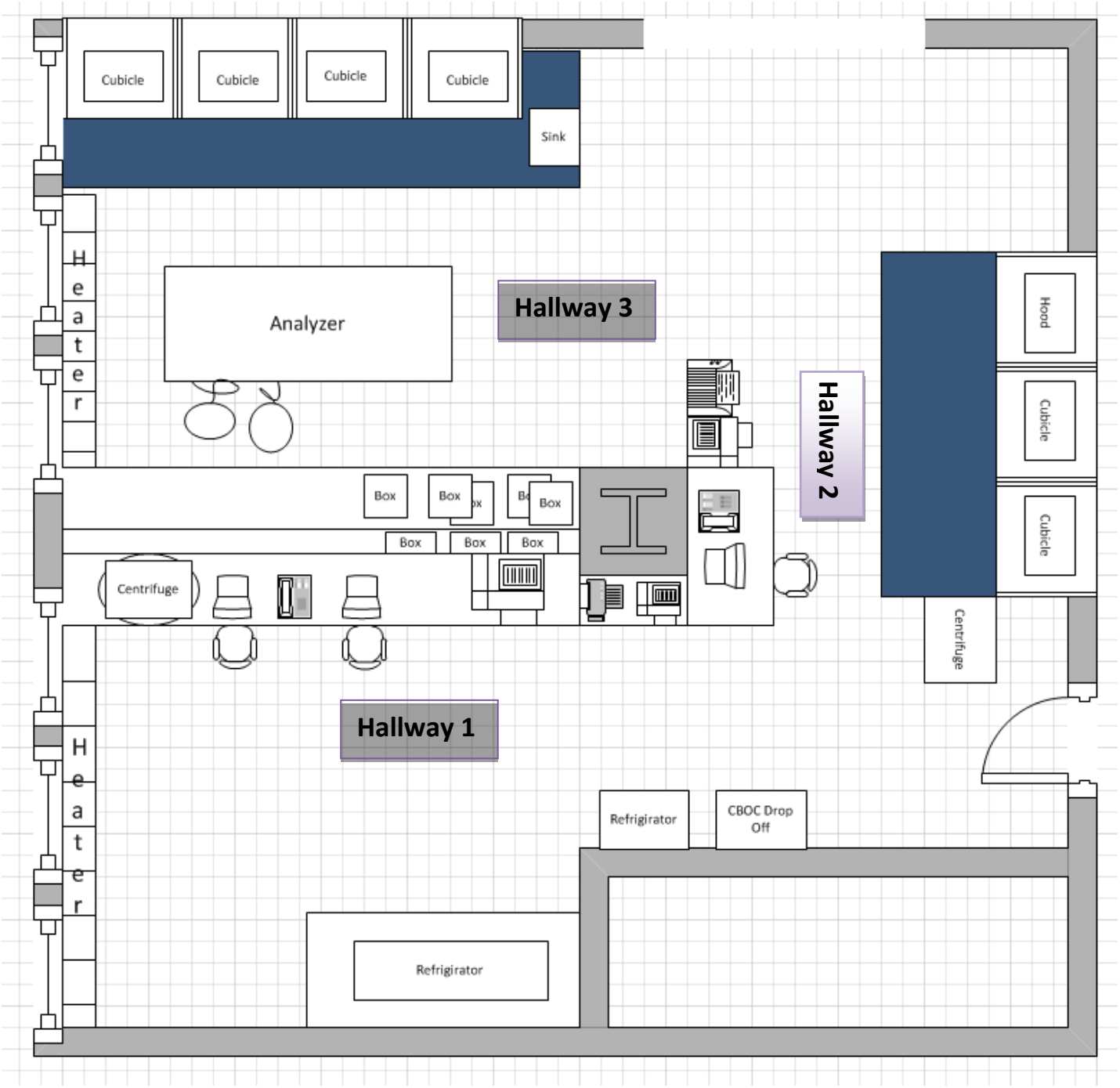

Figure 13: Chemistry laboratory as it is now

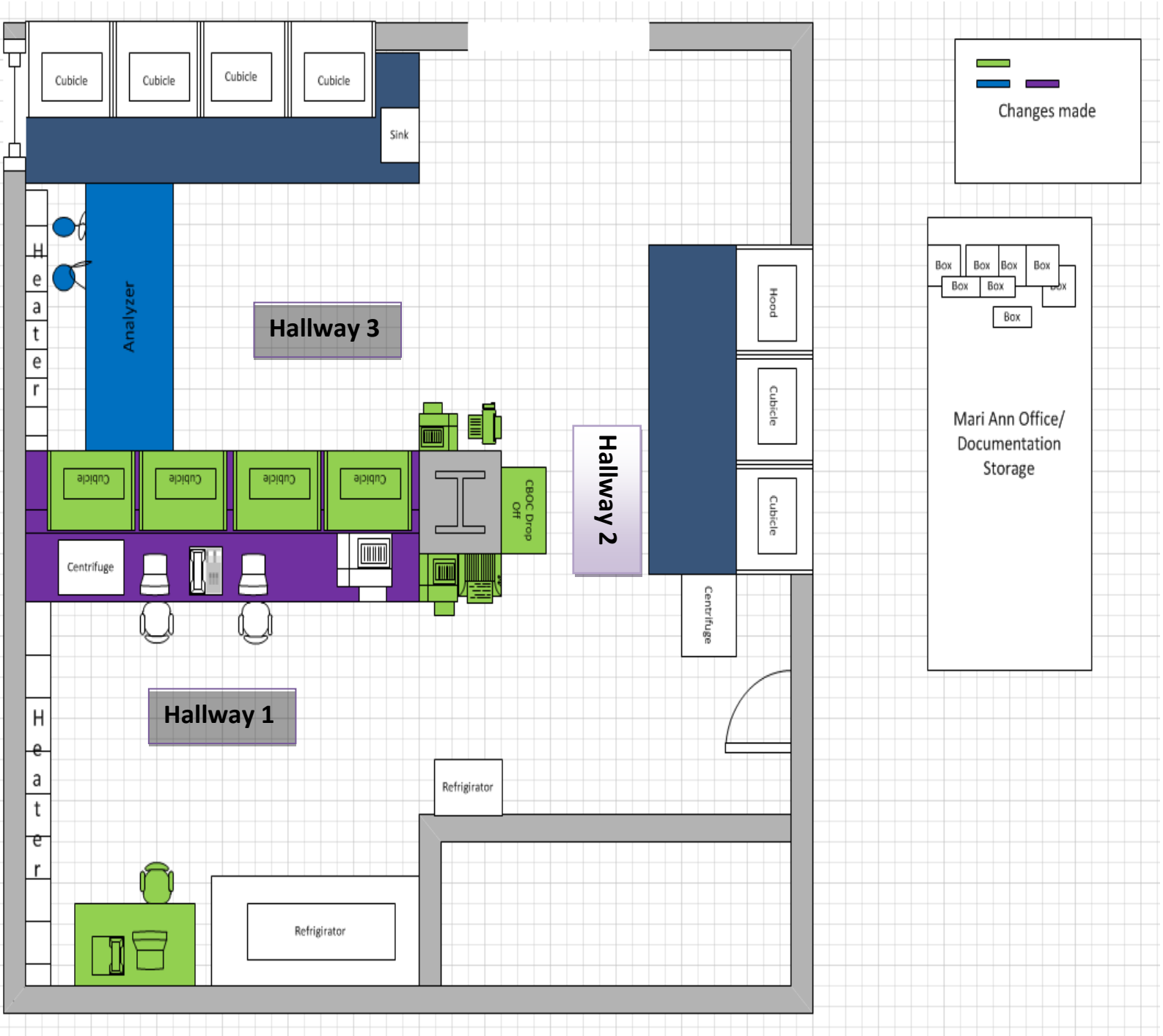

Figure 14: Future outlook of the Chemistry laboratory after the implementation of suggestions

In following the first two steps of the 5S were used to generate suggestions for improving organization in the laboratory:

Seiri: sort

- Remove of unnecessary objects in the work area in order to reduce waste; this allows for additional space and less clutter
- Suggestions:
    - Move the big bench with the computers to the left, remove boxes with documents, rotate chemistry analyzer machine so that it is facing Hallway 2, additional space will be on the left bench (Figure 13 compared to Figure 14)
    - Moving boxes on the bench with two computers gives room for a "cubicle" to be built which would include shield, cap holders, and additional space to hold solutions and buffers (Hallway 3 Figure 13 compared to Figure 14)
    - Long beakers and short ones on top of sink can be put away (Hallway 3e in Figure 12)
    - Red biohazard bag hanging from hood can be moved down and put into a bin (Hallway 2 in Figure 12)
    - Again in Hallway 2, coolers in front of the hood can be moved to where the CBOC's arrival stand will be which is where "Ed's station" is now (Figure 12)
    - Cartridge for fax machine can be moved under the fax machine in one of the cabinets (Hallway 3e in Figure 12)

Seiton: set in order

- Tools or equipment must be placed in their adequate spaces. The most used items should be kept in close proximity over the items which are slightly used

Suggestions:

- Purchase two gray holders which would contain test tube caps to be placed
    - Under bench shield in Hallway 3
    - Under bench shield Hallway 2
- Each of the four cubicles in Hallway 3 should contain(Figure 12):

        - Binders, ink for printers
        - Racks
        - Solutions and Buffers
    - Tupperware and green file can go in drawers or cabinets (Hallway 3a in Figure 12)
        - Box behind radio can be moved in order to put gray holder in it
    - CBOC'S arrival station should be moved to where Ed' station is right now (Figure 13 compared to Figure 14)
        - Bigger refrigerator will be coming which would eliminate the 2 refrigerators in Hallway 2 (Figure 12)
    - Move "Ed's desk/station" to across Rita's computer (Figure 13 compared to Figure 14)
    - MSDS shelves can be moved "on top" of cabinet on its left in Hallway 4 (Figure 12)
    - Each of the two cubicle in Hallway 2a should contain (Figure 12):
        - Racks
        - Binders, boxes, Styrofoam bags, racks with paper on them
    - Printers and container where documents with confidential information are disposed can be moved from Hallway 2 to Hallway 1 (Figure 13 compare to Figure 14)

Changes cannot be sustained by the whole team but only a portion, which includes mainly the Laboratory Supervisor, Mari Ann Amador, the Improvement Advisor, Abigail Krinsky and the technologists in the laboratory. Some recommendations that might facilitate the process would be to follow the remaining three steps of the 5S system:

Seiso: shiny clean

- Establishing a certain level of cleanliness and discovering original innovative methods to follow in order to keep order in the workplace

- Ideas to keep in mind include safety, easy utilization of items, maintenance issues that have been ignored for an extended amount of time
- Main question: how will the better-organized workplace improve the services being provided?

Seiketsu: standardized clean up

- Team should find a way to make the first 3S terms easy to follow
- Techniques include reminding employees of new methods to keep organized are posting up signs, labels, or banners in the workplace or a bulletin board
- Examples could be keeping an agenda or a binder with descriptions on how each work area should be cleaned, and a checklist of all the things that need to cleaned

Sustain

Shitsuke: sustain

Implementation and regular check up from the supervisor in order to assure the constant use of the checklist and the upkeep of the reorganized

In terms of space, as stated above, a checklist of should be made and kept by both the Laboratory Supervisor , Mari Ann Amador, and the technicians. This checklist can contain what should be on bench area, appropriate cleanup of spills, and removal of any unused equipment or tools. This checklist should be followed by the technicians at least once every two weeks, and should be approved by Laboratory Supervisor, Mari Ann Amador, every month.

Sample Flow

Map

The mapping process of the sample flow has been explained in detail in the first four sections of the Background Chapter. Figures 2, 3, 5, 6 and 7 illustrate the flow of samples from their various initial locations to their processing in the three departments of the laboratory.

Measure

The measurement tool used to determine productivity of the various departments was process observation worksheets. These forms track the amount of time various steps in the processes take, as well as monitor wait times where samples are not being attended to, and note the locations the samples travel to during processing. An additional column in the tables allows for documentation of reasons for wait times, and possible explanations for any issues during work flow.

The data collected in process observation worksheets shows that distractions, and not the actual procedures set in place by the lab are the usual cause for delay in sample processing. As shown in Tables 6 and 10, samples marked as STAT while following the normal work flow pattern at the laboratory are processed quickly and well within their expected times for STAT orders. Chemistry STAT samples are required to be completed in less than forty five minutes; a sample followed on November 9, 2011 was processed in twenty six minutes as shown in Table 6. CBC and Coagulation STATs are both required to be completed in less than thirty minutes. On November 15, 2011, both CBC and Coagulation STAT samples were processes in less than

twelve minutes (Tables 10 and 11). This proves that issues with lead time of samples are not an effect of the current procedures and technology the laboratory possesses. Distractions such as phone calls (Tables 7 and 8), interruptions from outside sources, for example waiting for a doctor's signature (Table 5), and possible understaffing on busy days (Table 8) , are the causes for delayed processing of samples. On November 30, 2011 as shown in Table 7, a sample was delayed more than six minutes due to telephone call interruptions, increasing the lead time from forty one minutes to forty seven minutes. Within six minutes, a CBC or Coagulation sample could be half completed, or two blood samples could have been drawn. Accession, as shown in all of the process observation worksheets, is commonly a rapid process, averaging only a matter of minutes, with the exception of machine difficulties as shown in Table 9.

Table 5: Out-patient process observation worksheet

Process Observation Worksheet			Process: Out-patient			Name: Darcy DelDotto Date: November 9,2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives at Phlebotomy Lab		0.00			
2	Orders are located on system		1.00	1.00		Orders were unsigned and patient requested second test
3	Samples are taken		6.35	1.00	5.35	
4	Samples are accessed		12.56	0:15	6:41	Waiting for doctor's signature
5	Samples are brought to Lab	From phleb to chem	15:30	0:52		
6a	Samples arrives in Lab	Near chem centrifuge	16:22		unknown	When sample arrived; this is the furthest the sample was followed
6b						The sample was placed in a rack on the bench near the chemistry centrifuge
6c						Two CBOCs were being unloaded; therefore the sample was of less priority
6d						The samples included one blue and one purple top, meaning sample has to be processed in hematology room

Table 6: STAT sample process observation worksheet

Process Observation Worksheet			Process: STAT			Name: Darcy Del Dotto Date: November 9, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Stat sample arrives	By centrifuge	0.00		1.03	Had to wait for centrifuge to be ready
2	Samples is centrifuged		1.03	9:00	1.45	Waited for machine to cool down
3	Sample is Analyzed (chem machine)	Chem machine	11.48	5:38		
4	Test is complete		18:38		5:21	Results were sitting in printer
5	Results picked up from printer	By Ed's desk	24:17			
6	Results Entered into Computer	Near old chem machine	25:10	0:50		
7	Sample Stored	On racks across from new chem machine	26:00			

Table 7: CBC process observation worksheet

Process Observation Worksheet			Process: CBC			Name: Darcy Del Dotto Date: November 30, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives in Lab, Information Gathered		0:00	0:45		
2	Accession		0:45	3:50		
3	Blood Drawn		4:35	0:30		
4	Sample Ready for Pick Up	Brought from phlebot to hem	5:20	1:04	1:16	
5	Sample arrive in Lab		26:02	0:00	9:59	No one in the hem room
6	Sample loaded in CBC Machine		36:01	4:24		
7	Sample Results Printed		39:43	2:34	4:39	Phone call, interrupted flow
8	Results Picked Up		44:22			
9	Results Entered into Computer	Computer closer to coag machines in hem	44:44	0:15	2:10	Phone call, interrupted flow
10	Samples Stored		47.11	0:15		

Table 8: Coagulation process observation worksheet

Process Observation Worksheet			Process: Coag			Name: Darcy Del Dotto Date: November 30, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives in Lab, Information Gathered		0:00	1:05		
2	Accession		1:05	0:23		
3	Blood Drawn		1:28	1:28		
4	Sample Ready for Pick Up	Brought from phlebot to hem	2:56		7:32	Only one tech, 2 phone calls back to back
5	Sample arrive in Lab		10:12	0:48	2:31	
6	Sample loaded in centrifuge		13:43	11:19		
7	Sample Ready		25:02		2:51	
8	Sample loaded into Coag Machine		28:11	12:25		
9	Test and Results Complete	Computer closer to coag machines in hem	40:36			
10	Results Picked Up		40:48	0:48		
11	Results Entered into Computer		41:04	0:16		

Table 9: Out-patient chemistry process observation worksheet

Process Observation Worksheet			Process: Out:Patient Chemistry			Name: Darcy Del Dotto Date: November 15, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives in Lab, Information Gathered		0:00	0:45		
2	Accession		0:45	0:27		
3	Blood Drawn		1:12	1:00		
4	Samples Ready for Pick Up	From phlebot to chem.	2:49	0:00	8:26	There were many samples waiting to be picked up or brought back
5	Samples arrive in Lab (chemistry)		11:45	0:00		
6	Samples Moved into New Rack		12:02	0:17	2:59	
7	Centrifuged		15:03	12:48	5:40	
8	Samples Organized	Moved from centrifuge area to machine area	33:29	2:38	21:38	Difficulties with Machine, Samples Backed Up
9	Samples Loaded into Machine		57:45	1:0:35		Samples processed slower when machine is full
10	Samples Unloaded		2:01:40	0.00	9:36	
11	Samples Stored		2:11:06	0:30		
12	Results Confirmed in Computer	Computer on other side of room	2:11:36	2:54		
13	Complete		2:14:30			

Table 10: CBC stat process observation worksheet

Process Observation Worksheet			Process: CBC STAT			Name: Darcy Del Dotto Date: November 15, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives in Lab, Information Gathered		0:00	0:44		
2	Accession		0:44	1:08		
3	Blood Drawn		1:52	1:12		
4	Sample Ready for Pick Up	Brought from phlebot to hem	3:05	1:25		No wait time because STAT
5	Sample arrive in Lab		4:30	0:00	0:40	
6	Sample Loaded		5:10	2:31		
7	Results Printed		7:41	0:00	0:11	
8	Results Picked Up		7:52	0:00	0:30	
9	Sample Loaded		8:18	0:20		Test Had to Be Rerun because barcode was not read, due to the fact that the sample was not loaded properly
10	Sample Ready		8:38		2:12	
11	Results Printed		10:30	0:00		
12	Results Entered Into Computer		11:17	0:47		

Table 11: Coagulation process observation worksheet

Process Observation Worksheet			Process: Coag			Name: Darcy Del Dotto Date: November 15, 2011
Step #	Description	Distance	Clock Time	Task Time	Wait Time	Observations
1	Patient Arrives in Lab, Information Gathered		0:00	0:49		
2	Accession		0:49	1:26		
3	Blood Drawn		2:15	0:30		
4	Sample Ready for Pick Up	Brought from phlebot to hem	2:45	1:04	1:16	
5	Sample arrive in Lab		3:49	0:00	0:09	
6	Sample Centrifuged		3:58	4:24		
7	Sample Moved to Coag Machine		8:55	2:34	0:11	
8	Results Printed		11:59	0:31		
9	Results Picked Up		12:30	0:00	0:10	
10	Results Enterd into Computer	On other Side of Room	12:40	0:34		

Change

Many of the opportunities for changes that would result in improvements in the bottlenecks and delays of the process flow of samples lie outside of the control of the lab. Being short staffed some days is out of the scope of planning; when all staff members are present the laboratory runs smoothly. Bringing in an addition staff member would be unnecessary because on the majority of days they would not be needed. Also interruptions from phone calls cannot be prevented but some suggestions for these particular delays have been addressed in the previous chapter. There is currently a form the laboratory is using for documenting issues with doctors not placing orders into the computer system, but any improvements to this type of obstacle are outside the reach for change within the laboratory.

One issue not addressed within the process observation worksheet, but identified by the technologists is the process of unloading the CBOC samples. Unlike inpatient and outpatient samples, CBOC samples have not been accessioned and therefore this has to be done upon arrival at the laboratory. This involves the technologists generating labels then cross checking the labels with tracking documents received from the CBOC sites. They are then required to enter into the Vista computer system that the samples have arrived and have been assessed. This is a lengthy process and also allows room for human error.

A possible way to simplify the CBOC accession process would be to use the available Howdy technology. If the Howdy program were to be instated, it would also be used in the phlebotomy laboratory to streamline their procedures as well. Howdy is a computerized phlebotomy login process which is compatible with the current computer system. With this

new system, all samples would be provided with barcodes to be scanned when they are drawn and accessed, reach the laboratory, are being testing, upon completion of testing, and when results have been entered into the computer. Use of this technology will not only track the various times each step of the process takes but it would also require the phlebotomist that has taken a drawn sample to enter an employee code into the Howdy computer monitor, allowing for accurate tracking of who accessed which samples. Other benefits of the Howdy system include automatic deletion of duplicate orders, which is currently an issue in the phlebotomy laboratory.

If the Bedford laboratory were to begin using the Howdy system, Howdy monitors for the phlebotomy laboratory and barcode scanners would have to be purchased, as well as installation of the software package to the current programs.

For the effect of the new system to reach the CBOC accession processes, the CBOC sites would also have to purchase the same equipment as well as barcode printers, which the Bedford laboratory already has. It is possible that this equipment could be purchased with funds from the Bedford VA if no resources are available at the clinics. Use of the HOWDY system at the four current satellite clinics would require training since these sites do not use a computerized accession process; therefore hand write all labels. With the necessary training phlebotomists at the clinics would actually minimize their work since there would no longer be a need to manually collect information from patients.

Howdy would allow for the technologist to only have to scan the samples as they arrived, instead of having to access. This technology would also reduce room for error and help keep better track of samples as they moved about the laboratory.

Sustain

Many of the responsibilities for sustaining any changes made regarding sample flow would fall on the hands of laboratory manager Doreen Robotnik and laboratory supervisor Mari Ann Amador. We would recommend a more complete analysis of the Howdy technology. If purchased, the Howdy technology's tracking capabilities can be utilized to monitor the amount of time each step of the processes takes. This data can be used to measure whether the new system is continuing to improve work flow or to pinpoint any additional areas for improvement.

Chapter 6: Conclusions and Recommendations

The main goal of this project was to maximize work flow to identify causes of delays by specifically examining the pre-analytical stage of the process at the Edith Nourse Rogers Memorial Veterans Hospital laboratory. The three main problems we focused on were telephone call interruptions, the limited amount of space, and tracking sample flow. Both telephone call interruptions and the limited amount of space had a negative impact on work flow and lead time. Telephone calls are primarily an issue during the busiest times of the day because the technicians either have to make a phone call to gather information about a sample being tested or receive incoming calls. Both situations cause distractions which in effect jeopardizes the efficiency of the technician's work. Incoming phone calls cannot be controlled but conversations can be managed, whereas outgoing calls should be made during busy periods only when essential to continue work. Some phone conversations can be short, but adding many short calls can take up approximately 10 to 20 minutes of a technicians work schedule. In terms of space, Figure 14 suggested changes using the 5S methodology, which includes the removal of the boxes containing documentation, the relocation of the CBOC drop off, Ed's desk, and the analyzer. The suggestions would help reduce clutter in the laboratory area resulting in an organized area with easy access to necessary specific work stations such as benches, printers, and/or machines (analyzer, centrifuges). Because some suggested changes require structure modification, they are not feasible without an appropriate budget. Even though there is no appropriate budget to fund the installation of the Howdy technology, its purchase would benefit both the laboratory and the satellite clinics for it would decrease or eliminate human

error when it comes to the accession of the CBOCs samples. Currently the technologists at the lab have to generate labels and cross check them with the tracking documents received from the CBOC sites, which is then entered into the Vista computer system that the samples have arrived and accessed. Multiple steps from this process can be eliminated with an investment in the Howdy technology. In the future, suggested changes stated within the project should be presented to the individual/s in the subsequent chain of command in order to request a budget.

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