REDUCTION IN TURNAROUND TIME FOR STAT SPECIMEN WITHIN A REGIONAL HEALTH SYSTEM CLINICAL LABORATORY

Workstation Design Project

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Abstract

Processing time for tests is often considered the most significant measure of performance within a clinical lab. This paper summarizes a project completed by four undergraduate students during a semester-long Workstation Design course. The project setting was a clinical laboratory that was not consistently meeting time requirements for completion of stat test results. The goal, as specified by laboratory management, was to reduce the total turnaround time for stat tests and increase the percentage of tests meeting time requirements. Many industrial engineering methods were utilized including direct observation, process analysis, and historical data analysis. Improvement opportunities that were identified focus on reducing delays caused by poor visual cues and the unnecessary use of automation. These delays can be mitigated by color coding the carriers that incoming test specimens arrive in, manually processing certain stat specimen instead of using the automated machine available, and using colored labels for stat specimen in order to provide a visual cue for all technicians within the lab. The colored labels were implemented with positive feedback, while the other opportunities are still under consideration. The project demonstrated the quality of applying industrial engineering tools to analyze and improve a key healthcare process.

Introduction

Diagnostic responsiveness is critical to providing optimal service in high volume patient care; this is particularly important in emergency and operating rooms. With 60-70% of the required information on a patient's chart coming from laboratory test results, the demand for quick service is translated into aggressive time requirements for cycle times of ordered tests (Holland, Smith, & Blick, 2005). In clinical laboratories, the time from when a test is ordered to when the results are verified is defined as the turnaround time (TAT). The effects of TAT have been studied to a high extent, with correlations being drawn between emergency department treatment and length of stay (Hawkins, 2007). As a result, TAT is often considered the most significant measure of a laboratory's service and is used by many clinicians to judge its quality.

This paper summarizes a project completed by four Undergraduate students during a semester-long Workstation Design course. The project focused on a clinical lab located within a Regional Health System. This health system contains 583 hospital beds and supports more than 20 regional and local hospitals clinics. The specimens processed in this lab include blood, fecal matter, urine, and other fluid samples. Specimens are categorized as stat, urgent, timed, or routine. Stat priority means that results must be completed within an hour, urgent results must be completed within two hours, timed have a specific time during the day they need to be completed by, and routine do not have a time specification.

Within this system's clinical lab, the stat and urgent specimens (which are generally treated the same) come primarily from emergency room and operating room patients. The lab processes over 1.1 million specimens annually. Stat specimens comprise 7% of the total throughput (over 77,000) or about 300 samples on a given weekday.

At the time of the project, the biggest problem facing the clinical lab was the inconsistency with which they were meeting time requirements for the stat specimens. Two common stat tests, Basic 8 and Troponin, require TAT's of 50 and 55 minutes, respectively. However, according to data provided by management, they were only meeting TAT requirements 78% and 63% of the time, respectively. The distributions of the TAT's for these tests are summarized in the histograms shown in Figures 1 and 2.

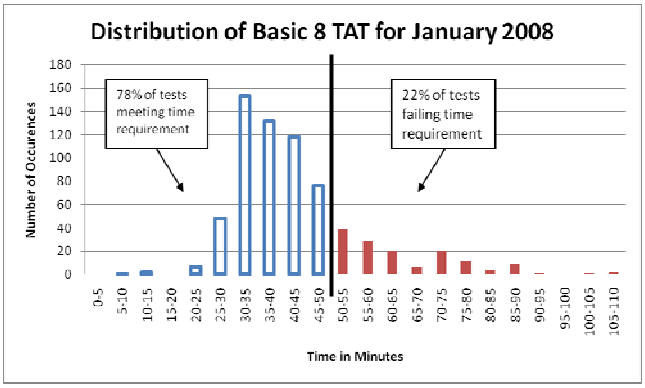

Figure 1: Distribution of Basic 8 TATs during January 2008.

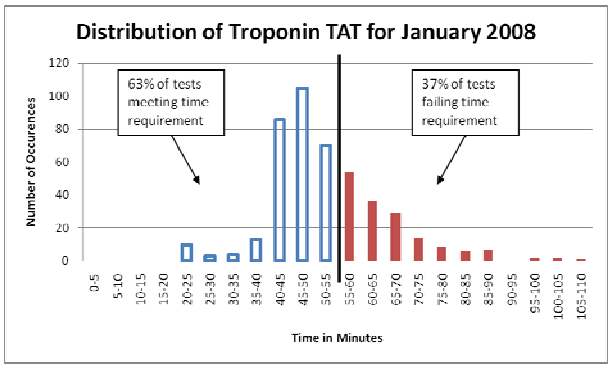

Figure 2: Distribution of Troponin TAT's during January 2008.

Total lab TAT is broken down into three main stages as shown in Figure 3. The portion of total TAT that lab management targeted as the main issue includes the time from when the specimen is collected by the phlebotomist until the specimen is queued for testing (shown as Stage 2 in Figure 3). The specific workstation analyzed constitutes only a portion of this stage. Due to the limited nature of the project, lab management specified the scope and workstation of interest.

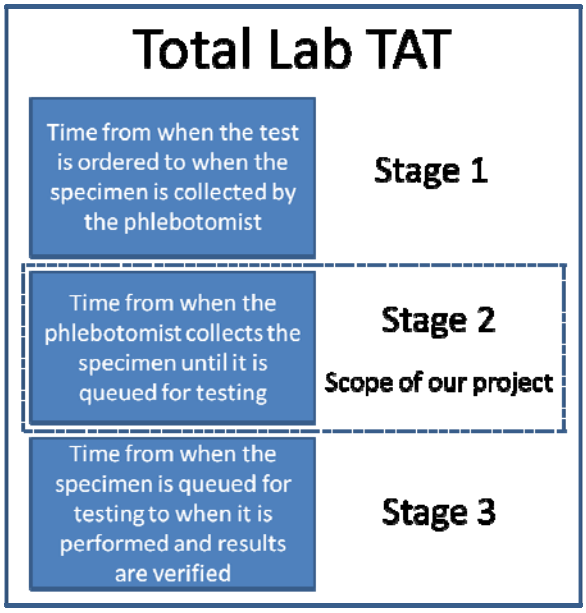

Figure 3: Breakdown of total lab TAT

The completion goal for Stage 2 is 10 minutes. At the time of the project, this goal was only being met 60%-70% of the time. A general benchmark for lab TAT is for 90% of tests to be completed within 60 minutes (Hawkins, 2007). This goal tends to vary from lab to lab as processing equipment and volume of specimens vary. For this specific lab, management believed that increasing the success rate of Stage 2 to 90% or better would greatly improve overall TAT.

Methods

We utilized various tools in order to understand the current state of the process and suggest improvements for achieving the goal set by management. The approach taken in analyzing this workstation began with direct observation followed by process analysis and the use of historical data. The steps taken are summarized in Figure 4.

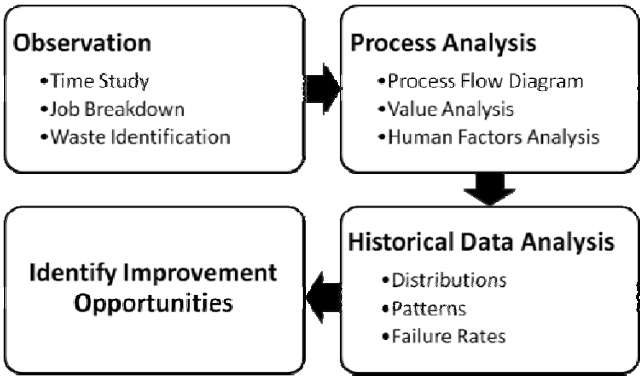

Figure 4: Methods and IE tools used

Current Process

The observed clinical lab specializes in processing and testing a variety of specimen including blood, fecal matter, urine, and other fluid samples. The specimens come from locations within the hospital as well as outside clinics. Specimens arrive in the lab by two different drop-off windows and a bullet system (similar to a bank's drive-up window). The specific workstation we focused on was responsible for retrieving the specimen from the arrival locations and preparing them for testing. This workstation contains a Modular Pre-Analytics (MPA) machine which performs spinning and aliquot operations before the specimens are queued for testing. The complete process flow for this workstation is depicted in Figure 5.

After documenting the process flow, time studies were performed in order to determine the composition of process times and potential areas of improvement. Standard times for the workstation were obtained by multiplying observed average times by a perceived pace rating with an addition of 15% allowance for fatigue. The resultant standard times are shown in Table 1. In analyzing the standard times, it was observed that transportation made up approximately 38% of the process. This was recognized as a potential area of improvement and historical data was analyzed to determine if other problems existed that would have a larger impact on TAT.

Specimen Process Times	
Element	**Std Time (s)**
Retrieve bullet *	10.5
Empty bag	5.6
Scan first specimen	6.1
Enter info. Into computer	17.4
Delay: process other specimens	9.9
Load rack	2.8
Deliver to MPA *	8.6
Load MPA	3.3
Return to workstation *	8.6
Total	74.8
*Transport = 38%	

Table 1: Standard process times

This lab processes approximately 4,500 specimens during a twenty-four hour day with the majority of the specimens arriving between 5 am and 2 pm on weekdays. From the historical data provided, the hourly trends in the number of specimens processed were analyzed over one week. The trends observed from this data are shown in Figure 6. Total specimens processed are highest at the beginning of the week and gradually decline until the end of the week. A steep drop-off is seen during the weekend (Saturday and Sunday) as a result of limited patient appointments.

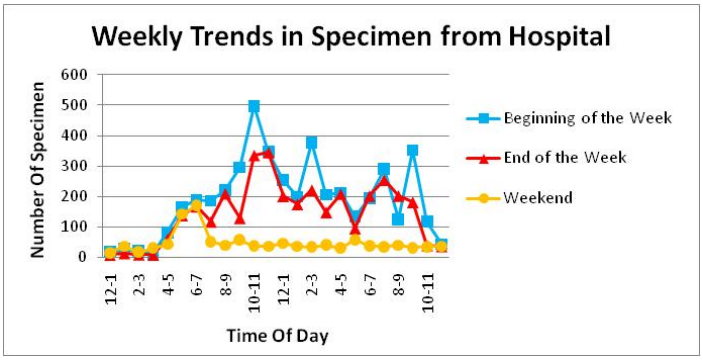

Figure 6: Number and time of hospital specimens received.

Further analysis of the historical data is depicted in Figure 7. As seen, a pattern appears to exist between the number of failures of two common stat tests (Basic 8 and Troponin) and the total number of specimens being processed.

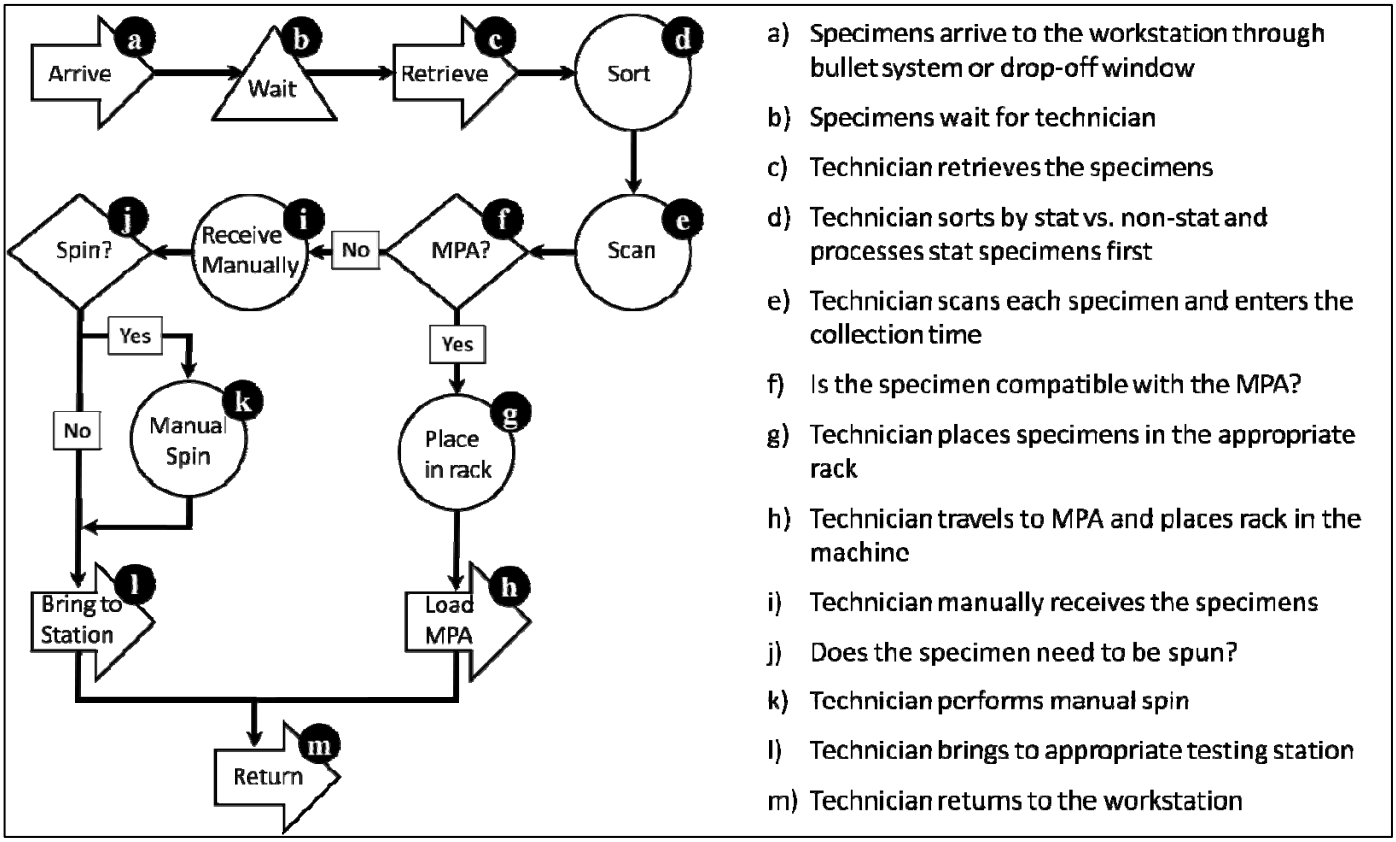

Figure 5: Process flow diagram of the workstation

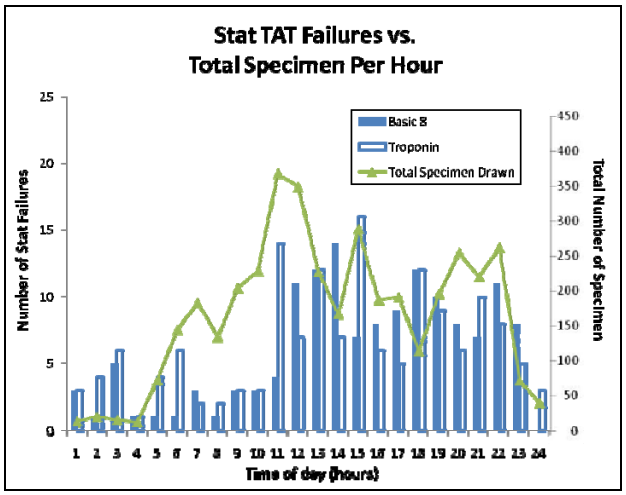

Figure 7: The relation between the number of stat TAT failures and the total number of specimens being processed.

It appears that larger processing delays for stat specimens occur when the lab experiences an increase in total specimens. Therefore, the following improvement suggestions focus on reducing these delays in order to reach the goals set by management.

Improvement Opportunities

Utilizing observation, process analysis, and data analysis methods, many improvement opportunities were proposed. Pareto analysis identified three specific opportunities the project team later determined may have the most significant impact on stat TAT:

1) Bullet Distinction
   - o Reduce delay for incoming specimens;

2) Manually receiving certain stat specimens
   - o Reduces stat process time by over 2 minutes; and

3) Improve Stat specimen tube labels
   - o Reduces delay for downstream processes.

Bullet Distinctions

Almost all specimens from within the hospital arrive at the receiving workstation by the bullet system. Of the many locations the bullets arrive from, the emergency room (ER) and operating room (OR) are the only locations that send stat specimens. Regular bullets (shown in Figure 8) are solid black in color while bullets sent from the OR are red. As is, the technicians cannot distinguish the ER stat specimen between non-stat specimen until opening and unloading the bullets. During observation, it was noted that incoming black bullets were neglected if the technicians were busy. In this case, bullets from the ER sat idle until the in-process specimens were loaded into the MPA, causing an unnecessary delay for stat specimen.

Figure 8: The bullet carrier and bullet carrier system.

The proposed solution was to use blue colored bullets for the ER. This would provide a visual cue for the technician to distinguish the priority of the specimens within the bullet without having to open them, thus eliminating the time stat specimens spend idle within the bullets.

Because the observational data that was gathered was not recorded during peak activity, the average delay occurring during this idle period was not measured. However, based on the description of operations during peak activity, this improvement has a potential to significantly reduce the processing times of stat specimens.

Manually Receiving Certain Stat Specimens

At the time of the project, all specimens that were compatible with the MPA were processed by the machine. While the MPA has taken much of the manual processing out of the hands of the technicians, in the case of the blue and purple topped tubes, the only operations that the MPA performs are to scan and queue them for testing. The MPA and the purple and blue topped tubes are shown in Figure 9.

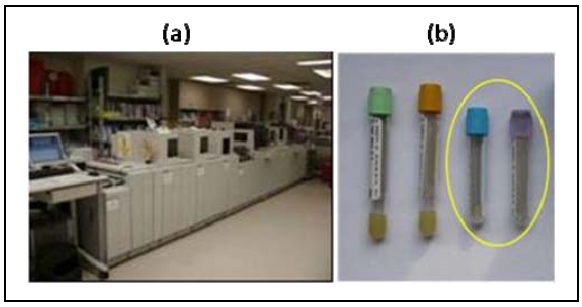

Figure 9: (a) The Modular Pre-Analytics machine (MPA); (b) Blue and purple capped stat specimen that should not be sent through the MPA.

While it is important to free up the technician's time, it is more important that the stat specimens get processed as quickly as possible. The average time for a rack of blue or purple topped tubes to go through the MPA (from when it is scanned to when it comes out) is approximately two to three minutes. During this time, the racks of specimen travel through the machine on a single-track conveyor,

wait in queues to be scanned, and are potentially blocked by other racks that are waiting for the centrifuge or aliquot.

The average time from our observations for manually scanning an average bullet of specimen and entering the collection information into the computer was approximately 33 seconds. In order to manually receive the specimen as opposed to sending them through the MPA, a similar process would occur, taking approximately 33 seconds. Therefore, manually receiving these specimens instead of sending them through the MPA will reduce over two minutes of the overall turn-around-time for each purple or blue topped stat specimen.

Stat Specimen Tube Labels

At the time of the project, the small code on the specimen label (shown in Figure 10a), was the only identification used to determine the specimen's priority for all stations downstream from receiving. Without a significant visual cue distinguishing the stat specimens for these technicians, the stat specimens waited while other samples at each station were tested and analyzed.

The suggestion for this issue was to print stat and urgent specimen with a colored border such as the one shown in Figure 10b. This would allow anyone in the lab to easily distinguish the priority and allow stat specimens to "leap-frog" others. Therefore, technicians would only process non-stat specimens when no colored labels (stat specimens) are in queue.

The current label printers utilized by the hospital have the capability needed for such labels. Therefore, the implementation costs would be minimal.

While the level of queues blocking the stat and urgent specimen was never measured prior to implementation of the new labels, this was identified as one of the largest delays in the pre-analytic process. This was confirmed through speaking with technicians downstream from the receiving area, which identified this suggestion as a significant improvement for their area.

Figure 10: (a) Specimen label at the time of the project; (b) A concept of how the labels could be printed to better distinguish stat specimen.

Further improvements

Since the completion of the original project, further improvement opportunities have been identified. These opportunities were uncovered by benchmarking articles of projects performed in similar settings and by performing further analysis of the historical data provided.

Process Benchmarking

One approach taken by previous researchers focused on the job roles of the receiving technicians and the lack of definition within their duties.

The job inherently has a long and unforgiving learning curve due to the high volumes and variety of specimen processed. Additionally, the technicians experience a lot of outside distractions such as phone calls, visits from other technicians, ordering stat tests, and dealing with rejected specimen. With a high paced demand placed on these activities, the technicians at this station experience high stress which contributes to a 58% turnover rate.

Persoon et al. (2006) approached a clinical lab facing similar job related issues and demonstrated the potential benefits of implementing the Toyota Production System. In implementing the four rules of the Toyota Production System shown in Figure 11, Persoon et al. (2006) focused on eliminating the use of batch processing, eliminating the need to expedite stat specimen processing, and creating five new workstations with specific descriptive titles. Benefits of the study include a 34% reduction in pre-analytic processing time (29 minutes reduced to 19 minutes) which contributed to the lab meeting the 60 minute TAT goal 80% of the time for 11 consecutive months. Other benefits include reduction in mislabeled tubes, missing specimen, and the elimination of unwritten or unapproved extraction of bloods samples by the phlebotomists.

Toyota Production System Rules
1. All work shall be highly specified as to content, sequence, timing, and outcome.
2. Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses.
3. The pathway for every product and service must be simple and direct.
4. Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization.

Figure 11: Four rules of the Toyota Production System which can be applied to the workstation of interest (Spear, Bowen, 1999).

With a similar approach and implementation of these same principles, specifically breaking down the tasks of each technician into highly specified job titles and utilizing

cross-training strategies, the clinical lab described in this paper would stand to receive similar benefits.

Further Analysis of Historical Data

Other potentials for improvement that were identified after the completion of the project pertain to the time from when the stat test is ordered to when the specimen is collected by the phlebotomist (Stage 1 from Figure 3). A breakdown of time requirement failures for Basic 8 and Troponin stat specimens are summarized in Figure 14. It was noticed that in both cases, the greatest contribution to overall TAT failures came from Stage 1 of the process. Although the original project focused on a workstation within Stage 2 (as decided by management), it appears that the greatest potential for improvement lies within Stage 1.

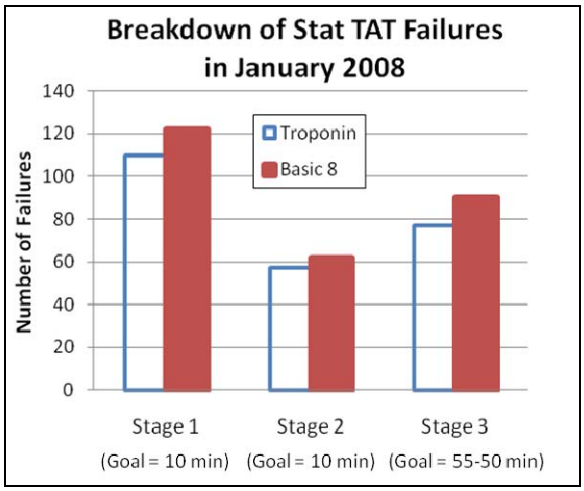

Figure 12: Occurrences of each stage failing to meet time requirements when overall lab TAT was not met during January 2008.

Conclusion

As with many clinical laboratories, the most significant measure of performance for the lab discussed in this paper is test turnaround time. The main issue experienced was the inconsistency with which their stat tests were meeting time requirements. Although only 7% of the total specimens processed are stat priority, with the high volume the lab experiences, roughly 115,000 stat specimens are processed yearly.

At the time of the project, two common stat tests, Basic 8 and Troponin, were meeting time requirements 78% and 63% of the time, respectively. Lab management specified the scope of the project and the workstation of interest. This workstation constituted a portion of Stage 2 of total TAT. The time completion goal of Stage 2 is 10 minutes, which was being met approximately 60-70% of the time. The overall goal of the project was to increase the success rate of Stage 2 to 90% or better.

Improvement opportunities that were identified to meet this goal focused on reducing delays caused by poor visual cues and the unnecessary use of automation. These opportunities include color coding the bullets that incoming test specimens arrive in, manually processing certain stat specimen instead of using the MPA, and using colored labels for stat specimen in order to provide a visual cue for all technicians within the lab.

Lessons learned from the project were consistent with the limited nature of an undergraduate course project. Consequently, the implementation, auditing, and evaluation of the suggested improvements were beyond the scope. One improvement that was implemented was the suggestion of colored stat specimen labels. However, the evaluation of results has not yet been performed to quantify the impact on stat TAT. The project team is confident that additional implementation of identified suggestions will further reduce stat TAT.

Aside from the improvements identified, a supplementary impact of the project came from its presentation. The current state of the lab's stat TAT failures and the analysis performed were shown to the head of the chemistry department, lab management, and technicians working in receiving and testing. Through this presentation, a widespread level of awareness of the high stat TAT failures was created, inspiring discussion for further opportunities.

Acknowledgements

We would first and foremost like to thank the technicians at the receiving station for allowing us to observe their work. We would also like to thank lab managers Shelly Evenson and Jane Voss for letting us record data and for taking the time to fully explain the intricate processes that take place in the lab. We would also like to thank James Klein for helping to identify the receiving station as a target for improvement and providing all historical data from the clinical lab. Finally, we would like to thank the faculty members within the NDSU Industrial and Manufacturing Engineering Department, especially Dr. John Cook, for the support and encouragement in the formation of this paper.

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All historical data was provided by the Regional Health System's Quality Improvement Department.

Biographical Sketch

Jason Thomas is a senior at North Dakota State University studying Industrial Engineering and Management. He is an active member of NDSU's IIE chapter where he is Vice President of Healthcare Systems. For the last four years he has worked part time as an Undergraduate Research Assistant at NDSU's Center for Nanoscale Science and Engineering as well as working at Bobcat in Bismarck from January-July 2009 as a Lean and Assembly Intern. He is currently working as an undergraduate research assistant for the NDSU IME department on a clinical efficiency project with the Veteran's Affairs.

Charla Lanoue is a senior at North Dakota State University studying Industrial Engineering and Management. She has worked for Dakota Manufacturing Extension Partnership as a Continuous Improvement Intern where she participated in a Lean Knowledge Certification Program. She is currently working part-time at Appareo Systems in Fargo as a Manufacturing Engineering Intern.