University of Michigan Health System
Program and Operations Analysis

Productivity Analysis of the University Hospital Operating Room
Instrument Decontamination Room

Final Report Draft

To: Marc Finch, Instrument Room Manager, University Hospital Administration
   Sam Clark, Industrial Engineering Lead, Program & Operations Analysis

From: IOE 481 Project Team 1, Program & Operations Analysis
      Kristina Behrens, Associate of UMH Program & Operations Analysis
      Tina Dimoski, Associate of UMH Program & Operations Analysis
      Rachel Perry, Associate of UMH Program & Operations Analysis

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Executive Summary

This project is a detailed account of the Program & Operations Analysis Team’s productivity analysis of the University Hospital Operating Room decontamination process, evaluation of alternative methods for a productivity tracking system, and recommendation summary. Marc Finch, Instrument Room Manager, asked the team to develop work standards to track employee productivity and develop a method of productivity tracking in the Decontamination Room.

The Instrument Room Supervisors does not have a sound method of tracking employee productivity throughout their shifts in the Decontamination Room. Through observations and data collection performed in the Decontamination Room at the University Hospital, as well as observations in the Decontamination Room at Mott Children’s Hospital for benchmarking purposes, the team developed two methods to track employee productivity. After evaluating the two options, the team determined the best productivity tracking system is to have the Instrument Processors tally tray completions and other non-routine tasks on a white board.

Background

The Decontamination Room currently does not have a method of tracking the Instrument Processors’ productivity; thus the supervisors do not have a system to evaluate employees. Without time standards and a productivity assessment system supervisors cannot determine if employees are performing their assigned duties during their shifts. Although work standards were developed for the Assembly Room in 2003, the Decontamination Room was not included in this study, and as a result, there is a lack of benchmarking for the decontamination process.

Methodology

- **Conducted Literature Search:** The team obtained a report from the project coordinator for the development of the current instrument assembly productivity tracking system, which the team used to establish a method of data analysis. This report illustrated the method used for the productivity tracking system development in the Assembly Room by finding process times, gathering tray attributes, and using scatter plots and regression analysis to determine attributes that predict processing time.

- **Interviewed Supervisors and Instrument Processors:** The interviews with the supervisors helped the team identify the flaws in the assembly productivity tracking system, including reliance on the honor system to record work performed and the large variance in processing time due to missing instruments. The supervisors gave the team a few suggestions along with their corresponding concerns. One suggestion was to file count sheets from trays to track work performed; however, their concerns were the inability of processors to identify every tray and the lack of count sheets included with every tray. Another suggestion for tracking productivity was to record trays decontaminated on a sheet, as done in assembly; however, the concern was that the papers would become contaminated once they are in the Decontamination Room. The team’s interview with the Instrument Processors consisted of informal discussion with
the intent to determine potential bottlenecks. The processors also assisted the team in
developing a process flow chart and time study methodology.

- **Observed Decontamination Room:** The decontamination process was observed
  by the team for six hours before beginning time studies. In addition to tray
decontamination, the team noted non-routine work performed in the
decontamination room. From observation, the team developed a standard time
study methodology.

- **Conducted time studies by tray:** The team collected 32 hours of data resulting in
  250 data points. The processing time for individual steps were recorded by tray.
  Tray attributes, asepti-zyme use, and a soil level evaluation were also recorded
during data collection.

- **Analyzed Time Studies:** Through data analysis, the team determined key predictor
  variables from the time studies using statistical methods. The methods used
  included: scatter plots, hypothesis testing, regression analysis, and basic statistics.
  The team then developed an algorithm to predict tray processing times using the
  conclusions generated from this study. The team did not find a direct correlation
  with the number of instruments on the tray or the presence of the attributes
  measured with the processing time. The team performed multiple regression
  analyses using different predicting factors and methods and consistently found
  these low correlations. The team eventually used percentiles of the data to predict
  the times set forth in recommendations.

- **Benchmarking at Mott Children’s Hospital:** The team observed and interviewed
  the Instrument Room Supervisor as well as the Instrument Processors in Mott
  Children’s Hospital. The team compared their decontamination process and
  productivity system to the University Hospital.

**Recommendations**

The team was asked to develop time standards for tray decontamination. Based on analysis, the
team recommends time standards of 1.9 minutes for hand wash trays and 8.4 minutes for
machine wash trays. These time standards do not reflect a prediction for an individual tray’s
decontamination time; rather, they represent long-run averages.

The team was also asked to develop a productivity tracking system for the Decontamination
Room in the University Hospital. The team recommends using a white board to tally the job
elements performed by each employee during their shift. This system will allow for visual
management so that the supervisor can quickly follow up on employee productivity throughout
the shift, as well as motivation through competition, separation of work performed by Instrument
Processor, and a measurement of non-routine work.

The employees will track elements such as: machine wash trays, hand wash trays, removing the
trash, and transporting the hand wash cart to assembly. The recommended time standards will be
used to track productivity.
**Introduction**

The University Hospital Operating Room (UH OR) Instrument Room is responsible for the flow of instrument trays within the Main Hospital Operating Room. The Instrument Room functions for trays include: assembly, storage, delivery, and decontamination. In 2003, a productivity tracking system was developed for the UH OR Instrument Room’s assembly process, but the developers did not include the decontamination process in this system. To monitor and improve productivity of the Instrument Processors performing decontamination, work standards needed to be developed for the decontamination process. In addition, the UH OR Instrument Room will be implementing an instrument tracking system in the future that will utilize barcode scanning technology. A standardized decontamination process, work standards, and productivity system will be necessary to implement the new technology.

The Program & Operations Analysis Team examined the activities of the Decontamination Room and conducted time studies of tray decontamination in order to calculate the requested work standards. The team then devised an algorithm to predict the time required to decontaminate a tray along with suggestions for implementation of a productivity system to track employee performance relative to this time standard. This report presents the team’s methodology, analysis, tray decontamination algorithm and recommendations for a productivity system.

**Background**

The UH OR Instrument Room has 30 employees including two day-to-day supervisors and one inventory supervisor. The day-to-day supervisors cover first and second shifts Monday through Friday, and are on call during the third shift and weekends. The UH OR Instrument Room has three assembly rooms and two decontamination rooms; however; only one decontamination room is currently in use. The remaining employees are Instrument Processors, who assemble, decontaminate, and store the instrument trays.

In 2003, a productivity system was developed for the tray assembly process to ensure a balanced workload among the employees and prevent the accumulation of sanitized trays awaiting assembly. This system provides an objective method of tracking employee performance. The current productivity system for the Assembly Room requires each staff member to record his daily activities on a sheet of paper throughout his shift and submit it to management at the end of the day. (See Appendix A.) The activities include: trays assembled, peel packs assembled, loads sent down to the Central Sterilization Services, loads put away into storage, and trips made to the operating rooms. All activities are assigned a point value that correlates to the amount of time each activity should take; each point is equivalent to five minutes. The system’s developers performed time studies to determine how long it took to perform each assembly task. The developers recorded tray attributes and characteristics that could potentially influence the tray assembly time. The system’s developers found that the following attributes best predicted the amount of time needed to assemble a tray: the number of instruments on the tray, the number of different instrument types, and the number of quality assurance (QA) checks. Based on these indicators, the developers used scatter plots with best fit lines to generate an algorithm that produces a work standard for the assembly of any tray based on the three aforementioned attributes. The developers created a productivity tracking system comparing the number of trays assembled by an employee in a particular time period against the work standards from the algorithm. The existing assembly work standards of this productivity system are not tray specific; they are a function of the point activity inputs.
The current system for assembly has several drawbacks. Staff members have expressed concerns about the productivity sheets for the tray assembly process, citing that the sheets are confusing and tedious to fill out. Productivity adjustments are made for temporary employees, which also leads to confusion. Furthermore, clerks who are responsible for scoring the employee productivity and entering point values for new instruments and trays have not entered all the new productivity data into the database. This lack of system maintenance causes certain trays to generate null point values, implying that the tray’s assemblers did not spend any time assembling those trays. An Industrial Engineer in the Programs & Operations Analysis Department provided the team with productivity data from a sample day, which confirmed these inaccuracies. The productivity tracking system estimates that workers can assemble 20-30 sets per 7.5-hour shift, but the data from the sample day showed that employees recorded 3-31 sets.

Employees sometimes split time between assembly and decontamination duties. Therefore, the existing productivity tracking system for the tray assembly process served as a reference point and benchmark for the development of a similar system for the decontamination process. For the employees’ ease of use and for the manager’s ease of comparison, the productivity tracking system for decontamination can be used in conjunction with the productivity tracking system for assembly. However, the team considered the flaws in the existing system. With these factors in mind, the team developed a productivity tracking system for the decontamination process, which can be used to track and improve employee productivity.

Project Details

The Program & Operations Analysis team examined the activities of the Decontamination Room. The primary parties involved in this project included the UH OR Instrument Room Manager, Supervisors, Surgery Technicians, Instrument Processors, and the nursing staff.

Key Issues

The following key issues drove the need for this project:

- A lack of current time standards in the Decontamination Room prohibits the ability to track employee productivity
- An absence of quantitative benchmarks and baselines restricts process evaluation for future process improvements
- Future implementation of barcode scanning technology requires a standardized decontamination process, work standards, and productivity tracking system

Project Goals

To develop a decontamination process productivity tracking system, the Program & Operations Analysis Team worked to achieve the following tasks:

- Develop work standards for tray decontamination
- Incorporate predicted times from work standards into a productivity tracking system for the decontamination process

Project Scope

This project included:

- The instrument decontamination process for UH owned trays of instruments decontaminated in the Decontamination Room
The process steps from when the tray entered the Decontamination Room until the point when the tray either entered the washer or was placed on the clean hand wash cart.

Time studies for tray types used during the team’s observations

The project excluded:

- Anesthesiology instruments
- Loaned instruments
- Instruments that were decontaminated individually and not as part of a tray
- Time studies for unused instrument trays, since surgeries did not require all tray types during the project’s data collection period
- Trays not decontaminated in the Decontamination Room

**Methodology**

To develop the productivity tracking system, the team used the following methods: literature search, observation, interviews, time studies, benchmarking, and mathematical analysis.

**Literature Search**

The team performed a literature search to identify best practices in hospital instrument decontamination processes and gathered information on the creation of the instrument assembly productivity tracking system. The team obtained a report from an Industrial Engineer in the Programs & Operations Analysis Department detailing the establishment of the productivity tracking system in the Instrument Assembly Room. This report served as a guide for the recommendation of a similar system in the Decontamination Room. The team also reviewed reports from former Industrial & Operations Engineering 481 project teams to determine if similar projects had been performed in the past.

**Observation**

The team observed the decontamination process for six hours to understand the decontamination tasks and develop methodology for data collection. The methodology developed for conducting time studies is discussed in the next section.

**Time Studies**

The team performed time studies by tray to determine the process time of each step in the decontamination process and the total work time. The team collected 32 hours of data during peak hours, Monday through Friday from 10am to 5pm, which resulted in 250 tray processing times.

To develop a time study methodology, the team referred back to their initial observations. They divided the decontamination process into measurable activities and created a data collection sheet. (See Appendix B.) Data collection times for trays that could go through the washing machine included: time for the processor to break down the tray and move it to either the sonic or the washing machine conveyor; and time that the tray was in the sonic (if applicable). For hand wash instruments, the data collection times were: time for the processor to break down the tray and move it to the hand wash cart; time that the tray waited to be washed; and time to hand wash the tray. The team entered the information collected on data collection sheets into a computer and later analyzed it.

Before beginning data collection on a particular day, the UH OR Administrator printed a report for the team which listed the surgery start times, operating rooms, case types, and instruments.
selected for the day’s surgeries. The team then re-labeled the report to assign every case and tray a unique alphanumeric identifier. The cases were each identified by a letter and each tray within that case by a number. For example, the first tray of the first case was called A1 and the first tray of the second case was called B1.

Once in the Decontamination Room, the team requested identifying information from the Surgery Technicians for each incoming tray. This information included the operating room in which the case took place and the name of the tray. With the Surgery Technicians’ assistance, the team matched the tray to its unique alphanumeric identifier from the report. A team member labeled the tray by sticking a piece of sterilization tape on to it with the identifier written in permanent marker. This labeling system allowed the team to track the tray through the decontamination process. The team also used the identifiers to refer back to the tray at a later point for gathering information, such as the number of instruments on the tray.

Meanwhile, another team member recorded the times at which the individual trays moved through the decontamination process. The information collected by this team member also included characteristics of the tray – whether or not it had scissor or clamp-like instruments, cannulated instruments, or instruments with complex shapes that tend to trap bio-burdens such as solid tissue. These three types of instruments generally require additional time to process; scissor-like instruments must be individually opened and loaded onto a stringer, instruments with tubes or holes must be individually cleaned with a small brush on the inside, and instruments with complex shapes may require extra effort from the processors to ensure that no bioburden remains on them. Another factor that could influence processing time was whether the surgery technician sprayed the tray with asepti-zyme to prevent blood from hardening onto the instruments. The team member recording data noted this factor and assigned a number to each tray indicating its soil level on a scale of 0 (unused or no visible blood) to 3 (completely soiled with very visible bioburden). The instrument processors in the Decontamination Room often assisted the team by calling out the alphanumeric identifier as they moved the trays through the process, which enabled accurate data collection.

Interviews
The team interviewed two Instrument Processors on first and second shifts in the Decontamination Room to gain more project background as well as a better understanding of the decontamination process. The team interviewed supervisors to understand the problems with the current assembly productivity tracking system and to obtain suggestions for a decontamination productivity tracking system. A list of questions used during the interview can be found in Appendix C.

Benchmarking
The team observed and interviewed employees at Mott Children’s Hospital Instrument Room to understand the Mott Children’s Hospital Decontamination Room productivity tracking system. Mott Children’s Hospital has similar instruments and trays, but a different decontamination process and productivity tracking system. The team investigated the productivity tracking system to determine the viability of adopting a similar system in the UH OR Instrument Room.

Analysis
The team analyzed the time study data to determine key predictor variables that influence the processing times. For example, predictor variables used in the development of the assembly room productivity tracking system included: number of instruments in a tray, number of different types of instruments, and number of QA checks. The team identified similar predictor variables for the Decontamination Room. From this analysis, the team developed an algorithm that predicts processing times for the decontamination of each tray.
Qualitative Findings and Analysis

The qualitative findings and analysis were useful in developing the productivity tracking system. The qualitative findings included the results from observation, literature search, interviews, and benchmarking at Mott Children’s Hospital.

Development of Decontamination Process Flowchart

The team first sought to document the process flow of the Decontamination Room. Based on their observations and conversations with the Instrument Processors, the team created flow charts for the machine wash and hand wash processes. Figure 1 on the following page shows the machine wash decontamination process for instruments that go through the washing machine.

As shown in Figure 1, the machine wash process has many decision points. The process contains a large human element, requiring the Instrument Processors to make many subjective decisions throughout the process. Therefore, the amount of time needed to decontaminate an instrument tray fluctuates. This figure provides a general representation of the process; the steps may vary depending on the individual processor’s judgment.

Figure 2, the subsequent flow chart, shows the flow chart that the team developed based on observations for the decontamination process of hand wash instrument trays, which cannot go through the washing machine. The hand wash process illustrated in Figure 2 has fewer decisions and requires less human interaction than the machine wash process in Figure 1.

In addition to the machine wash and hand wash decontamination tasks, the team observed the Instrument Processors performing non-routine tasks throughout their shift. These tasks included: taking out garbage, recycling, and laundry; changing the water in the sinks and basins; troubleshooting the broken dishwashers; processing trays with higher priority for immediate use; and changing protective clothing.

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Figure 1: Machine Wash Decontamination Process

Set tray from surgery on racks (Surgery Tech)

Did Surgery Tech pre-spray w/ Asepti-zyme?

Pre-spray with asepti-zyme

Break down tray

Remove any electronic equipment, drills, cords, or micro-sets and send to hand wash cart (See Figure 2)

Scrub with asepti-zyme

Soil level high?

Scrub with asepti-zyme

Instrument cannulated?

Yes

Squirt out and brush each tube with asepti-zyme, syringe or pipe brush

Comes out bloody?

Yes

No

Scissors or clamps?

Yes

String scissors on stringer or leave open

No

Remove towel and remaining sterile tags

Many instrument crevasses?

Yes

Has tray been used?

Yes

Place in sonic for 5 or 10 minutes based on soil level

No

No

Place tray on washer rack

Washer open?

Yes

No

Enter washer

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Figure 2: Hand Wash Decontamination Process

1. Set trays from surgery on racks (Surgery Tech)
2. Place hand wash items on cart
3. Scrub in sink with Asepti-zyme
4. Rinse in alcohol and water solution
5. Set on semi-dry table
6. Can item go in the dryer? (Yes/No)
   - No: Set on clean cart
   - Yes: Place in dryer for 2-3 hours
8. Set on clean cart
9. Wheel to assembly room
10. Instrument trays placed in sanitizer
11. Tray assembled by Instrument Processor
Determination of Productivity Tracking Elements

The team performed a literature search to research best practices for hospital instrument decontamination process productivity tracking systems and unfortunately did not find any relevant articles. However, the team consulted the report and findings defining the UH OR Instrument Room assembly productivity tracking system. (See Appendix D.) This report outlines the time studies performed by the Programs & Operations Analysis staff in the Assembly Room of the UH OR Instrument Room. While conducting these time studies, the researchers also recorded attributes of the instrument trays, including the number of instruments on the trays, the number of different types of instruments on the trays, and the number of quality assurance checks that processors performed on the trays. Using scatter plots, the researchers determined that these attributes significantly impacted the time needed to assemble a tray. They constructed an algorithm based on these findings which was able to predict the time needed to assemble any given tray based on its attributes. The project team for the Decontamination Room study found this report insightful for modeling a similar system for the decontamination process. This report influenced the team’s data collection of three inherent attributes of the trays: presence of scissor-like instruments; presence of cannulated instruments; and presence of complex or crevassed instruments. As mentioned in the Methodology section, the team also recorded variable attributes, such as whether the surgical technicians sprayed the incoming trays and the soil levels of these trays. The team recorded this data in hopes of finding a similar relationship between tray processing times and attributes, as had occurred in the Assembly Room.

Additionally, the Instrument Room Manager provided the team with documents to enhance their understanding of the decontamination process. These documents included job descriptions of the Instrument Processor roles and a sample daily productivity record sheet for the Assembly Room. They also included our project client’s staff expectations and a PowerPoint presentation titled, “Cleaning: Step One in the Sterilization Process”, which outlined the proper decontamination technique and gave explanations for the process. The PowerPoint presentation helped in comparing the decontamination process at the UH OR to the decontamination process at Mott Children’s Hospital. The staff job descriptions and expectations helped the team understand the culture of the UH OR Instrument Room.

Identification of Suggestions and Concerns for Decontamination Productivity Tracking System

The team interviewed three Instrument Room Supervisors and two Instrument Processors working in the decontamination room. The purpose of these interviews was to assess the existing productivity tracking system in the Assembly Room and to obtain opinions on implementing a similar system in the Decontamination Room.

Instrument Room Supervisors

The team first asked each supervisor to evaluate the productivity tracking system used for assembly in terms of strengths and weaknesses. The supervisors indicated three key weaknesses in the existing system. First, the Instrument Processors are on their honor to record the work they have performed, meaning that they could potentially write and submit anything. Second, analyzing the written forms is time consuming because they are not compiled in any central database. Third, the current system has a large variance in the tray assembly times, even between the same trays. The variances can be due to missing instruments, which can take as long as an hour to track down, or questions about tray assembly procedures. These legitimate disruptions are difficult to separate from variance due to worker breaks or idle time under the current system.

The team then asked each supervisor to list suggestions for or concerns about the implementation of a productivity tracking system for the decontamination process. The main concern identified by each supervisor was the inability to remove items from the Decontamination Room. Whereas
the productivity tracking sheets from the Assembly Room can be removed from the room because the room and all items within it are sanitized, items from the Decontamination Room are considered bio-hazardous and may not be removed or handled without special precautions. This factor severely limits the feasibility of a productivity tracking system for the Decontamination Room similar to that of the assembly process. A second issue raised by the supervisors was how they would know which trays the Instrument Processors had decontaminated. Due to the differences in decontamination time between different trays, the Instrument Processors would need to record the individual trays they decontaminate. However, most Instrument Processors have not been working in the UH OR Instrument Room long enough to distinguish every tray. Identifying sheets, known as count sheets, are supposed to be included in each tray, but often these arrive as a bundle with the completed operation case or do not arrive at all. If the Instrument Processors are unable to record the identifying numbers for the trays they decontaminate, the productivity tracking system would be unable to assign a time standard to that tray and would therefore have no merit. Even if the count sheets were included in each individual tray, a third issue identified by the supervisors would be that of the time required to write down each tray’s identifying information. One suggestion for a productivity tracking system emerged from these concerns. One supervisor suggested creating bins for each employee in which they could place the count sheets for their trays and then total these at the end of the day.

Instrument Processors
In addition to speaking with the Instrument Room Supervisors, the team informally interviewed the Instrument Processors that work in the Decontamination Room. Much of the information they provided was used by the team to initially understand the decontamination process and to brainstorm a data collection methodology. However, the Instrument Processors also expressed concerns about the decontamination process. They mentioned that the washers were unreliable and frequently caused backlogs. They agreed that a bottleneck point is the sonic machines, which loosen blood and bio-burden from the instruments, and that the addition of at least another sonic would be helpful. During the observation, the team frequently requested qualitative information from the Instrument Processors, such as gauging the level of activity in the Decontamination Room. Such judgments were subjective, but helped the team to understand the flow of the decontamination process.

Evaluation of the Decontamination Process at Mott Children’s Hospital

The team interviewed the Mott Children’s Hospital Instrument Room Manager and observed the decontamination process and productivity tracking system at Mott. The purpose of this benchmarking task was to compare the process at Mott with the process in the UH OR Instrument Room and evaluate potential best practices.

Through the interview with the Instrument Room Manager at Mott Children’s Hospital and the observations conducted in the Instrument Room, the team developed a flow chart of the process at Mott Children’s Hospital. (See Appendix E.)

There are three main differences between the decontamination process at Mott Children’s Hospital and the process at the University Hospital. First, at Mott, the bi-pod remains in the Decontamination Room and becomes the responsibility of the Instrument Processors to send through to the Assembly Room, whereas in the UH OR Decontamination Room the Surgery Technicians remove the carts as soon as all of the trays have been set on the rack. Second, the Instrument Processors at Mott track and count the instruments before sending them to assembly. In the UH OR Decontamination Room, the instruments do not get counted until they have been decontaminated and sent over to the Assembly Room. Third, at the end of a shift at Mott, the Instrument Processors gather all of the count sheets and seal them in a peel pack labeled with the date and number of sheets contained. The Instrument Processors record their productivity
throughout their shift on a white board by keeping a running tally of the type and amount of trays completed during their shift. At the end of their shift, they record this information onto a productivity sheet. The following day, the supervisor evaluates the productivity by reviewing the count sheets and productivity sheets. She uses her discretion to determine whether or not the processors are performing at an appropriate level. The UH OR Instrument Room Decontamination Room does not conduct a similar procedure.

Additional observations from the visit to Mott include notable differences in communication, instrument knowledge, and experience. The Instrument Processors at Mott Children’s Hospital communicate continuously throughout the shift whereas the processors in the UH OR Decontamination Room communicate roughly twice a shift. This communication enabled a smoother flow in the decontamination process since the processors were quick to move from the Assembly Room to the Decontamination Room when needed. The processors at Mott have extensive knowledge and experience – often over 20 years – which makes identifying and counting the instruments a quick and easy process.

Quantitative Findings and Analysis

Time Studies Classification

The team performed time studies by tray to determine the time of each step of the decontamination process and the total work time. The team collected 32 hours of data. The team separated the times from their data collection sheets into three categories: processing time, machine time, and queue time.

Processing Time

The team defined processing time as the time the Instrument Processors spent actually working on the tray. Processing time applies to both hand wash and machine wash trays. For hand wash trays, processing time included the time needed to break down the tray and move it to the hand wash cart and the time needed to wash the instruments on the tray. For machine wash trays, processing time included the time needed to break down the tray and move it to either the sonic machine or the washing machine conveyor. If the tray went through the sonic, then the time to move it from the sonic to the washing machine conveyor was also included in processing time.

The team regarded processing time data with the highest priority in the creation of work standards as it represents the total time that the processors handled the trays. The team’s analysis, which will be discussed later in this section, was centered about these processing times.

Machine Time

The team recorded machine times for those instrument trays which went through the sonic. Although the sonic machine has five- and ten-minute cycles, the team never witnessed the use of the ten-minute cycle. The Instrument Processors confirmed that this cycle was rarely used because the five-minute cycle generally shakes loose all blood and bio-burden. If not, the processors explained that it is more efficient to run two five-minute cycles and manually shake the tray in between the cycles. Although the five-minute machine cycle time would suggest that the trays only stay in the sonic for five minutes, they often sit in the sonic longer because the Instrument Processors may get occupied with decontaminating other trays. Consequently, the team defined machine time to be the total time that the tray sat in the sonic – five minutes plus any additional time until the Instrument Processor came and removed the tray.

Although machine time does not directly reflect the time that the Instrument Processors spend working on a tray, the team decided it was important to collect this data to understand the total cycle time for a tray to move through the decontamination process.
Queue Time
The team defined queue time as time spent by trays waiting for an Instrument Processor to work on them. Both hand wash and machine wash trays entered a queue on the rack for incoming trays. Hand wash trays experienced a queue on the hand wash cart while waiting to be washed by the Instrument Processor. Machine wash trays experienced their second queue while waiting on the conveyor for a washing machine. Although the team’s data collection tracked the time that instrument trays sit in the queue before being processed, the order of tray processing did not necessarily follow a first-in-first-out approach.

The time in that trays spent in the three queues varied widely depending on factors such as day of the week, time of day, and number of Instrument Processors working. Some were processed immediately and spent no time in the queue; others waited almost three hours in all three queues. The team did not factor queue time into the development of their algorithm because it does not reflect the time that the processors spend working and it is too variable. The team did, however, keep track of basic statistics of the queue times.

Time Studies Analysis
The team began data analysis by adding together the processing time and machine time (if any) for each tray to obtain the total time, excluding queue time. When the team members graphed these data points, they noticed differences in the total times for hand wash trays versus machine wash trays. The team decided to stratify the data into hand wash and machine wash trays. The team held these two tray types separate for the remainder of analysis. Figure 3 shows box plots of total time for each process, which provide visual justification for the separation into hand wash and machine wash categories.

The box plots show that the variance of hand wash total time is less than the variance of the machine wash total time. The machine wash processing time had a standard deviation of 7.67 and median of 7.3 minutes. The hand wash processing time had a standard deviation of 1.23 minutes and median of 1.1 minutes. The box plots also show that the median of the machine wash time is greater than the median of hand wash time. Based on this observation, the team tested the hypothesis that the total time for hand wash trays was less than the total time for
machine wash trays. The team performed a two sample t-test to test this hypothesis and obtained a p-value of 0.000, indicating that the difference between the two means was indeed significant. (See Appendix F.)

To tailor more accurate time standard predictions to the two tray categories, the team divided all subsequent analysis into hand wash and machine wash categories.

**Hand Wash Analysis**

As discussed earlier, the hand wash data had a smaller variance than the machine wash data. The histogram of hand wash times in Figure 4 shows that the data fits into the narrow range of zero to five minutes for processing time. The histogram also appears to have a normal distribution of the data. The p-value less than 0.005 in the probability plot in Figure 5 confirms the fit of this data to a normal distribution.

*Figure 4: Histogram of Hand Wash Minutes of Processing Time*
The team calculated basic statistics for the hand wash processing times, which are summarized in Table 1.

Table 1: Basic Time Statistics for Hand Wash Process

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.593</td>
</tr>
<tr>
<td>Median</td>
<td>1.083</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.230</td>
</tr>
</tbody>
</table>

The fact that the mean and the standard deviation are near equal implies that this process has high variance of time. The team accounted for this variance by analyzing whether the number of instruments in the trays impacted their total processing times.

Figure 6 shows a scatter plot of the total processing time for the hand wash trays versus the number of instruments in the trays.
The scatter plot shows some correlation between the number of instruments in a tray and the total processing time. The team performed a regression analysis to test the strength of this correlation (see Appendix H for calculations). The regression analysis found that the factor for number of instruments in a tray had a p-value of 0.036, which was considered significant at an alpha of 0.05. However, the R-squared value was 15.3%, meaning that using number of instruments in the trays to predict their processing times accounts for only 15.3% of the total process variance.

**Machine Wash**

The team performed several statistical analyses to determine predicting factors for tray decontamination time. The team first constructed a scatter plot of all machine wash trays showing decontamination time versus the number of instruments in the tray (see Figure 7).
The data points did not appear to be particularly centralized about the regression line. The R-squared value was 5.2%, indicating that only 5.2% of the variability in tray processing time could be attributed to the number of instruments in the tray.

The team had noted during data collection that trays often stayed in the sonic longer than the set cycle time of five minutes. As a result, the team decided to isolate time spent in the sonic to determine if they could establish a stronger correlation to processing time on the trays and the number of instruments in the trays. The team defined the processing time of a tray as the time that the Instrument Processor performed work on the trays, including the time to break down the tray and move it to the sonic or washer conveyor. If the tray went through the sonic process, then the work performed also included the time to move it from the sonic to the washer conveyor. A histogram of the sonic machine times is shown in Figure 8.
The team calculated basic statistics for the sonic time. The mean time that trays spent in the sonic was 8.45 minutes, with a standard deviation of 4.11 minutes. The team performed a two-sample t-test to determine if the mean processing time differed depending on whether the tray went through the sonic. The p-value for this test was 0.000, indicating a significant difference in means. (See Appendix H.) This test justified the stratification of sonic time from processing time. Figure 9 provides a histogram of the machine wash data after the removal of the sonic times.
The histogram shows that the data is skewed right with high variance. The variance could be attributed to heavily soiled trays or interruptions during the processing of the tray. Table 2 summarizes the basic statistics of the processing time excluding machine time.

Table 2: Basic Time Statistics for Machine Wash Process Excluding Machine Time

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.744</td>
</tr>
<tr>
<td>Median</td>
<td>1.450</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.395</td>
</tr>
</tbody>
</table>

The team re-plotted the processing times excluding the machine time versus the number of instruments. This scatter plot yielded a lower correlation. The R-squared value from this regression was 3.3%, meaning that only 3.3% of the variability in processing times could be attributed to the number of instruments.

The team then decided to perform a stepwise regression, which performs repeated regression analyses to determine the optimal combination of predicting factors. (See Appendix I.) The regression found scissors, spraying, and number of instruments to be statistically significant; however, the R-squared value was only 8.3%. Although spraying was considered significant, the sample size of sprayed trays was 28, which the team considered too small to draw any relevant conclusions. Furthermore, spraying and soil level are non-predictive factors and could not be used to predict processing times. The team therefore decided to eliminate spraying and soil level from further analysis.

Since the team could not account for a large portion of the variance, the team attempted several other regression techniques, including transforming the data lognormally and grouping the trays by number of instruments. The regression analyses on both of the data sets yielded insignificant R-squared values.

The results of the team’s analyses could not conclude any significant predicting factors for machine wash tray processing times.

**Recommendations**

Based on the analysis discussed in the previous section, the team has outlined a series of recommendations for the development of time standards for trays and the implementation of a productivity tracking system based on these time standards.

**Time Standards**

For the hand wash tray time standard, the team recommends 1.9 minutes. Since the hand wash data had little variation, the team used the 70th percentile of the data to calculate this time. The 70th percentile takes into account the variation in the process.

The team recommends a time standard of 8.4 minutes for machine wash trays. The machine wash time data had high variation and did not correlate with any predictive factors the team analyzed. Since there was a significant difference in the processing times of trays processed by the sonic and trays not processed by the sonic, the team took these differences into account in the
time standard. From the data, 59.4% of trays are processed by the sonic. Based on this percentage, the team developed an algorithm predicting the expected tray decontamination time.

\[
\text{Tray Decontamination Time} = (\text{processing time}) + (\text{sonic time}) \times (\% \text{ through sonic}) \\
= 3.33 \text{ minutes} + 59.4\% \times 8.45 \text{ minutes}
\]

This equation takes the total processing time, including the time to break down, time to move the tray to the sonic, time to move the tray to the dishwasher rack, and adds the total sonic time multiplied by the percentage of trays that go through the sonic. Therefore, the resulting time is not the exact time for a particular tray, but a long run average of tray processing time. The team took the 70th percentile of the processing time, to be sensitive to the high variation and used the 50th percentile of the sonic processing time because machine time has less variation.

**Productivity Tracking System**

In developing a productivity tracking system the team was most sensitive to the concern of contamination and bio-hazardous material leaving the decontamination room. The team compared two possible systems, 1) Use a white board to tally tray completion, 2) File instrument count sheets to count trays completed.

**White Board Tally System**

The team considered hanging a white board for the Instrument Processors to tally completed trays and activities. This system is modeled after the productivity tracking system in the decontamination room at Mott Children’s Hospital. When an Instrument Processor completes a task listed on the board, he would make a tally mark in the correct category. If more than one Instrument Processor is working, different colors would be used. At the end of the day the Instrument Processor would sum the tallies and record the values on a productivity tracking sheet which would list the same tasks from the white board. The productivity tracking sheet would be turned into management daily or weekly. This system would provide visual management; a manager or supervisor could quickly stop in the decontamination room and use the board to gauge the productivity. The system would also motivate the Instrument Processors through competition because the board displays the work performed by each processor and the processors will want to remain equally productive. Since the white board would list tasks in addition to tray completions, the system would measure the non-routine work performed in the decontamination room. A disadvantage to this system would be the creation of additional walking for the Instrument Processors because they would have to walk to the white board to tally each completed task. This would system also rely on the honor system; Instrument Processors are on their honor to tally their own decontaminated trays. One way to mitigate this problem, however, would be to have the Instrument Processors file the count sheets into stackable letter trays and seal them in a peel pack at the end of the day. Management could compare the tally sums and number of count sheets to ensure they are equal.

**Instrument Count Sheet Filing System**

When interviewing the supervisors, the team and supervisors brainstormed filing the instrument count sheets. In this system, Surgery Technicians would place each instrument count sheet into the corresponding tray before setting the tray on the rack in the Decontamination Room. When an Instrument Processor begins the decontamination process, the Instrument Processor would file the instrument count sheet into a stackable letter tray with his name on it. At the end of the shift, the Instrument Processor would count the number of instrument count sheets in his tray and write the total on the productivity tracking sheet. The productivity tracking sheet would be turned into management daily or weekly.

Filing the instrument count sheets would minimize the additional time required to track productivity because the Instrument Processor could quickly place the paper into the letter tray
when he selects the tray from the rack. The file system would also provide a method to follow up that the work was performed since the supervisors could total the count sheets and compare this total to the total on the productivity tracking sheet. A disadvantage to file system is that it lacks visual management. Another disadvantage is that the system would rely heavily on the Surgery Technicians to place the count sheets in the trays before setting the trays on the rack. The final disadvantage is that the file system would not capture the time spent performing non-routine tasks.

**Recommendation: White Board Tally System**

The team considered advantages and disadvantages of each productivity tracking system and recommends using a white board tracking system. The white board tracking system is easier to implement and sustain because it does not rely on another department. The team observed the Instrument Processors performing non-routine work throughout their shift and the white board tracking system documents this work. The team recommends the following tasks to be listed on the white board for tracking: machine wash trays, hand wash trays, trash (including recycling and laundry), and hand wash cart transported to assembly. The white board tracking system also has visual management to help supervisors engage with Instrument Processors throughout the shift. The completed work tallies will be used in conjunction with the previously recommended time standards to calculate productivity score.

**Recommendations for Future Studies**

The team had initially hoped to devise a mathematical function to predict tray decontamination times based on tray attributes. However, as previously discussed, the analysis did not yield any strong predicting factors. The team hypothesizes that the attribute data collected was not detailed enough to bring out this correlation. The team used a binary scale to indicate the presence of certain types of instruments. Therefore, the team recommends using the existing time study data and adding more specific tray attributes, such as the number of scissors or cannulated instruments.

The scope of this project excluded loaned and peel pack instrument trays, so the team did not conduct time studies for these trays. Future studies should collect data including these trays to determine an overall long-range percentage of trays that go through the sonic. This new value could be used to improve the accuracy of the recommended algorithm.

**Expected Impact**

In conducting this study, the team developed a productivity tracking system for the UH OR Instrument Room decontamination process. The time studies provide work standards and the white board system will help management assess worker productivity and performance. With the potential implementation of barcode scanning technology, the work standards will provide a baseline to measure its effectiveness along with the effectiveness any other future process changes.
Appendix A: Sample Daily Activity Sheet

<table>
<thead>
<tr>
<th>NAME:</th>
<th>INITIALS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE:</td>
<td>1ST BREAK: out in</td>
</tr>
<tr>
<td>SHIFT HOURS:</td>
<td>LUNCH: out in</td>
</tr>
<tr>
<td>OVERTIME HOURS:</td>
<td>2ND BREAK: out in</td>
</tr>
<tr>
<td>DAILY ASSIGNMENT: Core:</td>
<td>PRIME TASK:</td>
</tr>
</tbody>
</table>

### POINT ACTIVITIES:
*Put a tick mark for each time activity done*

<table>
<thead>
<tr>
<th>Activity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel Packs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loads Set Down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loads Put Away</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Of Times Steril/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autoclave/Sterrad/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unload Washer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trips to Core:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assist OR Staff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(tie per 2 min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set up/Clean Up</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

**I HAVE COMPLETED ALL WORK AS I LISTED:**

**SIGNATURE:**

### TIMED ACTIVITIES:
*List # minutes spent for each activity done*

<table>
<thead>
<tr>
<th>Activity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decontam:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restock:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core C Travel:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc: List out activity &amp; times:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### WRAPPED ITEMS (No Count Sheet):
*List Wrapped Items with No Count Sheet*

<table>
<thead>
<tr>
<th>Wrapped Items</th>
<th># Wrapped</th>
<th>Interruptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Please document your work legibly to ensure you get credit for it!

Revised: 8/16/2007

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### Appendix B: Time Study Data Collection Sheet

<table>
<thead>
<tr>
<th>Data Collection:</th>
<th></th>
<th>&quot;X if condition is yes&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case</th>
<th>Tray</th>
<th>Tray placed on rack</th>
<th>Processor grabs tray off rack</th>
<th>Tray on rack</th>
<th>Tray on</th>
<th>Tray in rack</th>
<th>Tray on conveyor</th>
<th>Tray enters washer</th>
<th>Tray exits washer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

23
Appendix C: Supervisor Interview Questions:

1. Describe your role in the instrument room.

2. What are the pros and cons of the current productivity system in the instrument room?

3. What are any ideas that you may have as to tracking the productivity system in the decontamination room?
Appendix D: Reports

Appendix E: Mott Children’s Hospital Decontamination Process Flow Chart

1. Surgery Technician delivers bi-pod with instrument trays

2. Instrument Processors selects tray and count sheet

3. Instrument Processors initials, dates, and timestamps the count sheet

4. Instrument Processor counts instrument and checks off on count sheet

5. All instruments checked?
   - Yes
   - No
     - Notify supervisor who begins to track down missing instrument

6. Rinse machine available?
   - Yes
     - Place in rinse machine
   - No
     - Place in sonic machine

7. Washer open?
   - Yes
     - Place tray in washer
   - No
     - Place on cart
Appendix F: Machine Wash vs. Hand Wash Processing Time T-Test

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of P/T-HW</td>
<td>29</td>
<td>1.59</td>
<td>1.23</td>
<td>0.23</td>
</tr>
<tr>
<td>Total P/T Mins</td>
<td>201</td>
<td>7.67</td>
<td>7.10</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Difference = μ (Minutes of P/T-HW) - μ (Total P/T Mins)
Estimate for difference: -6.075
95\% upper bound for difference: -5.166
T-Test of difference = 0 (vs <): T-Value = -11.04  P-Value = 0.000  DF = 222
Appendix G: Hand Wash Processing Time Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SE Mean</th>
<th>StDev</th>
<th>Variance</th>
<th>Minimum</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of P/T</td>
<td>1.593</td>
<td>0.228</td>
<td>1.230</td>
<td>1.512</td>
<td>0.200</td>
<td>0.717</td>
<td>1.083</td>
<td>2.250</td>
</tr>
</tbody>
</table>

N for Variable
<table>
<thead>
<tr>
<th>Variable</th>
<th>Maximum</th>
<th>Range</th>
<th>Mode</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of P/T</td>
<td>5.083</td>
<td>4.883</td>
<td>0.933333</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix H: Machine Wash Processing Time Regression Analysis Output

The regression equation is
Minutes of P/T = 1.13 + 0.0848 No of Instruments

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.1254</td>
<td>0.3011</td>
<td>3.74</td>
<td>0.001</td>
</tr>
<tr>
<td>No of Instruments</td>
<td>0.08478</td>
<td>0.03839</td>
<td>2.21</td>
<td>0.036</td>
</tr>
</tbody>
</table>

S = 1.15248  R-Sq = 15.3%  R-Sq(adj) = 12.2%

Two-sample T for Total P/T Mins vs P/T excl Mach Time

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total P/T Mins</td>
<td>201</td>
<td>7.67</td>
<td>7.10</td>
<td>0.50</td>
</tr>
<tr>
<td>P/T excl Mach Time</td>
<td>201</td>
<td>2.74</td>
<td>3.40</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Difference = mu (Total P/T Mins) - mu (P/T excl Mach Time)
Estimate for difference: 4.923
95% CI for difference: (3.831, 6.016)
T-Test of difference = 0 (vs not =): T-Value = 8.87  P-Value = 0.000  DF = 286
Appendix I: Stepwise Regression for Machine Wash Instruments 04/17

Stepwise Regression: P/T excl Mac versus No of Instru, Sprayed, ...

Alpha-to-Enter: 0.15  Alpha-to-Remove: 0.15

Response is P/T excl Mach Time on 5 predictors, with N = 177
N(cases with missing observations) = 24 N(all cases) = 201

<table>
<thead>
<tr>
<th>Step</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.784</td>
<td>1.951</td>
<td>1.739</td>
</tr>
<tr>
<td>Scissors</td>
<td>1.52</td>
<td>1.48</td>
<td>0.99</td>
</tr>
<tr>
<td>T-Value</td>
<td>3.26</td>
<td>3.18</td>
<td>1.75</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.001</td>
<td>0.002</td>
<td>0.082</td>
</tr>
<tr>
<td>Sprayed</td>
<td>-1.10</td>
<td>-1.14</td>
<td></td>
</tr>
<tr>
<td>T-Value</td>
<td>-1.59</td>
<td>-1.66</td>
<td></td>
</tr>
<tr>
<td>P-Value</td>
<td>0.113</td>
<td>0.099</td>
<td></td>
</tr>
<tr>
<td>No of Instruments in Tray</td>
<td>0.0114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-Value</td>
<td>1.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-Value</td>
<td>0.128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>3.09</td>
<td>3.08</td>
<td>3.07</td>
</tr>
<tr>
<td>R-Sq</td>
<td>5.73</td>
<td>7.09</td>
<td>8.33</td>
</tr>
<tr>
<td>R-Sq(adj)</td>
<td>5.19</td>
<td>6.02</td>
<td>6.74</td>
</tr>
<tr>
<td>Mallows Cp</td>
<td>3.0</td>
<td>2.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>