University of Michigan Health System

Program and Operations Analysis

Analysis of the Sterilization Process of Surgical Instruments to Reduce Turnaround Time in the Central Sterile Supply at the University of Michigan Hospital

Final Report

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Executive Summary

Introduction and Background

The primary task of the Central Sterile Supply (CSS) is to sterilize instruments used for surgical procedures. These surgical instruments come from the Operating Room Instrument Room (OR IR), the Cardiovascular Center (CVC), Mott's Children Hospital, and other University of Michigan Health System facilities (UMHS). Previous studies on the CSS have taken place as past IOE 481 projects. In 2003, another IOE 481 team recommended the addition of two new sterilizers. Even with these additions, backups and long turnaround times still occurred. Further analysis was needed to reduce turnaround time, which is the time instrument carts are sent to the CSS to when they are sent back to its original location. Therefore, the Manager of the Central Sterile Supply has asked DYVP Associates to analyze the sterilization process and provide recommendations to reduce the turnaround time for carts sterilized in the CSS.

Current Sterilization Process for the CSS

Currently, the CSS receives carts from the OR IR via a single cart elevator. The carts are removed from the elevator and loaded into one of four sterilizers when available. The cart is sterilized for either 4 minutes or 8 minutes depending on what instruments are on the cart. Once the carts are finished sterilizing, they are removed from the sterilizer and dried for forty-five minutes and cooled for one-hour. If the cart contains implants, the cart must be quarantined for a three hour period. After this process, the sterilized instruments are sent back to the OR IR for storage.

Goals and Objectives

To assess the problems that are contributing to the overall sterilization turnaround time, DYVP Associates identified two main goals:

- Identify the bottlenecks that cause the slow turnaround time
- Provide recommendations in the areas of staffing, communication, and equipment

The objectives for this project included:

- Allocating human capital more effectively
- Removing process bottlenecks
- Reducing process variance
- Enabling CSS to communicate more effectively with external entities
- Shifting cart flow from batching to continuous

Project Scope

The scope of the project included all three shifts of the CSS and OR IR. Furthermore, only the carts coming from the OR IR were taken into account. The team also only analyzed the four steam sterilizers.

Data Collection

Data collection occurred from January 18th – March 7th. Six methods of data collection were used to assess the slow turnaround time of the sterilization process.

- Process Flow Log Forms: A form that tracked the time of the instrument cart through each part of the sterilization process. Used to assess what part of the sterilization process was most prone to slowdowns.
- Observations: All three shifts of the CSS and the OR IR were observed. Used to understand the process of sterilization.
- Cart Tracking Form: A form created by DYVP Associates that required CSS employees to record the time when carts were received from the OR IR and shipped back to the OR IR. Used to identify the peak travel time between the OR IR and the CSS.
- Receipts and Load Statistics: Print outs from the sterilizers that recorded the time when instrument carts were loaded into the sterilizer and when they were removed from the sterilizer. Used to validate the reliability of the Process Flow Log Forms.
- Interviews: Interviews occurred with the Manager of the CSS, the Manager of the OR IR, and the CSS and OR IR employees. Used to provide expert opinion of the slow turnaround time.
- Literature Searches: Previous IOE 481 projects and Sterilization journals were provided to DYVP Associates by the Manager of the CSS. Used to provide a general background of the sterilization process.

Findings and Conclusions

Analysis of the CSS found that three areas –staffing, communication, and equipment were the cause of slow turnaround time for the CSS.

Staffing – Night shift has smallest workforce but the highest productivity

- Only two employees are scheduled to work the night shift.
- The night shift received more carts.
- Bowie Dick test is run during the night shift utilizing all four sterilizers.
- Night shift sterilizer utilization rate is higher than the other shifts.

Communication – Lack of communication between CSS and OR causes delay

- No alert system when elevator arrives in both the CSS and OR IR.
- Mean travel time for carts is 14 minutes and 23 seconds with a standard deviation of 23 minutes and 44 seconds. The ideal cart travel time is 5 minutes.
- No alert system for when sterilization of the carts are complete.
- Mean time in sterilizer is 1 hour and 28 minutes. The ideal sterilization time is 1 hour and 15 minutes.

Equipment – Insufficient number of instrument carts between the CSS and OR IR induces batching

- A computer simulation created by DYVP suggests that at a given time 10 of the 12 carts can be in the CSS.
- Observations indicate times when OR IR does not have any carts to load instruments on, which causes batching of the carts sent to CSS.

Recommendations

Based on the findings shown above, DYVP has concluded that the CSS can improve staffing, communication, and equipment in order to reduce the turnaround time for carts needed to be sterilized.

- Staffing - Add an extra employee to the 11pm – 6am shift, Monday – Friday (Night Shift)

- Communication - Install an alert system with audio and visual signals to notify employees that a cart has arrived by elevator and that an instrument cart is done being sterilized.

- Equipment - Purchase 2 – 4 carts to run between the OR IR and CSS

Introduction

The main function of the Central Sterile Supply (CSS) Center at the University of Michigan Hospital is to ensure that the instruments coming from the Operating Room Instrument Room (OR IR), the Cardiovascular Center (CVC), Mott's Children Hospital, and other University of Michigan Health System (UMHS) facilities are properly sterilized. Currently, the CSS is experiencing long turnaround times, which is defined as the time instrument carts are sent to the CSS to when they are sent back to their original location. The CSS staff is interested in finding ways to reduce the turnaround time in order to make the sterilization process more efficient. Therefore, the CSS has asked DYVP Associates to analyze the sterilization process and provide recommendations in the areas of staffing, communication, and equipment in order to reduce the turnaround time for carts sterilized. The purpose of this report is to present DYVP's methods, findings, and recommendations developed to make CSS more efficient at sterilizing instrument carts.

Background

In 2003, another IOE 481 team conducted research on the turnaround time for carts in the Central Sterile Supply ("Analysis of Turnaround Time for Sterilization Carts Between Operating Room and Central Sterile Supply." *E. Battjes, B. Beyerlein, M. Crowe, S Kabacinski*). Recommendations of two additional steam sterilizers were suggested to the Manager of the Central Sterile Supply, however, the changes did not improve the process turnaround time as much as expected. Therefore, CSS has asked the team to analyze the current sterilization process and determine how the turnaround time can be reduced.

Carts containing supplies to be sterilized are assembled in the OR IR, CVC, and other facilities in the UMHS. These carts are then sent to CSS to be sterilized. Currently, CSS is experiencing surges in demand for sterilization which result in backups and bottle necks in the current sterilization process. Carts from the OR IR are transported to the CSS in an equipment elevator that connects the CSS and the OR IR. The elevator is designed to hold one six foot cart. Carts from the other UMHS facilities are delivered to the CSS by courier.

When a cart arrives at the CSS, it is placed into one of four steam sterilizers if one is available; otherwise the cart enters a queue. The sterilization process consists of running a cart through the steam sterilizer for either a 4- or 8- minute cycle depending on what items are on the cart. The cart stays in the sterilizer for a 45- minute drying period and then is removed from the sterilizer for a 1-hour cooling time. If the cart contains implant materials, the cart is held for a 3-hour biological verification period. The cart is then shipped to its original location.

Goals and Objectives

The primary goal of the project was to identify the bottlenecks in the sterilization process and to provide recommendations in the areas of staffing, equipment and communication to reduce the slow turnaround time.

DYVP Associates met the following objectives when completing this project:

- Allocated human capital more effectively
- Removed process bottlenecks
- Reduced process variance
- Enabled CSS to communicate more effectively with external entities
- Shifted cart flow from batching to continuous

Project Scope

The following areas will be included and excluded in the team's project:

- Included:
  - All 3 shifts
  - Process flow studies in the CSS and the OR IR
  - Carts sent from OR IR to CSS
- Excluded:
  - Carts that used the gas sterilizers
  - Carts entering CSS from any other UMHS facilities

Key Issues

The key issues that were considered are listed below:

- The elevator that transports a cart between the OR IR and CSS has a one cart capacity.
- The addition of another elevator is not feasible.
- Carts tend to build up at both the CSS and the OR IR towards the end of shifts.
- Carts that contain implants must stay in the CSS until the 3-hour verification test has been completed.
- No device signals an employee that a cart remains in the elevator after it has arrived.

Since the capacity of the elevator is predetermined and cannot be increased, it acts as a binding constraint. Without a signal for CSS or the OR IR to know that a cart is in the elevator, a cart may sit in the elevator for an extended period of time. This prevents the transport of any other cart between the CSS and OR IR. All of these issues brought to the team's attention were analyzed after data collection to determine their validity.

Data Collection

DYVP, from January 18th through March 7th collected data in both the CSS and the OR IR. Six methods of data collection were used to analyze the causes of the bottlenecks that occurred in the CSS. Detailed information of each type of data collection is shown below.

Process Flow Log Forms

The team created a Process Flow Log Form to be completed by CSS employees (seen in Appendix B) in order to track carts through the sterilization process. The following information was collected from the log forms:

- Log Sticker with log number and date of each cart
- Time cart was received/removed from the elevator
- Time cart was loaded into the sterilizer
- Time cart was removed from the sterilizer
- Time cart was sent to destination
- Whether the carts contained implants

The data collected from the Process Flow Log Forms provided DYVP Associates an understanding of which parts of the sterilization process were most prone to slowdowns.

Observations

From January 18th - March 7th, DYVP observed all three shifts of the CSS and OR IR. The following information presents the team's observations.

CSS

The team spent the majority of the available observation time in the CSS. Below is a list of the observations made.

- During times of high demand, carts were often sent in batches, which led to bottlenecks.
- The Bowie Dick test (an industry-standard daily sterilizer test) was run at midnight every day.
- CSS experienced the highest demand from 12:00 AM – 4 AM.
- Carts from the OR IR arrived at the end of the shifts.
- CSS held approximately five empty carts at any given time (to be used for Motts and CVC loads).
- CSS staff, who work the morning and afternoon shifts, have less work to do than the night shift staff.
- Sometimes there was a time delay between when carts arrived at CSS and when CSS staff unloaded them from the elevator.
- The CSS staff had a great deal of expertise and knowledge about the sterilization process.

OR IR

Although most of the data collection was done in the CSS, DYVP spent 10 minutes of each hour observing the OR IR. Below are DYVP's OR IR findings.

- For nearly all loads, multiple carts had similar items loaded simultaneously (as opposed to one cart being loaded with those items more quickly).
- More carts were sent down to CSS at the end of a shift than at any other time during the rest of a shift.
- While the OR IR staff always remembered to notify the CSS of an incoming cart, the cart wasn't always sent down at the time indicated.
- Genesis cases (a certain type of item that is used by the OR IR) must be below everything else on the cart, except for other genesis cases.
- Sometimes there was a shortage of carts when the OR IR had four to five loads of material ready to be sent to the CSS.

Cart Tracking Form

In addition to the Process Flow Log Forms, each cart had an accompanying tracking form, per CSS protocol. The tracking forms provided the following information for 292 loads:

- Time the OR IR sent a cart to the CSS
- Time the CSS received the cart
- Time the CSS sent the cart back to the OR IR
- Time the OR IR received the cart

The data was useful in helping DYVP understand the duration of key parts of the sterilization process. In addition, the team was able to use the data to identify the peak cart travel time between the OR IR and CSS.

Receipts and Load Statistics

CSS also provided DYVP with receipts from the sterilizers which documented the exact time a sterilization cycle started and ended. The data was used to verify the reliability of the Process Flow Log Forms. CSS has also provided the team with load statistics, which documented the number of carts and items sterilized each day starting from January 1st, 2008.

Interviews

DYVP Associates interviewed the Manager of the CSS, the Manager of the OR IR and the employees working in both the CSS and the OR IR. Some of the main questions DYVP asked employees are listed below:

- How often do carts arrive in the CSS?
- What is the process of sending the carts down to the CSS (OR IR specific)?
- What is the process of receiving the carts from the OR IR (CSS specific)?
- Where do the problems arise in the process?
- How are items sorted onto carts for sterilization?

The interviews helped the team understand the sterilization process from an employee viewpoint. The information was crucial in identifying non-measured issues, such as tensions between CSS and OR IR staff members. The interviews also helped DYVP understand the differences between how the process should work and how it actually works.

Literature Search

The Program and Operations Department has given the team a project report completed by a previous IOE 481 team. The report, "Analysis of Turnaround Time for Sterilization Carts Between Operating Room and Central Sterile Supply." *E. Battjes, B. Beyerlein, M. Crowe, S Kabacinski,* has provided the team with additional information on the background of the Central Sterile Supply prior to the changes the department made.

In researching the possibility of changing the time the Bowie Dick test is conducted, the team also referenced *Sterilization, Part I. Sterilization in Health Care*, published by the Association for the Advancement of Medical Instrumentation which defines the national standards for sterilization.

Findings and Conclusions

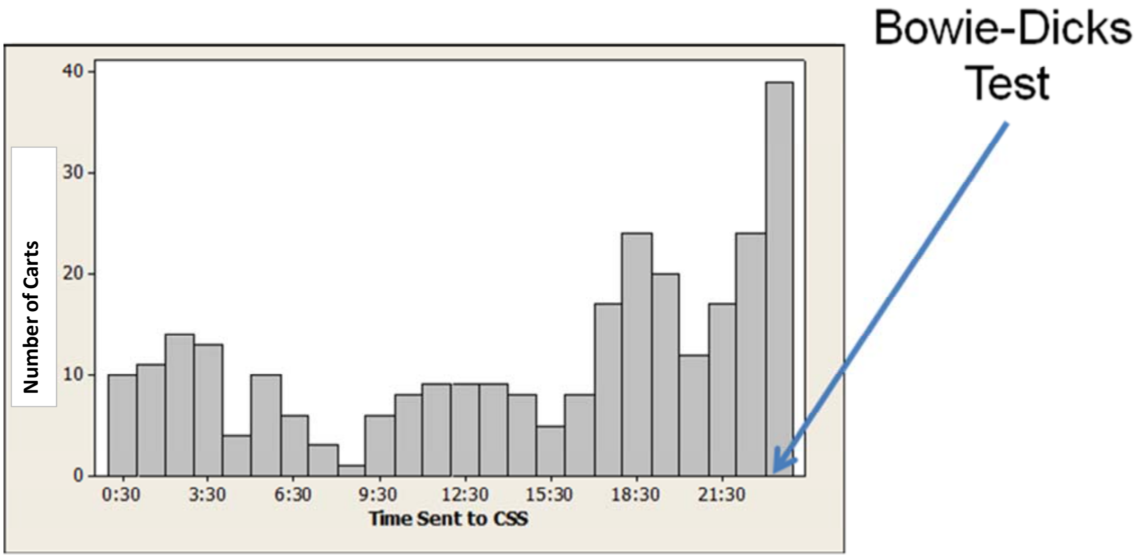
Using the Process Flow Log Form and the CSS Tracking Form, DYVP was able to obtain the following data for analysis

- Time when carts are sent to CSS
- Time when carts are sent back to the OR IR,
- Time carts arrive in the OR IR
- Time when the carts should be ready to be sent to CSS
- Travel time of carts from the OR IR to CSS
- Time carts spend in the CSS before being sent back to the OR IR
- The utilization of the sterilizers in CSS
- Comparison of CSS sterilization workload and staffing

With the information provided above, the team has conducted analysis in three areas-staffing, communication, and equipment.

Staffing Analysis - Night shift has smallest workforce but the highest productivity

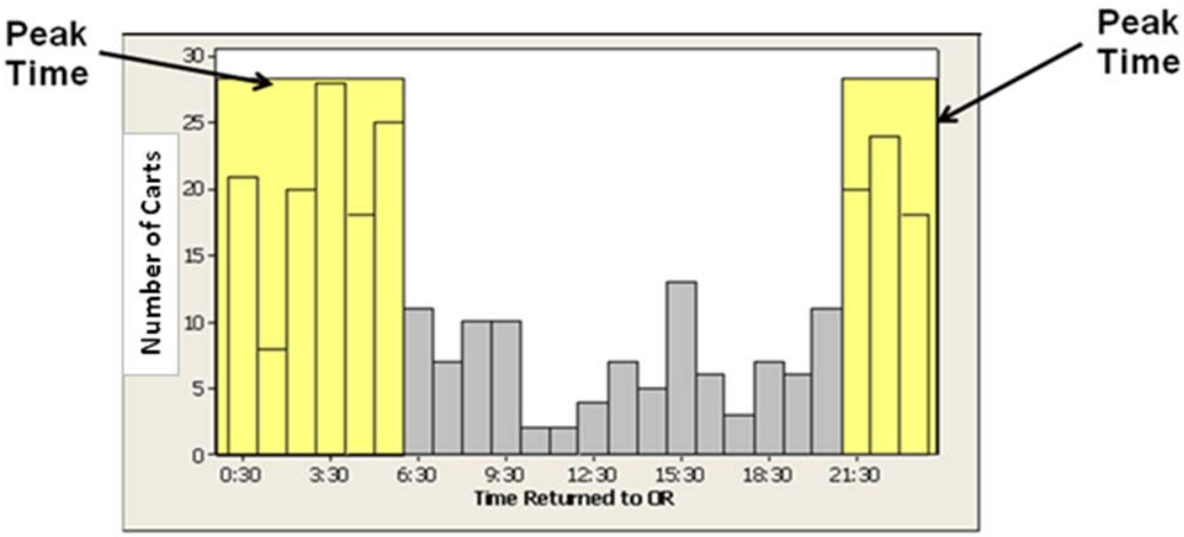
The team created a histogram from a sample of 292 Process Flow Log Forms collected from Jan 18th, 2008 to February 14th, 2008. The histogram is shown below.



** Data collected from 292 tracking forms between January 18th – February 14th 2008**

Figure 1: Night shifts received more carts compared to other shifts.

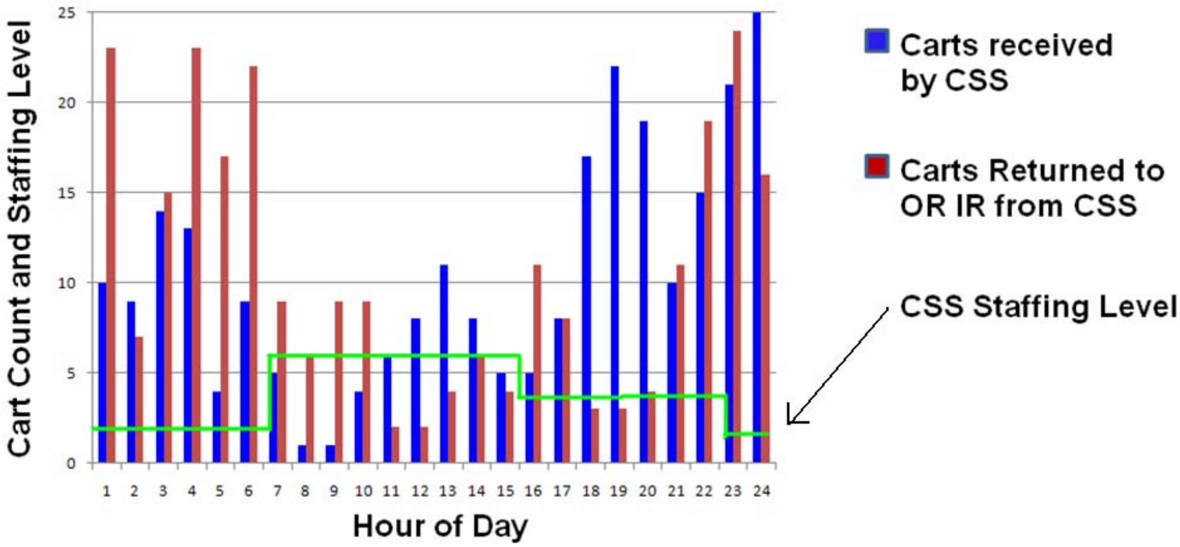
Figure 1 shows a large influx of carts sent to the CSS from 6:30 PM to midnight, establishing that CSS received more carts during this time of day than any other time of day. Also shown in Figure 1 is the time the Bowie-Dicks test is run daily. This test is run on each of the four steam sterilizers to confirm a vacuum seal. The team also created a histogram showing the distribution of when these carts were sent back to the OR IR. This histogram, shown in Figure 2, indicates that from 9:30 PM to 6:30 AM most of the carts in the CSS are returned to the OR IR.



** Data collected from 292 tracking forms between January 18th – February 14th 2008**

Figure 2: CSS night shift sent more carts back to OR IR compared to other shifts.

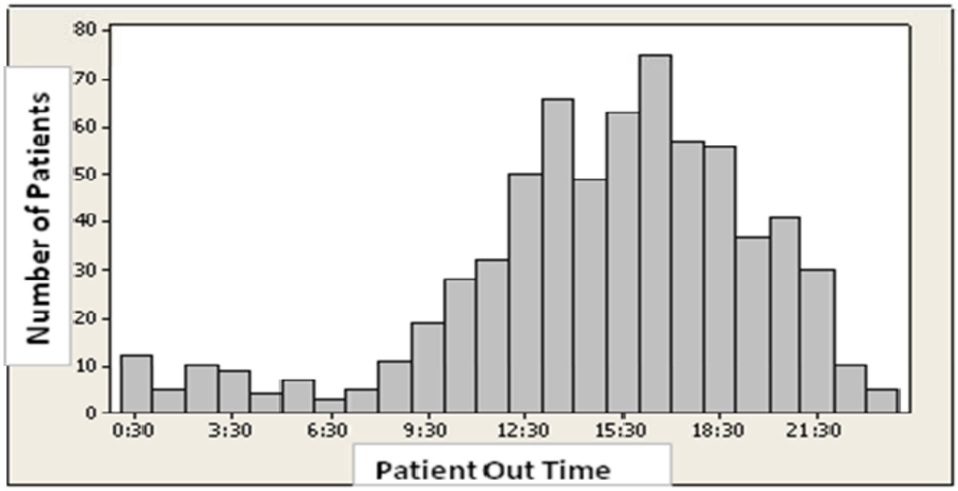
To determine when the sterilization workload was the highest for the CSS and what the workforce level was during that period, the team constructed a two bar graph showing the distribution of carts sent to the CSS and the distribution of carts returned to the OR IR by the hour of day. The team also juxtaposed these distributions with the CSS staffing levels. This graph can be seen below.



** Data collected from 292 tracking forms between January 18th – February 14th 2008 and from CSS and OR IR Staff

Figure 3: Compared to all shifts, CSS sterilization workload was highest and workforce was lowest

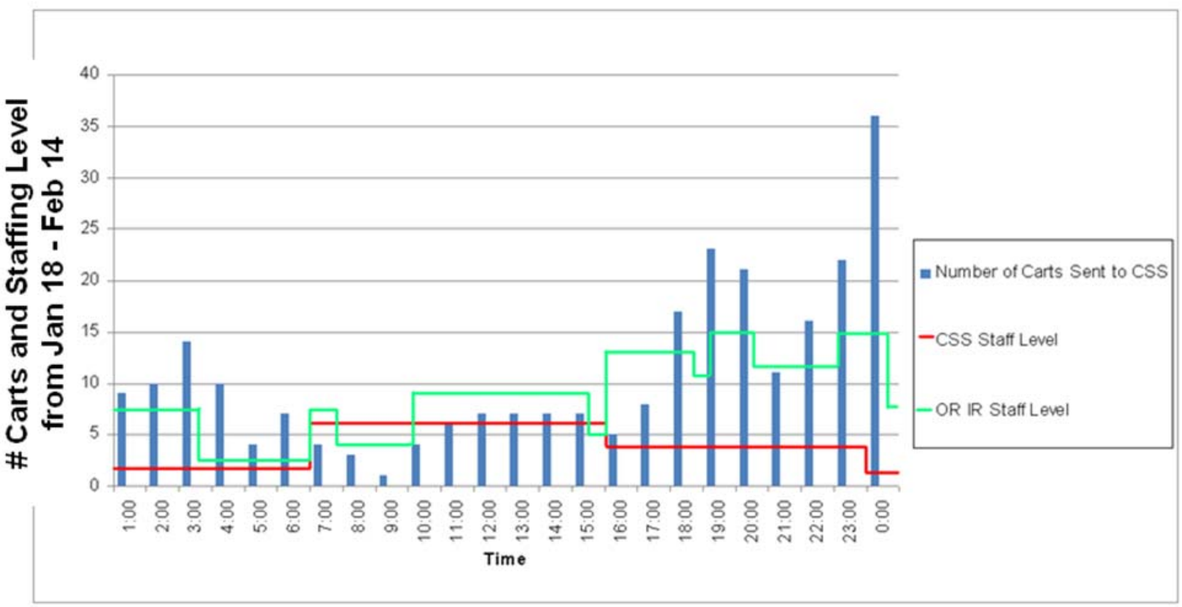
Figure 3 indicates that CSS has its largest sterilization workload between 9 PM and 6 AM, which is also when CSS has its lowest workforce. At 11 PM the CSS workforce drops from 4 to 2 until 7 AM the next morning. Further analysis of this information was needed to understand what was causing the increase workload. Therefore, the team decided to see when the OR IR received carts after surgeries. To do this, the team analyzed the patient out time for a total of 684 patients between the dates of January 18th 2008 through February 14th 2008. The figure below shows the team's findings.



** Data collected from 684 patient surgeries between January 18th – February 14th 2008**

Figure 4: Patient Out Time is normally distributed which should cause CSS cart arrivals to be normally distributed with a 2 hour shift to the right.

According to the OR IR Manager, the expected decontamination time is 2 hours after patient out time. The distribution for carts sent to the CSS should follow the same distribution as in Figure 4 but with a slight shift of 2 hours to the right. However, as seen in Figure 1, this is not the case. The team decided to conduct further analysis on the spike in carts sent to CSS by comparing the distribution of carts sent to CSS with the workforce levels of both the CSS and the OR IR. This can be seen in the figure below.



** Data collected from CSS Tracking Forms between January 18th – February 14th 2008 and from CSS and OR IR Staff**

Figure 5: CSS staffing is lowest when OR IR staffing is highest

Figure 5 shows that the OR IR has its largest workforce when CSS has its smallest workforce and that the CSS also has its largest workload at this time. This discrepancy in the CSS staffing levels caused concern about whether or not the night shift workforce was properly staffed to handle the increased workload.

Using the times provided by the CSS Tracking Form, DYVP calculated the ideal and mean time for carts sterilized in the CSS. This is shown in Table 1. Table 1 verifies that the mean time for carts sterilized in the CSS is a third greater than the time it should be.

Table 1: Mean time in CSS is a third greater of the ideal time

Cart Type	Ideal Time in CSS	Mean time in CSS	Std. Deviation	Difference (Actual-Ideal)
Without Implants	**2 hours 13 minutes**	**3 hours 16 minutes**	**1 hour**	**1 hour 3 minutes**
With Implants	**4 hours 13 minutes**	**5 hours 53 minutes**	**2 hours 44 minutes**	**1 hour 40 minutes**
All	**2 hours 44 minutes**	**3 hours 59 minutes**	**2 hours 2 minutes**	**1 hour 15 minutes**

** Data collected from 292 tracking forms between January 18th – February 14th 2008

Table 2 below shows the difference of each shift's turnaround time excluding data collected from the weekends. The night shift is shown to have the highest turnaround time of all three shifts.

Table 2: Turnaround time is greatest for the night shift

Shift (Non-weekend)	Median Turnaround Time
6 AM- 3 PM	**3 hour 29 minutes**
3 PM- 11 PM	**3 hours 32 minutes**
11PM- 6 AM	**3 hours 57 minutes**

** Data collected from tracking forms between January 18th – February 14th 2008**

DYVP also decided to calculate the utilization of all the sterilizers by shift. Table 3 shows the calculate results.

Table 3: Sterilizer utilization rate is the greatest during the night shift

Shift	Utilization
6 AM- 3 PM	**23.6%**
3 PM- 11 PM	**31.0%**
11 PM- 6 AM	**41.7%**

Data collected from sterilizer receipts and load statistics from January 18th – February 14, 2008

As can be seen from Table 3, the night shift (11 PM-6 AM) has the highest utilization. From this information the team determined that the night shift is the busiest.

Table 4 shows that even though the night shift has a smaller workforce and a larger sterilization workload, carts spend less time in the sterilizers and less time in the CSS.

Table 4: Night shift sterilizes carts faster than other shifts but all shifts exceed the ideal time needed to sterilize carts

Metric	Night Shift	All Shifts
Time from sterilization start to OR IR return	**3 hours 20 minutes** **Expected Value:** **2 hours 44 minutes**	**3 hours 26 minutes**
Mean time in sterilizer	**1 hour 15 minutes**	**1 hour 23 minutes**

** Data collected from tracking forms between January 18th – February 14th 2008**

From this information, the team decided that the night shift is more efficient in sterilizing carts since less time was wasted loading and unloading carts in and out of the sterilizers. Even though the night shift produced better results than the morning or afternoon shift, its process was still 36 minutes over the ideal time in the sterilizer.

Communication Analysis - Lack of communication between CSS and OR IR causes delay

DYVP Associates found the following areas were of concern to the CSS in regards to communication between the CSS and OR IR:

- The CSS and OR IR employees were not alerted when the elevator arrived with a cart.
- CSS employees were not alerted when the sterilizer cycle ended.
- CSS employees were not alerted when biological tests for carts containing implants were completed.

The team decided to analyze the mean travel time of carts sent from the OR IR to CSS to determine the time wasted while a cart remained unloaded in the elevator. Table 5 shows this information.

Table 5: Mean travel time is greater than ideal time it takes a cart to be sent from the OR IR to the CSS

Mean Travel Time	Std. Deviation
14 minutes 23 seconds	**23 minutes 44 seconds**

** Data collected from tracking forms between January 18th – February 14th 2008**

Table 5 shows that the mean travel time is 14 minutes and 23 seconds and has a standard deviation of 23 minutes 44 seconds. Even with a time buffer the travel time shouldn't last more than 5 minutes. This means that the current travel time is 9 minutes and 23 seconds over the ideal time it should take a cart to be sent from the OR IR to the CSS.

Next, DYVP analyzed how much actual time carts spend in the sterilizers. The actual sterilization time should be 1 hour 15 minutes. Table 6 shows the calculated mean time for carts sterilized in the CSS.

Table 6: Mean time in sterilizer is greater than ideal time a cart takes to be sterilized

Mean time in sterilizer	Ideal time in sterilizer
1 hour 28 minutes	**1 hour 15 minutes**

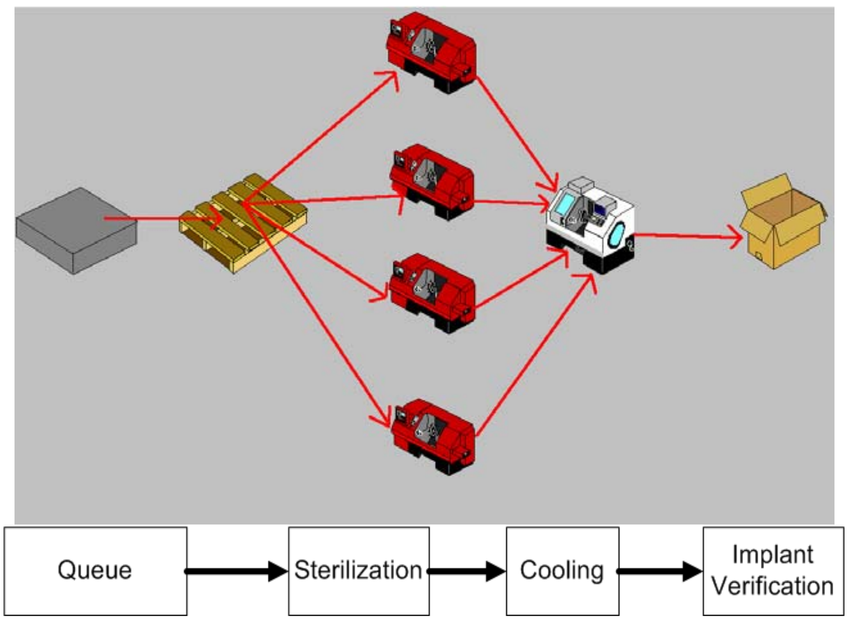
** Data collected from tracking forms between January 18th – February 14th 2008**

Carts spend 13 minutes more than they should in the sterilizers according to Table 6. Although this may not seem like a significant amount of time, 39 carts are processed on average per day, which can lead to an extra 8 hours and 27 minutes of sterilization per day. The team also found that carts containing implants are supposed to spend three hours after sterilization to confirm a biological test. The team made observations that found carts sometimes spend three additional hours in the CSS past the verification period.

Equipment Analysis - Insufficient number of sterilization carts between the CSS and OR IR induces batching

From examining the trends of when carts are trafficked between CSS and OR IR, DYVP believes that some of the delay in turnaround time is due to surges in carts at peak times. Recalling Figure 5, carts travel back and forth during peak times in batches, leading to bottlenecks and reduced efficiency. DYVP felt that a potential cause of this was an insufficient number of carts. If more carts were available, OR IR would be able to send carts to CSS on a more continuous basis.

To further its understanding of the implications of the total number of carts, DYVP developed a computer model of the CSS sterilization process using ProModel, a simulation software package. The model focused on the night shift (11 PM–6 AM) because the night shift had the heaviest workload and the longest turnaround time. A picture of the model can be found below in Figure 6.



ProModel Simulation Computer Software Program

Figure 6: Picture of the ProModel Simulation of the CSS Sterilization Process

Computer models are predictive and imperfect representations of complex processes. While DYVP made every effort to mimic the real process, simplifying assumptions had to be made in the construction of the model. Below are DYVP's assumptions:

- All carts were sterilized for the ideal sterilization time, 1 hour 15 minutes
- Since 26% of carts during the evening shift contain implants, 26% of carts in the simulation were assumed to be implant carts. This was assigned randomly.
- Carts were loaded first into the sterilizer at the top of Figure 6 and last into the bottom sterilizer.
- The model was preloaded with the conditions inherited from the previous shift
- All four sterilizers were shut down for 1 hour 15 minutes at midnight to mimic the Bowie Dick's test
- The simulation was run for 7 hours, the length of the night shift
- The model had a 12 cart capacity

Using Minitab, a statistical software package, DYVP was also able to estimate the distribution of cart arrival times with 95% confidence. This distribution was used to govern the arrival of carts during the course of the simulation.

To validate this model for resemblance to the real system, DYVP compared the model and the real system across three measures:

- The number of carts sterilized during the night shift
- The mean sterilization time
- The sterilizer utilization rate.

As shown in Table 7, DYVP's model is a bit leaner than the real system but it still provided an adequate representation of the sterilization process. The differences between the model and the real system can be attributed to the simplifying assumptions made in the model. Another key difference is that the model, being a computer program, follows the rules assigned to it whereas the real human system doesn't always do so.

Table 7: Comparison of Computer Model to Actual Sterilization Process Across Key Metrics

Parameter	Model	Real System
Total Carts Sterilized	**14**	**14**
Average Time in System (hrs)	**3:15**	**3:57**
Sterilizer Utilization	**59%**	**41.7%**

Data output given to DYVP from ProModel Software

The model also revealed a few more statistics about the system that DYVP was unable to collect during its research process. As shown below in Table 8, CSS could have up to 6 carts waiting during the night shift. This means that at least 10 carts (6 waiting and 4 sterilizing) could be in CSS at a given time. This number is potentially higher depending on how many carts are cooling or being held due to implant material. Recalling that there are only 12 carts for use between the CSS and the OR IR, the model shows that at peak times the OR IR can potentially have only one or two carts on which to load its instruments. Observations indicated that 4-5 loads worth of material ready for sterilization are waiting to be loaded onto carts to be sent to the CSS.

Table 8: ProModel Simulation indicates that 10 of 12 carts could be located in CSS at any given time.

Parameter	Model
Maximum queue length	**6**
Average carts cooling	**1.75**
Average carts being held for implants	**1.56**

Data output given to DYVP from ProModel Software

With a working model in place, DYVP altered the model to show what would happen if 2 additional carts were purchased. All assumptions from the previous model were held constant. The results from this altered model are shown below in Table 9.

Table 9: Optimization of the CSS process indicates that the addition of 2 carts would allow for 6 free carts at any given time.

Category	12 Carts	14 Carts
Average time in system (hrs)	**3:15**	**2:45**
Maximum queue length	**6**	**1**
Average carts in cooling	**1.75**	**1.56**
Average carts being held for implants	**1.56**	**1.26**

Data output given to DYVP from ProModel Software

In all categories examined, the 14 cart system is more efficient. Perhaps the most promising result of all is that the queue length was reduced dramatically, thus freeing up more carts for circulation between CSS and OR IR. This also reduced the peak-hour batching that DYVP has observed and spread out the workload over a larger time span.

Recommendations

To improve the turnaround time in the CSS, the team made recommendations in three areas: staffing, communication, and equipment.

Staffing Recommendations – Add employee to the night shift

Since the sterilization workload is the largest from 11 PM-6 AM and the workforce is the smallest, the human capital resources are not sufficient to meet the workload demands in the night shift. The turnaround time is still 36 minutes over the ideal sterilization time. Thus, an ideal place to add an additional worker would be the night shift. The large surge of carts arriving to CSS during this shift makes the night shift the ideal choice for adding an extra employee. Since the client indicated that she had two job openings, DYVP decided that the next best shift to add an employee would be the 9 PM-5 AM shift. This shift is a reasonable time to add an extra employee because most carts are sent back to the OR IR at this time. The Bowie Dick test should also not run at midnight but instead run at the slowest time during the day, which is 11:00am.

Communication Recommendation- Install visual and audio signal in CSS and OR IR

Communication is insufficient between the CSS and the OR IR. The communication process lacks consistency and reliability, which adds to excess turnaround time. To reduce the mean travel time of the instrument cart, an alert system should be added to the CSS and OR IR. An alert system with both visual and audio signals is necessary to ensure that once the cart reaches the CSS, it will be removed from the elevator. CSS should install a system that has a light flash along with a subtle yet noticeable alarm that goes off when the elevator arrives to the respective area. In the OR IR, the light and alarm should be placed in the area where the decontamination takes place. Adding an alert system with audio and visual signals would decrease the travel time of carts from the OR IR to CSS by about 10 minutes (from over 14 to 2-3 minutes) and improve the flow of carts between the CSS and OR IR.

Equipment Recommendations- Purchase 2 additional carts

After observing cart buildup and batching in both the OR IR and CSS and developing a computer model to represent the current sterilization process, the team found that the system is less strained with the addition of carts. The data shows that carts are batched between CSS and OR IR during the busiest hours, leading to bottlenecks that induce excess turnaround time. Through observations conducted by the DYVP team and through output from the computer model, the team has verified that there are up to 10 carts in CSS, leaving few others for use by the OR IR staff.

DYVP re-configured the computer model to represent a sterilization process that would utilize 14 carts between CSS and OR IR instead of 12. According to the model, the addition of two carts will decrease turnaround time by 30 minutes. Therefore, the team recommends the purchase of 2-4 additional carts.

Support Received for this Project

The Program and Operations Analysis Department was a major resource for completing this project. Mary Duck (Senior Management Consultant, UMH Program and Analysis) and Sam Clark (Senior Management Engineer, UMH Program and Analysis) provided the necessary guidance and support needed to complete the project. In addition, they helped the team ensure that the data collection encompassed the scope of the project. Furthermore, their offices have provided the tools to research previous studies and projects conducted on this topic.

Karen Bett, Manager of CSS and the CSS staff, along with Marc Finch, Manager of the OR IR and the OR IR staff, were integral resources for this project. With their assistance, the team has observed the process on site and gained valuable knowledge and insight into sterilization of surgical instruments. Information obtained from the CSS and the OR IR Managers, and the CSS and OR IR staff has complemented the information obtained from our observations and research of past analyses.

Expected Impact

Focusing first on the more concretely quantifiable impact, the team believes cart turnaround time could be reduced by approximately 52 minutes per load. This stems from a 9 minute reduction in travel time, a 13 minute reduction of time in the sterilizer, and a 30 minute reduction by adding carts.

The addition of staff during the night shift will decrease turnaround time by reducing the workload for the night shift workers. The degree to which this will happen is uncertain. Further analysis will be needed to quantify the actual time saved by adding an additional employee.

It is important to note that all estimates of expected impact in this project are forward looking statements and do not constitute a guarantee, although the team does believe strongly in its recommendations and their potential for the sterilization process.

Appendix A: Minitab Output of Statistics

Descriptive Statistics: Carts Sent to CSS/Received by CSS (All)

```
Variable                    N  N*      Mean   SE Mean     StDev   Minimum
Sent to CSS/Received_Non  292   0  0.010010  0.000964  0.016480  0.000000

Variable                        Q1    Median        Q3   Maximum
Sent to CSS/Received_Non  0.003472  0.005556  0.010417  0.177083
```

Descriptive Statistics: Carts Received by CSS/Returned to OR IR (All)

```
Variable                    N  N*     Mean  SE Mean    StDev  Minimum       Q1
Received/Returned_NonImp  292   0  0.16568  0.00497  0.08484  0.02917  0.11458

Variable                   Median       Q3  Maximum
Received/Returned_NonImp  0.14167  0.20260  0.75347
```

Descriptive Statistics: Carts Received by CSS/Returned to OR IR (Non Implants)

```
Variable                    N  N*     Mean  SE Mean    StDev  Minimum       Q1
Received/Returned_NonImp  212   0  0.13569  0.00289  0.04208  0.02917  0.10764

Variable                   Median       Q3  Maximum
Received/Returned_NonImp  0.12153  0.15191  0.34028
```

Descriptive Statistics: Carts Received by CSS/Returned to OR IR (Implants)

```
Variable                   N  N*    Mean  SE Mean   StDev  Minimum      Q1
Received/Returned_Implan  80   0  0.2452   0.0127  0.1139   0.1215  0.2023

Variable                  Median      Q3  Maximum
Received/Returned_Implan  0.2139  0.2306   0.7535
```

Appendix B: CSS Tracking Form

Instrument Room Time Record Sheet, Date: _____/_____/_____

Time cart is done loading	Time Loaded into elevator	Time received from elevator	Does load contain anything that will be used for implant surgeries? (Yes/No)