Patient Medication Delivery in the Thoracic Intensive Care Unit
Final Report
Department: Thoracic Intensive Care Unit

December 13, 2005

Client: Jole Mowry, Clinical Nurse Specialist: TICU
Coordinator: Barbara Radloff, Senior Management Coordinator, Program and Operations Analysis

University of Michigan Health Program and Operations Analysis
Team Members:
Brandelyn Heath
Jacob Rassner
Robin Rosenbloom
Seema Singh
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Executive Summary</strong></td>
<td>4</td>
</tr>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>Findings, Conclusions, and Recommendations</td>
<td>4</td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>Background</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>Project Goals</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>Project Scope</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>Approach and Methodology</strong></td>
<td>8</td>
</tr>
<tr>
<td>Performed Time Studies in the TICU and TICU Annex</td>
<td>8</td>
</tr>
<tr>
<td>Conducted Interviews with Key Personnel</td>
<td>8</td>
</tr>
<tr>
<td>Made Observations of the TICU and NICU</td>
<td>9</td>
</tr>
<tr>
<td>Conducted a Literature Search</td>
<td>9</td>
</tr>
<tr>
<td><strong>Time Studies</strong></td>
<td>9</td>
</tr>
<tr>
<td>Current Situation</td>
<td>10</td>
</tr>
<tr>
<td>Findings and Conclusions from Time Studies</td>
<td>10</td>
</tr>
<tr>
<td>Outliers in the Collected Data</td>
<td>12</td>
</tr>
<tr>
<td>Recommendations Based on Time Studies</td>
<td>13</td>
</tr>
<tr>
<td><strong>Interviews</strong></td>
<td>13</td>
</tr>
<tr>
<td>Findings from Interviewing Key Personnel</td>
<td>13</td>
</tr>
<tr>
<td>Conclusions from Interviews</td>
<td>15</td>
</tr>
<tr>
<td>Recommendations from Interviews</td>
<td>15</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>17</td>
</tr>
<tr>
<td>Neurological Intensive Care Unit</td>
<td>17</td>
</tr>
<tr>
<td>Shift Differences</td>
<td>17</td>
</tr>
<tr>
<td><strong>Cardiovascular Center Recommendations</strong></td>
<td>18</td>
</tr>
<tr>
<td>Background</td>
<td>18</td>
</tr>
<tr>
<td>Findings</td>
<td>18</td>
</tr>
<tr>
<td>Conclusions</td>
<td>20</td>
</tr>
<tr>
<td>Recommendations</td>
<td>20</td>
</tr>
<tr>
<td><strong>Action Plan</strong></td>
<td>21</td>
</tr>
<tr>
<td><strong>Appendices</strong></td>
<td></td>
</tr>
<tr>
<td>Appendix A: Current Process Flow</td>
<td>23</td>
</tr>
<tr>
<td>Appendix B: Data Collection Form 1</td>
<td>24</td>
</tr>
</tbody>
</table>
Appendix C: Data Collection Form 2 25
Appendix D: Process Averages 26
Appendix E: Current Value Stream Map 27
Appendix F: CVC Calculations 28
Appendix G: Literature Search Works Cited 29
Appendix H: Future State Value Stream Map 30
Appendix I: Future State CVC Value Stream Map 31

Tables and Figures
Table 1. Median Process Times 5
Figure 1. Current State Timeline 9
Figure 2. Process Capability of Tech Sweeps 10
Figure 3. Boxplots of Medication Ordering Process Times 11
Figure 4. Boxplot of Time Elapsed in Retrieval Step 12
Figure 5. Ideal State Timeline 21
Executive Summary

Introduction
The staff of the Thoracic Intensive Care Unit (TICU) in the University of Michigan Hospital System (UMHS) perceives delays in obtaining patient medications from the pharmacy. The nurses in the TICU believe that the pharmacy is not picking up orders as frequently as needed. They stated that the problem is mainly with STAT and first time medications. Since nurses must often go to the pharmacy to retrieve drugs, responding to this perceived delay wastes expensive resources (nursing staff).

The job of our student team was to observe the process, conduct a literature search, interview key personnel, and perform time studies to determine the root causes of the problem. After completing the preliminary work, the student team was to propose recommendations to improve the process flow between ordering and delivering the medication to the TICU and to determine how to decrease non-value added time. In addition, these recommendations will be considered for the new Cardiovascular Center (CVC). The CVC is scheduled to open in May 2007, and may utilize our recommendations about staffing in the satellite pharmacy.

The team’s approach included an ongoing literature search, one week of medication ordering process observations, eight interviews with TICU and pharmacy staff, and 40 hours of time studies on the overall medication dispensing process in the TICU.

Findings, Conclusions, and Recommendations
From the data collected, the process was analyzed to find the root causes of the delay. Recommendations were formulated and based on both quantitative and qualitative findings and conclusions.

Quantitative Results
Quantitative findings, conclusions, and recommendations resulted from time studies. Time studies were performed for the overall processes in the nursing unit and broken down into individual task times on the following processes:

- Prescription order is written
- A TICU clerk processes the order and delivers it to pharmacy by one of the following ways:
  - Places it in a basket
  - Sends it through a pneumatic tube
  - Faxes the order
  - Walks the order to the pharmacy
  - Phones in refill orders
- Pharmacy receives the order by one of the methods listed above
  - A pharmacist reviews any drugs being administered to a patient for the first time to avoid potential reactions or complications
- Pharmacy technicians then deliver patient medications and pick up new orders from the basket every hour to the TICU, referred to as rounding

A flowchart of this process is shown in Appendix A.
From the 40 hours of time studies conducted, 25 data points were collected and the medians of the elapsed process times (minutes) are summarized in Table 1 below.

### Table 1. Median Process Times.

<table>
<thead>
<tr>
<th>Processing Step</th>
<th>15 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieval Step</td>
<td>16 minutes</td>
</tr>
<tr>
<td>Delivery Step</td>
<td>59 minutes</td>
</tr>
</tbody>
</table>

The delivery step has a wide range and two outliers, which accounts for the high variability. Although most of our findings conclude that medications are being delivered in a timely manner, the process is inefficient and labor-intensive. To improve process times, the student team recommends the implementation of a future Industrial Engineering student project to research and analyze pharmacy efficiency and staffing. In addition, the Orders Management Project (OMP), a computerized order entry system which is scheduled to go live in the fall of 2006 in the TICU should lessen the elapsed time in the processing step.

Time studies were performed on the average time elapsed between rounds by a pharmacy technician. The pharmacy technicians are supposed to arrive hourly to pick up and deliver medications. TICU staff reported that the pharmacy was not arriving hourly. The calculated average time was 60 minutes (one hour), proving that in our observations, pharmacy followed the one-hour guidelines in making rounds. TICU staff could have misperceived the situation due to the fact that the pharmacy technicians do not inform anyone when they arrive; they simply stock the Omnicell, pick up orders, and move on with their rounds. The student team recommended that the pharmacy technicians inform the TICU that the rounds begin on the hour, so they will know approximately when the pharmacy technician will be arriving in the TICU.

**Qualitative Results**

Qualitative findings, conclusions, and recommendations resulted from observations made in the TICU and eight interviews: two TICU clerks, four TICU nurses, one fifth-floor pharmacist technician, and one pharmacist at Englewood Hospital and Medical Center in New Jersey.

Findings from the interviews revealed a lack of standardization in the medication dispensing process. Interviews revealed that outliers in the process are often caused by human error. Nurses expressed that they would like to see more drugs stocked in the Omnicell. From these interviews, the team developed the following recommendations:

- Stock the Omnicell with more medications
- Standardize the prescription ordering process in the TICU
- Develop a first review notification system
- Work towards implementing an electronic order entry system

Observations were conducted in the main unit, TICU annex, Neurological Intensive Care Unit (NICU), and Englewood Hospital and Medical Center’s pharmacy and Cardiovascular and Thoracic Intensive Care Unit (CTICU) in New Jersey. The observations in the NICU determined that the medication order and delivery process is similar to TICU’s except for the first round post-operative (post-op) orders. These orders are inputted using a computerized
system. The current system is not beneficial because there are formatting inconsistencies between the NICU and pharmacy, causing processing errors. The team does not recommend implementing of this type of computerized system in the TICU due to the ineffectiveness in the NICU.

Observations were made in the ten-bed main unit and four-bed annex. The team found no significant differences in process times between the two units. Observations were also made during the day, night and weekend shifts. No differences in process times were found between weekday and weekend shifts. However, significant differences were found during day and night shifts. During the night shift, the TICU does not have a clerk and no pharmacy rounds are made after midnight. As a result, the number of trips TICU staff must make to the pharmacy are significantly higher for the night shift than the day shift. The team recommends developing a new process to fill and deliver orders in a timely fashion after midnight.

CVC Results
The satellite pharmacy in the CVC will be open limited hours and the nearest satellite pharmacy is approximately 0.4 miles from the CVC TICU. This distance presents a problem when the TICU staff has to make trips to the pharmacy. We extrapolated data from the number of trips to the pharmacy per shift in the current TICU to calculate the total number of hours that will be wasted on travel time if the CVC pharmacy is not open 24 hours a day. The time spent traveling between the CVC TICU and the nearest satellite pharmacy will be 12 hours (1.5 FTE) per day on weekdays and 18 hours (2.25 FTE) per day on weekends.

The team also researched a military base in Fort Gordon, Georgia that used an automated medication dispensing system. The system allowed a pharmacist to control the automated drug dispensing system from a remote location while nursing staff had 24-hour access to drugs. Additional literature was reviewed on an Army hospital in Fort Carson, Colorado to determine the benefits that automated systems provide such as: notification of first review, ability to scan itself for low volumes, and patient medical record updates with prescriptions.

Observations at Englewood Hospital and Medical Center provided the team with insight into a different approach to the medication-order fill process. This hospital does not utilize strip order for prescription ordering, but rather faxed prescriptions. The automated drug dispensing machines used at Englewood Hospital release one tablet at a time so that nurses are not responsible for counting tablets. Additionally, technicians are only responsible for refilling low quantity medications in the dispensing machines.

To overcome the problem of non-value added time when staff travel to the pharmacy, we recommend that UMHS:
- Utilize incremental staff or volunteers
- Open the pharmacy for extended hours
- Implement newer Automated Drug Dispensing System (ADDS) technology
- Utilize locked bedside medication carts
Introduction

The Thoracic Intensive Care Unit (TICU) in the University of Michigan Hospital System (UMHS) is comprised of adult patients who have recently undergone, or in some instances are to undergo, thoracic surgery. The TICU staff perceives that they are not obtaining patient medications from the pharmacy on time. Many of these drugs must be administered at certain times and in specific time increments. Therefore, TICU patients must receive their medications on time, as the timeliness of medication administration greatly affects the patients’ condition and recovery. The nurses in the TICU indicate that the problem is with the pharmacy. The nurses report that the pharmacy is not picking up orders as frequently as needed, and as a result are not delivering medications to the TICU on time. Additionally, responding to this perceived delay poses a problem as the TICU staff needs to frequently leave the unit to obtain medications. Responding to this delay causes a waste of expensive resources (nursing staff).

The Clinical Nurse Specialist wanted to further investigate the source of the delay. She asked us to perform time studies, interviews, and observations to find the root of the problem and to develop an approach to reduce or eliminate delays. From our conclusions, we determined how to decrease the amount of non-value added time in the process and improve the process flow. In addition, these recommendations will be considered for the new Cardiovascular Center (CVC) which is scheduled to open in May 2007 which may utilize our recommendations on improving the prescription ordering process. The purpose of this report is to present the findings, conclusions, and recommendations for this project.

Background

The TICU at the University of Michigan houses patients who have had cardiac and thoracic procedures and those needing critical care. The TICU includes a ten-bed unit and a four-bed annex; the unit is particularly active and usually operates at 100% of its patient capacity. The nurses employed in this unit are responsible for administering medication to patients at a scheduled time starting at a designated time after surgery. These medications are administered on time. The perceived problem occurs when drugs are not received by the TICU on time from the pharmacy. The TICU staff believes the problem is mainly with STAT and first time medications.

In the TICU, pharmacy technicians are supposed to pick up patient prescriptions every hour, on the hour, from a basket in the unit. Prescriptions can also be hand delivered, phoned, faxed, or delivered through a pneumatic tube to the pharmacy. Once patient prescriptions are delivered to the pharmacy, a pharmacist reviews any drugs being administered to a patient for the first time to avoid potential reactions or complications. Pharmacy technicians then deliver patient medications every hour to the TICU. However, nurses report that the pharmacy technicians do not appear to come every hour for pick ups and deliveries, but instead appear sporadically.

Project Goals

To determine the supply and demand of drugs from the pharmacy to the TICU, the Program and Operations Analysis team completed the following tasks:
• Observed the processes associated with drug delivery from the pharmacy to the TICU and documented the process flow
• Interviewed nurses, pharmacists, clerks and technicians
• Performed time studies on the process flow

With this information, we developed recommendations to:
• Decrease any non-value added time
• Improve the process flow between dispensing and administering the medication to the patient (supply and demand)

Project Scope

The student team only investigated medication turn-around time within the TICU and the TICU annex. Medication turn-around time began when the patient entered the TICU with a prescription and ended when the prescription was delivered to the TICU.

The following aspects are not included in the project scope. Any task not connected to the medication turn-around time in the TICU was not included in this project. Specifically, pharmacy errors in order filling or incorrect Medicine Administration Records (MARs) were not studied. Delays in the internal workings of the fifth-floor satellite pharmacy were not investigated. Recommendations for other departments were also excluded from the scope of this project. However, the hope is that these findings can be extended to other units in the future.

Approach and Methodology

The team performed data collection using four types of tasks: time studies, interviews, observations, and literature search. Forms used to collect data are depicted in Appendices B and C.

Performed Time Studies in the TICU and TICU Annex
The team completed 40 hours of time studies and recorded 25 data points. Times were taken from the time the order was written to the time the medication was delivered in the TICU from the pharmacy. Task times and overall process times were calculated for the following steps:
• Prescription written
• Order processed
• Order received by the pharmacy
• Medication delivered to TICU

Detailed average process times for the overall process as well as task times stratified by delivery methods are shown in Appendix D.

Conducted Interviews with Key Personnel
The team interviewed two TICU clerks, four TICU nurses, one fifth-floor pharmacy technician, and one pharmacist supervisor at Englewood Hospital and Medical Center in New Jersey. The pharmacist in New Jersey was interviewed to learn about an alternative prescription order-fill process, and how it was conducted. The team also spoke frequently with Brian Callahan,
Administrative Manager of Healthcare, UMHS Inpatient Pharmacy Services, and directed pharmacy guideline and standards questions to him.

**Made Observations of the TICU and NICU**
The team observed the medication ordering process during the week of October 9, 2005. Team members took 90 minute shifts to get accustomed with the medication dispensing process. Each member observed two shifts. Altogether, eight shifts of observations, totaling 12 hours, were conducted. Day, night, and weekends were observed. The team observed processes in the main unit, annex, and Neurological Intensive Care Unit (NICU).

**Conducted a Literature Search**
The team reviewed literature to investigate alternative medication dispensing processes. The team researched isolated military bases that do not have a pharmacy to learn about the possibility of operating the CVC after surgical operating hours, without a staffed pharmacist. Literature on an army hospital was also reviewed to determine the benefits of implementing an automated dispensing system. We also contacted the Administrative Manager of Healthcare, UMHS Inpatient Pharmacy Services to pharmacy guidelines on STAT and NOW medications as well as technician rounding times. We compared the collected data with the pharmacy standards for pharmacy technician rounds and STAT medication turn-around time.

**Time Studies**

**Current Situation**
The medication turn-around time process begins with writing a prescription order and ends with medication delivery to the TICU. Once a prescription order is written, it is placed in the patient’s binder, and the dial on the binder is turned to yellow. A TICU clerk then processes the order. The order is either placed in a basket, sent through a pneumatic tube, faxed, or phoned if it is urgent. The most common method is by the basket. A pharmacy technician arrives at the TICU hourly to pick up new orders and deliver medications into the Omnicell. The current state is exhibited in a value stream map in Appendix E, which depicts the process flow and includes wait times and process times (which are negligible and are indicated as “0 minutes”). A current state timeline, which gives average times for each step of the process, is shown in Figure 1 below.

![Figure 1. Current State Timeline.](image)

<table>
<thead>
<tr>
<th>Order Write</th>
<th>Order Processed</th>
<th>Order received</th>
<th>Drug received</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.4</td>
<td>21.0</td>
<td>91.2</td>
<td></td>
</tr>
</tbody>
</table>

Total Process Time: 141.6 minutes

Sample Size: 40 hours, 25 data points

This timeline is based on 25 data points which cover all methods of delivering and receiving drugs, and includes any variation and outliers inherent in our data. Units are in minutes.
Findings and Conclusions from Time Studies

The average time elapsed between rounds by a pharmacy technician is 60 minutes (one hour). Only 12% of the observed times lay outside of a 15 minute window past the expected elapsed time of 60 minutes, and 100% of the elapsed times lay within a 120 minute (two hour) time period. The two data points that lay outside the 15 minute window are due to undetermined variables and therefore cannot be removed from the analysis. The process stability is displayed below in Figure 2 using a control chart of the elapsed time between technician rounds.

![Figure 2. Process Capability of Tech Sweeps.](image)

In Figure 2, the upper control limit is 70 minutes and the lower control limit is 0 minutes. As demonstrated in the graph, only two points lie outside these control limits.

This data shows that the perception that the pharmacy is not making hourly rounds is incorrect. The fact is that the pharmacy follows the one hour guideline in making rounds. The misconception may be because the pharmacy technicians do not inform anyone when they arrive; they simply stock the Omnicell, pick-up the strip orders out of the basket, and continue with their rounds.

The prescription ordering process can be stratified into three main sets of tasks: prescription processing, retrieval of the prescription by the pharmacy, and delivery of the drug to the TICU.
by the pharmacy. The comparative boxplots in Figure 3 show the median process times. For both Figures 3 and 4, the bottom line corresponds to the 25\textsuperscript{th} percentile mark, the middle line indicates the median, the top line is the 75\textsuperscript{th} percentile mark, and the asterisks represent outliers.

The medians of the elapsed times are 15 minutes for the processing step, 16 minutes for the retrieval step, and 59 minutes for the delivery step. The time between order written and order processed accounts for 21\% of the overall process time, the time between processing and pharmacy retrieval accounts for 15\% of the overall process time, and the delivery time is 64\% of the process time. The delivery step (from pharmacy to TICU) takes the longest with the 25\textsuperscript{th} percentile at 40 minutes and 75\textsuperscript{th} percentile at 118 minutes, and two existing outliers. We would expect this step to have the longest time to completion, but the boxplot also shows that this step has excessive variation.

Figure 3 shows that the process times are highly variable due to the wide interquartile ranges (IQRs) and outliers. Even with the high variation in process times, patients are receiving drugs on time. The extra time and variation in this process means it is too inefficient and labor-intensive. In addition, the proportion of the process time for order written to order processed (the first boxplot) is high which is due to the fact that the orders are not always given to the clerk as soon as they are written.

The elapsed times in the retrieval step support the conclusions made about the time between the pharmacy rounds. This step corresponds with the prescription reaching the pharmacy either by fax, phone, tube, hand delivery, or strip order pick-up by a pharmacy technician. The time elapsed between the rounds made by a pharmacy technician does not have any effect on the time
between processing and pharmacy reception of the prescription when the order is delivered by fax, phone, tube, or hand. Therefore, a separate boxplot in Figure 4 was made for the time elapsed between processing and retrieval for only those prescriptions that were ordered by strips placed in the basket. This boxplot revealed a median time elapsed of 25 minutes and a 75th percentile time elapsed of 49 minutes.

The results of this boxplot display that the strip orders are picked up within an hour which indicates that the pharmacy technicians are making their rounds within the hour.

Outliers in the Collected Data
The three stars in the boxplots in Figure 3 represent outliers. These outliers skew the results of the collected data. In addition to the normal process delays, these outliers represent delays due to unforeseen circumstances. Potential causes of these outliers include:

- Errors in communication
  - Illegible handwriting on forms
  - Incorrect dosage written on strip orders
  - Incorrect or missing patient name on strip orders
  - Incorrect or missing drug name on strip orders
  - Missing signatures
  - Lapsed order
- No confirmation of received faxed orders
- Incorrect computer entry by the pharmacy
- Lost orders
- Observer did not notice technician during rounding
**Recommendations Based on Time Studies**

Although the TICU staff believes that the pharmacy rounds are not being made within an hour, the data displays that the pharmacy technicians are in fact making their rounds within the one-hour guidelines. This misconception leads to a longer perceived wait time. To fix this problem, the team recommends:

- The data can be presented to the TICU staff to convey that the pharmacy is coming within an hour to pick up the strip orders
- The TICU staff also needs to be informed that the rounds begin on the hour, so they will know approximately when the pharmacy technician will be arriving in the TICU. An approximate pick-up/delivery schedule can be printed out and posted near the basket in the TICU
  - If the approximate time is not known, a strip order can sit in the basket for up to an hour, if it was placed there immediately after a pharmacy technician left the TICU
- The pharmacy technician can announce their arrival in the TICU
- Orders Management Program (OMP), a computerized order entry system scheduled to go live in Fall 2006 in the TICU should lessen the elapsed time between order written and order processed

The team advises that studying process times within the pharmacy become a future Industrial Engineering student project.

**Interviews**

Interviews conducted with TICU clerks, TICU nurses, a UMHS pharmacy technician, and a pharmacy supervisor at Englewood Hospital and Medical Center in New Jersey provided informative anecdotal data.

**Findings from Interviewing Key Personnel**

The team found several possible causes of process delays by conducting interviews with the TICU and pharmacy staff.

**TICU Clerks**

The two clerks that were interviewed work in the TICU and the TICU annex. The responsibility of the clerk is to remove strip orders from each TICU patient’s medical binder and place the orders in a basket. Due to the importance of administering STAT drugs within a 20 minute span, clerks are sometimes asked by TICU nurses to deliver prescriptions to the pharmacy and pick-up medications from the pharmacy. If a patient’s medical binder is updated while the clerk is out of the unit (break, lunch), the binder sits in a rack or on the desk waiting for the clerk to return. Additionally, one clerk noted that a delay in the processing time for strip orders occurs when a strip order is not filled out correctly. This clerk will not send the strip order to the pharmacy until the order is corrected, which most often requires waiting for a doctor’s signature. This creates a delay in the turn-around time.
**TICU Nurses**

The four nurses that were interviewed work in the TICU and the TICU annex. The responsibility of the nurse in the medication ordering process is mostly situational, but always involves administering ordered medications. The nurses stated that they have written prescriptions, delivered prescriptions to the pharmacy, picked-up medications, called the pharmacy about receiving medications, and even mixed medications for patients during emergency times—a task which should only be done by the pharmacy. The nurses indicated that they mix medications on the unit to avoid the delay in obtaining pre-mixed and first reviewed medications from the pharmacy. In addition, the nurses do not feel comfortable with the pneumatic tube system because there is no confirmation that the orders have been received in the pharmacy.

The nurses believe that stocking more medications in the Omnicell would decrease long-turn around times and make the TICU more self-sufficient. During the course of this project, two frequently used antibiotics, Cefazolin and Vancomycin, were added to the Omnicell. Nurses who were interviewed noticed that delays have decreased with the introduction of these medications into the Omnicell.

The nurses also expressed their frustration with accessing some medications that are in the Omnicell but must go through a first review by a pharmacist before being administered to a patient. Nurses do not receive notification when the medication has been reviewed by the pharmacy and therefore will try multiple times to unlock the Omnicell and obtain the medication.

**Fifth-Floor Pharmacy Technician**

The pharmacy technician that was interviewed works in the fifth-floor satellite pharmacy; the pharmacy that TICU relies on during the hours of 7AM to midnight everyday. The responsibility of the pharmacy technician in the medication turn-around process includes: picking up orders, receiving and sending tubed orders, order entry, filling prescriptions (including STAT medications), answering phone calls, and bringing medications to the respective units. Technicians that serve the TICU are responsible for: two Intensive Care Units, 4DN/4CI (annex), 4DS; one intermediate telemetry unit, 4B/C; and one general care unit, 4A. Technicians aim to make rounds every hour to deliver medications and pick up new orders.

**Pharmacist at Englewood Hospital and Medical Center, NJ**

Leslie Turitz is the pharmacy supervisor at the Englewood Hospital and Medical Center in Englewood, New Jersey. In this hospital, prescriptions are sent to the pharmacy via fax or tube. There are five fax machines in the pharmacy; four machines receive regular prescriptions and one receives STAT prescriptions. The hospital is currently using Diebold MedSelect automated dispensing machines. These machines hold common medications for the specific unit, and do not hold patient medications. These machines are stocked by the pharmacy technicians when medications have reached a minimum level. When technicians restock the MedSelect, they must enter the quantity that they are filling, and when nurses remove medications, they must enter the quantity they are taking. This system allows the pharmacy to monitor medications and refill those that are low in quantity. Additionally, the Cardiovascular Thoracic Intensive Care Unit at Englewood Hospital used locked bedside carts to store each patient’s medications, as well as the MedSelect. The bedside carts are approved by JCAHO and are specific to each patient’s needs.
**Conclusions from Interviews**

From the interviews conducted the following conclusions were made:

- Incorrectly filling out a strip order is a source of human error
- A source of non-value added time is when nurses leave the TICU to go to the pharmacy
- Nurses have created “work-arounds” in order to obtain medications in a timely fashion.
  - These “work-arounds” include faxing a sheet of orders to the pharmacy at the beginning of the shift to obtain all the needed medications for the day, or hand delivering prescriptions instead of using the tube system
- A bottleneck occurs in the pharmacy when there are large amounts of prescriptions that need to be filled at once
- The technician believes an extra pharmacist is needed on days when there is a high prescription demand
- Prescription strip orders are occasionally lost in the pharmacy
- Medication ordering systems used at Englewood Hospital should be researched further for the future CVC TICU

**Recommendations from Interviews**

From the conclusions made, the team made the following recommendations.

*Stock the Omnicell with More Drugs*

Based on the interviews of the TICU nurses, the team noted that all four nurses have noticed fewer delays since two major antibiotics (Cefazolin and Vancomycin) were added to the Omnicell. The team recommends stocking a larger variety of frequently used medications in the Omnicell which would allow the TICU to become more self-sufficient. Additionally, the TICU will suffer from fewer extended turn-around times, since most medications will be located within the unit. The team asked six TICU nurses to specify medications that they would like to have access to in the Omnicell. The team recommends that the following drugs be stocked in the Omnicell: Procainamide, Lasix(oral/injectable), Imdur, Digoxin, Albumin (premixed), Ativan (tablets), Neutra-Phos, Esmolol. Additionally, the team believes that the pharmacy should ask all TICU nurses “What medications do you want in the Omnicell?” when determining what medications to stock.

*Standardize the Medication Ordering Process*

The team recommends standardizing the prescription ordering process in the TICU. Each nurse has his/her own way of obtaining medications, therefore making the process confusing. The following recommendations are based on different conditions and circumstances.

- **Condition 1**
  If a nurse orders a medication that does not need to be administered within two hours of processing, the strip order system should be used

- **Condition 2**
  If a medication is NOW, which means it should be administered within 90 minutes of ordering, the tube system should be used. Minutes after tubing the prescription, nurses should call the pharmacy and make sure the pharmacy has received the order,
can read it, and are aware that it is a NOW medication. We also suggest that nurses tell the pharmacy what time they would like to administer the drug by so that the pharmacy has a deadline

- **Condition 3**
  If a medication is STAT, which means it should be administered within 20 minutes of ordering, a TICU clerk, TICU nurse technician, or the TICU host should hand deliver the prescription to a pharmacist in the pharmacy or use the tube system. The TICU employee should make sure that the pharmacy does not have any questions about the prescription. The pharmacy can then decide to hand deliver the medication to TICU or tube the medication to TICU

In addition, the team advises that a new system is developed to handle STAT medications to make the process more standardized. Some suggestions include:

- Dedicating a fax machine in the pharmacy to only handle STAT medications
- Dedicating a member of the pharmacy staff whose sole responsibility is receiving, mixing, and delivering STAT medication orders

- **Condition 4**
  If a nurse is working with a very critical patient, we recommend that the nurse plans ahead for the entire shift. At the start of the shift, nurses should review the patient’s medications and check the Omnicell to see what will have to be ordered. The nurse should use the TICU medication fax sheet to fill out all the medications that are not in the Omnicell, or are in low quantity in the Omnicell and then fax the medication ordering sheet to the pharmacy. Every time the nurse goes into the Omnicell to get a patient’s medication, he/she should take note of which medications have been delivered already. The nurse is essentially looking ahead and realizing that a problem may occur if a medication is not delivered and contacting the pharmacy when the medication is needed but not available

*First Review Notification*

We recommend developing a system in which the pharmacy notifies nurses when first review has been completed. Once such a system is in place, some non-value added time will be eliminated because nurses will not be checking the Omnicell numerous times to see if the first review has been completed.

*Electronic Order Entry System*

To remove the risk of human error associated with the strip orders and thus decrease the number of people involved in filling a prescription, we recommend that UMHS uses an electronic order entry system. We believe that the hospital is working on this system and that it will be available soon.
Observations
The team observed the process for one week. Observations were made during all shifts and in an additional intensive care unit.

Neurological Intensive Care Unit
The team observed the medication ordering process in the NICU because the unit uses a different method than the TICU.

Findings
The student team spent one 90 minute shift observing the medication dispensing process in the NICU and interviewed the Clinical Nurse Specialist in the NICU. The NICU uses the same process as TICU except for first round post-op orders. For these orders, NICU has a computerized system for entering orders. A member of NICU staff inputs the prescriptions, prints out the list, and places it in the basket for pharmacy to pick up. After first round orders, NICU returns to writing out strip orders and delivering them to pharmacy using the same methods as TICU.

Conclusions
The computer systems used by Pharmacy and NICU differ in formatting, causing process errors. The computerized list is not ergonomically efficient because there is no spacing between the lines which poses a problem because pharmacy can easily miss a medication due to human error. In addition, a range of doses can not be entered into the pharmacy computer system. The computer system in pharmacy will only allow the inputting of a single dose for a prescription which can cause a problem because the computer system in the NICU has the ability to have ranges for a medication order.

Recommendations
Since this computerized system causes more problems than benefits, the team does not recommend its implementation in the TICU. The rest of the medication order and delivery process used by the NICU is similar to the processes used in TICU and therefore, no recommendations can be made.

Shift Differences
The team observed the process during different shifts because process times often vary based on time of day.

Findings
Observations were made in the ten-bed main unit and four-bed annex. The only difference between the two units is that the tube system is not located directly within the annex. The methods of order pick-up and delivery are the same in both units. There are no significant differences in process times between the two units.

Since process times are variable, depending on time of day, observations were made during the day, night, and weekend shifts. A day shift occurs from 7:00AM to 7:00PM and a night shift occurs from 7:00PM to 7:00AM. Weekend shifts are on Saturday and Sundays. There were no differences in process times found between weekday and weekend shifts. However, significant
differences were found during day and night shifts. During the night shift, there is no clerk in the TICU and no pharmacy rounds are made after midnight. Nurses in the TICU make sure to order all the drugs that they know they will need for the night shift before the last round is made. If additional drugs are needed after the last round is made, a nurse will call pharmacy and the drug will either be tubed down or a nurse or nurse technician will pick it up from pharmacy if the delivery time is taking too long. A tally sheet was kept in TICU for three days (six shifts) asking staff members to record how often they had to make trips to the pharmacy. The average number of trips for the day shift was three and the average number of trips for the night shift was eight.

Conclusions
Although the annex is only a four-bed unit, and the demand is lower, there was no significant process time differences from the main unit. In addition, since there are no rounds made after midnight by pharmacy technicians, the number of trips TICU staff make to pharmacy are significantly higher for the night shift.

Recommendations
Since there are no significant differences between the weekend and weekday shift, no recommendations can be made. For the night shift (after midnight), a new system should be developed to make sure orders are filled and tubed to the unit in a timely fashion.

Cardiovascular Center Recommendations
The new CVC will contain a larger TICU to accommodate the high demand. The team investigated new processes and technology to be implemented in the unit which will make the medication ordering process more efficient and in effect, benefit the patients.

Background
The CVC TICU will potentially face the problem of having a pharmacy that operates during limited hours. According to both our client and our coordinator the pharmacy is currently scheduled to only be open on weekdays from 9AM to 5PM. When this pharmacy is closed, the unit staff will need to travel to a satellite pharmacy in the main hospital. From the CVC blueprints, the group estimated that the closest pharmacy is approximately a .4 mile round trip from the CVC TICU. This problem is analogous to the situation that the TICU night shift faces. In the current TICU the pharmacy technicians do not make rounds after midnight. Therefore, to place prescription orders the TICU staff can not use the strip system until the rounds begin again in the morning. The result of not having pharmacy technicians making rounds is an increased number of times the TICU night staff has to leave the unit to go to the pharmacy.

Findings
The team researched the design of the new CVC TICU location in relation to the pharmacy location. The team also researched alternative medication ordering processes to be used in the new unit.

Creation of Additional Non-Value Added Time
We found that during the day, when there are rounds being made by pharmacy, the unit staff leaves the TICU an average of three trips per shift or .25 trips per hour. We also found that
during the night shift there is an average of eight trips per shift made by the unit staff. Taking away the three expected trips that occur even when there are rounds, there are five trips per shift or .7 trips per hour that occur because of no rounds being made. These findings are from the ten-bed TICU. The TICU in the CVC will be a twenty-four bed unit, but the pharmacy that will serve the CVC will only operate for limited hours. In the current state, pharmacy rounds occur 17 hours of the day. In the CVC, pharmacy rounds will only occur 8 hours of the day. The increase in number of beds and hours without pharmacy rounds will cause an increase in the number of trips to the pharmacy made by the TICU staff. We are assuming that these increases will be linearly related.

From the calculations in Appendix F there will be approximately 41 trips (36 of which will be to the pharmacy not located in the CVC) made out of the unit on weekdays and 54 (all of which will be made to the pharmacy not located in the CVC) made on weekends. This round trip will take no less than 20 minutes, which results in a total of 720 minutes being wasted during each weekday and 1080 minutes during each day on weekends. This equates to one full 12-hour shift (1.5 FTE) of travel time on the weekdays and one and a half shifts or 18 hours (2.25 FTE) on weekend days.

Literature Search Results: Alternative Methods using New Technology

The team conducted a literature search to find alternative medication ordering processes and technology. Since the CVC will be served by a pharmacy that will only operate during limited hours, the team researched isolated military locations with pharmacist shortages. The works cited is located in Appendix G.

An initial literature search was conducted about a U.S. Army base in Fort Gordon, Georgia which was facing a shortage of pharmacists. To combat the shortage of military pharmacist, Fort Gordon installed an Automated Drug Dispensing System (ADDS) that would allow a pharmacist to be at a computer workstation in another city and dispense medication from a remote-controlled dispensing machine. Fort Gordon installed two dispensing cabinets that stored prepackaged liquids, creams, inhalers and 60 different medications in packets of nine or 18 which are locked and password protected. The ADDS computer workstation manages the drug inventory as well as interfaces with the patient’s electronic medical record, automatically adding prescriptions to the patient’s file. The military hopes that ADDS could supply pharmaceutical solutions to soldiers deployed in remote locations. ADDS is a type of telepharmacy technology that allows pharmacists to dispense drugs anywhere there is a phone line.

Evans Army Community Hospital in Ft. Carson, Colorado (USA MEDDAC) has also implemented the ADDS to account for pharmacist shortages. With this new technology, drugs are correctly labeled and automatically entered into the patient’s profile. Drug-to-drug interactions and duplicate drug therapy are examined to prevent allergic reactions and or complications due to medications. A benefit noted by USA MEDDAC is cost savings because “Although we haven’t completed an analysis of cost comparisons, the FlexRx system has allowed us to close the pharmacy after 23:00, thus saving the cost of maintaining a pharmacist on staff to work that shift.” A certified pharmacy technician at the hospital believes that the “annual technology cost is equivalent to about one-third of the cost of a staff pharmacist.” Additionally, the pharmacy staff now spends more time stocking the ADDS but less time running medications to the requested units.
Conclusions
Due to the greater distance between the TICU and the pharmacy, the medication ordering process times will increase. The team concludes that the trips between the TICU and the pharmacy could be reduced with the implementation of newer, more efficient ADDS. There are many advantages of ADDS:

- The CVC would be able to operate without a pharmacist being on the same floor or unit
- Newer models of ADDS would interface well with the Orders Management Project (OMP) because the physician would enter the order, which would be sent to the pharmacy while updating the patient’s electronic medical record
- ADDS has an automated notification of first review which would eliminate nurses having to continuously check the Omnicell for approved access of the medications
- ADDS has the ability to keep track of low volumes of drugs and will notify the pharmacy when to restock the machine
- Some ADDS have drug mixing capabilities, allowing nurses to devote more attention to patient care
- These systems meet the Joint Commission of Accreditation of Healthcare Organizations (JCAHO) standards because they are locked and require passwords to access the drugs

Recommendations
There are three sets of recommendations which could be implemented. Each set of recommendations approached a different level of the problem. The goal of each recommendation is to reduce the time wasted by nurses making trips out of the unit to a satellite pharmacy.

- Reducing the utilization of nurses in traveling to the pharmacy
  - A system using incremental staff or volunteers should be developed
  - The incremental staff or volunteers should be dedicated to making trips to the pharmacy when the trips are necessary

- Reducing the amount of travel time associated with trips to the pharmacy
  - The reasons that there is so much non-value added time associated with the trips to the pharmacy is that the nearest satellite pharmacy on the fifth floor is approximately 0.4 miles from the CVC
  - The distance between the CVC TICU and the fifth floor satellite pharmacy can not be changed
  - The only way to reduce the amount of travel time associated with trips to the pharmacy is to reduce the number of trips necessary to the fifth floor pharmacy
  - This can be done by increasing the possible number of trips to the closer pharmacy that is located in the CVC. To increase the number of trips that can be made to the CVC pharmacy instead of the one on the fifth floor the hours of operation for the CVC pharmacy could be increased

- Eliminating the need for the trips to the pharmacy that result in non-value added time.
The only way to completely overcome the problem of extensive non-value added
time created by trips to the pharmacy is to reduce the number of necessary trips
out of the unit to the pharmacy.
A way to decrease the number of trips necessary to the pharmacy is to implement
more state-of-the-art automated drug dispensing systems (ADDS).
Based on the literature search that we conducted we found that there are machines
that have been developed since the Omnicell was put into use in the current TICU
that are much more technologically advanced.
The CVC should add locked bedside medication carts to decrease the amount of
time nurses need to travel back and forth from the patient’s area to the ADDS.
The implementation of the machines described in our section on the literature
search will decrease the number of trips to pharmacy being made by the TICU
unit staff.

**Action Plan**

Since Orders Management Program (OMP) will be implemented in the fall of 2006, the
following recommendations should be followed as a temporary solution in the TICU:

- Stock the Omnicell with more drugs
- Inform TICU staff of scheduled pharmacy round times
- Standardize the prescription ordering process
- Develop a system for first review notification
- Develop a system in which medications are tubed down efficiently during night shift
- Implement future student team projects to analyze pharmacy delays

Implementing these recommendations will improve process times for ordering drugs. A future
state value stream map is shown in Appendix H. The future state is defined as prior to OMP and
includes wait times and process times (which are negligible and are indicated as “0 minutes”).
The timeline in Figure 5 displays the ideal times (minutes) for the prescription ordering process.

![Figure 5. Ideal State Timeline.](image)

Total Process Time: 105 minutes
Sample Size: 40 hours, 25 data points

In addition, the following recommendations are applicable to the CVC TICU which will open in
May, 2007:

- Investigate advanced Omnicells
• Look into bedside medication carts for the bigger unit in the CVC
• Extend pharmacy hours in the CVC
• Develop a system using incremental staff

The addition of newer ADDS to UMHS is something that administration should investigate for future installation in all units.

An additional future state value stream map for the prescription ordering process in the CVC TICU is shown in Appendix I.
Appendix B. Data Collection Form 1.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix C. Data Collection Form 2.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>1</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>2</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>3</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>4</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>5</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>6</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>7</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>8</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>9</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>10</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>11</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>12</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>13</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>14</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>15</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>16</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>17</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>18</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>19</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>20</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
<tr>
<td>21</td>
<td>Date</td>
<td>Times Tech Came to TICU to deliver/pick up</td>
<td>Time Elapsed</td>
<td>Minutes</td>
</tr>
</tbody>
</table>
## Appendix D. Process Averages.

<table>
<thead>
<tr>
<th></th>
<th>time elapsed (order written-order processed)</th>
<th>time elapsed (order processed-received by pharmacy)</th>
<th>time elapsed (received by pharmacy-received in TICU)</th>
<th>time elapsed (order written-received in TICU)</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Average</td>
<td>29.4</td>
<td>21.0</td>
<td>91.2</td>
<td>125.7</td>
<td></td>
</tr>
<tr>
<td>Annex Average</td>
<td>99.0</td>
<td>35.0</td>
<td>53.5</td>
<td>187.5</td>
<td>only 2 observations</td>
</tr>
<tr>
<td>Basket Average</td>
<td>36.3</td>
<td>26.4</td>
<td>72.0</td>
<td>124.5</td>
<td>main method</td>
</tr>
<tr>
<td>Fax Average</td>
<td>7.0</td>
<td>8.0</td>
<td>44.0</td>
<td>267.0</td>
<td>only 1 observation</td>
</tr>
<tr>
<td>Phone Average</td>
<td>15.0</td>
<td>0.0</td>
<td>252.0</td>
<td>37.5</td>
<td>only 2 observations</td>
</tr>
<tr>
<td>Tube Average</td>
<td>0.0</td>
<td>0.0</td>
<td>37.5</td>
<td>59.0</td>
<td>only 1 observation</td>
</tr>
</tbody>
</table>
Appendix E. Current Value Stream Map
Appendix F. CVC Calculations.

The following calculations were used to determine travel time between the CVC TICU and the pharmacy:

3 trips/shift: during the day when there are rounds
12 hours/shift
3/12 = .25 trips/hour when there are rounds

8 trips/shift: during night shift
12 hours/shift
7 hours without pharmacy rounds –
8 trips during night shift – 3 trips during day shift = 5 trips due to no rounds
5/7 = .7 trips/hour due to no rounds
.7 + .25 = .95 total trips/hour when there are no rounds

24 / 10 = 2.4 times as many beds in CVC TICU
.25*2.4 = .6 trips/hour with rounds in CVC TICU
.95*2.4 = 2.28 trips/hour without rounds in CVC TICU – have to go to non-CVC pharmacy

CVC pharmacy open 9-5 weekdays
Weekdays
16 hours no rounds, 8 hours rounds
16*2.28 + 8*.6 = 41 trips total during weekdays
16*2.28 = 36 trips to non-CVC pharmacy

Weekends
24 hours no rounds
24*2.28 = 54 trips to non-CVC pharmacy

Approximately 20 minute travel time
36*20 = 720 minutes of travel time during weekdays
720/60 = 12 hours of travel time
12/12 = 1 shift of travel time

1 FTE = 8 hours
12 hours of travel time/8 hours (1 FTE) = 1.5 FTE

54*20 = 1080 minutes of travel time during weekends
1080/60 = 18 hours of travel time
18/12 = 1.5 shifts of travel time

1 FTE = 8 hours
18 hours of travel time/8 hours (1 FTE) = 2.25 FTE
Appendix G. Literature Search Works Cited.


Appendix H. Future State Value Stream Map
Appendix I. Future State CVC Value Stream Map.