University of Michigan Health System
Program and Operations Analysis

Developing New Time Standards for Inserting a Peripherally Inserted Central Catheter

Final Report

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Executive Summary

Introduction

In 2004, Lorelei O’Donnell, the University of Michigan Hospital Systems’ (UMHS) Vascular Access Services (VAS) Manager, reported that VAS was understaffed and that workload was allocated sub-optimally. Therefore, last year, she asked a Fall 2004 Program Operation and Analysis (POA) team in Industrial Operations Engineering (IOE) 481 to analyze VAS’ activity patterns and to suggest methods to enhance staffing specifically for peripheral line, midline, and Peripherally Inserted Central Catheter (PICC) line placement. In the Fall 2004 project, older PICC time standards were used. The time standard for PICC line placement used in the Fall 2004 project was 129 minutes. Unfortunately, the onsets of new technology and methods have caused the time standard for PICC line placement and the incidental work around PICC line placement to become obsolete. Therefore, this year, Mrs. O’Donnell asked our Winter 2005 POA team in IOE 481 to develop a new time standard that more accurately represents the time required to insert and complete the incidental work for a PICC. This time standard includes the time necessary to complete incidental work for PICC placement as well as the time necessary to complete the new PICC insertion techniques. The new time standard can then be used to update the findings of the previous project so staffing recommendations can be implemented more accurately. Mrs. O’Donnell also requested that we offer any recommendations on how to make the PICC process more efficient.

Approach and Methodology

To create a new time standard for the PICC process, four phases were completed:

1. Researched time studies via literature search
2. Observed the PICC nurses to learn about the steps in the PICC process needed to create the data collection sheet
3. Practiced collecting data in pairs to increase inter-rater reliability and collected data on PICC process
4. Analyzed the data collected on each step of the PICC process to create time standards

Findings and Conclusions

The average time standard for PICC line placement including the incidental work was found to be 69 minutes. Using the 83\textsuperscript{rd} percentile the total time for the PICC process was 84 minutes, which is approximately 45 minutes less than the older time standard of 129 minutes. This means that 83\% of the time, the PICC process will be complete within the time standard of 84 minutes. Delays account for four of those minutes. The portion of the average time standard for the PICC insertion is 38 minutes, which includes a negligible amount of delay. The portion of the time standard accounting for the delay for the incidental work around the PICC line placement is 31 minutes. After entering the new time standards we created from our data collected into the Fall 2004 IOE 481 project team scheduling program, the number of required FTE’s recommended per day by the program has decreased on average by 2 FTE’s In order to calculate an accurate time standard we needed sample size of 375, using calculations from the UCLA power calculation
Unfortunately, since we only collected 86 sets of data, we do not have sufficient data to make a statistically significant time standard. However, we still believe that the time standard calculated based on the 86 samples is adequate to determine necessary staffing for VAS.

**Recommendations**

Upon the insertion of our time standard into the Fall 2004 IOE 481 staffing program we recommend that the VAS department uses the program with the updated time standards. Inserting our team time standards into the already existing program will allow VAS to accurately calculate the appropriate staffing levels for the nurses inserting PICCs. Additionally we recommend that more data collection be completed on other types of IV lines to ensure there is no difference in their time standard.

Based on our data analysis, 40% of the time, a PICC insertion was not attempted. A nurse was unable to attempt a PICC if the patient was not in room, patient not consenting, patient changing rooms, if the doctor has not completed the written order for the PICC, if there are positive lab values, or if the results of lab values i.e. INR, blood cultures or platelets are still pending. The PICC nurses were unsuccessful in inserting PICCs on the first try 10% of the time due to difficulties with accessing patient veins, trouble with threading the catheter through the entire vein, and having to call for assistance. As a result, PICC insertions are successful on the first attempt 50% of the time. Therefore, setting up appointments for the PICC nurses to place the PICC may reduce the number of unsuccessful attempts.

Also, a programming change should be made to the VAS website enabling the floor nurses to update any information regarding a PICC order. For example, if a patient has been moved to another room or if a doctor has cancelled a PICC order, the floor nurses should be able to update the website with this information.

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Introduction

Vascular Access Services (VAS) has had a history of being understaffed and overworked based on the perception of the nurses. There were on average between 15 to 20 Peripherally Inserted Central Catheters (PICCs) in queue at the end of the day shift in Fiscal Year 2004, which meant long wait times for patients, sometimes prolonging discharge. This data was taken from the UMHS database for PICCs in queue at 5:00 p.m. Therefore, VAS has seen a 40% increase in nurses since September 2004 to a current staff of 29 nurses in an attempt to decrease the long wait times for patients. Even with this increase in staff, the scheduling of the nurses is still sub-optimal.

Last year, Lorelei O'Donnell, the University of Michigan Hospital Systems’ (UMHS) VAS Manager, asked a Fall 2004 Industrial Operations Engineering (IOE) 481 team to analyze VAS’ activity patterns and to suggest methods to enhance staffing specifically for peripheral line, midline, and PICC line placement. The previous Fall 2004 IOE 481 Project Team analyzed the schedule problems and created a program based on the month, day, hospital and floor to determine the level of staff needed. In this program, they used outdated time standards from the 1970s on PICC, midline and peripheral placements. The time standard used in the program for PICC placements was 129 minutes. In order to update the scheduling program, a new time standard must be created and inserted into the program. Once the program is updated, it will provide more accurate recommendations for staffing levels.

The current time standards used to schedule the work shifts for the VAS nurses are outdated; therefore, they may be inaccurate. The purpose of this project was to develop new time standards that more accurately represent the time required to insert a PICC. This includes paperwork, new technologies used to place the PICC, and new PICC insertion techniques. These technologies and insertion techniques include Navion, ultrasound, and Modified Selldinger Technique (MST). Once we analyzed the data, we inserted the new time standard into the existing nurse scheduling program created by the previous Fall 2004 IOE 481 team, which improved staffing levels.

Goals and Objectives

The following goals were associated with this project:

- Increase patient and employee satisfaction
- Decrease wait time for patient to receive a PICC line
- Create accurate time standards of the PICC insertion process
- Improve productivity of nursing staff
- Input time standards into the existing nurse scheduling program

Methodology

Our POA team performed time studies on the entire PICC process, which is performed by the nurses of VAS. The purpose of the time studies was to create new time standards for the PICC process. The primary affected parties from our project are the patients, patients’ families, VAS department, Medical Care Team, Nursing, Radiology, Discharge Planning, HomeMed Training team, and Pharmacy.
This project was divided into 4 phases: research, observation, data collection, and data analysis.

**Research**

Our team performed a literature search to obtain information regarding work measurement, specifically, time studies. We also found information with respect to the PICC process to gain a better understanding of the process. Our team looked through the VAS database on PICC placement which shows when a PICC was ordered and when it was placed for FY03 to FY04. Additionally, we reviewed the final report completed by the Fall 2004 IOE 481 team to obtain more information about the outdated time standards that were used and to acquire more background information about the VAS department. We used Maynard’s Industrial Engineering Handbook\(^2\) and The Handbook of Industrial Engineering\(^3\) to aid in the formulation of the time standard.

**Observation and Informal Interviews**

Each team member initially observed a PICC nurse for approximately six hours for a total of 24 hours. During observations, notes were taken on the entire PICC process, which are displayed in the data collection sheet in Appendix A. The data collection sheet was developed and used as a tool for recording the times required to complete the various elements of the PICC process. The process was divided into specific elements based on the notes taken during observations; these elements can be viewed in a flowchart in Appendix B. Our team also conducted informal interviews with the nursing staff to better understand the PICC process.

**Data Collection**

During data collection, each team member shadowed the PICC nurse measuring each element of the PICC process. Each team member assigned a pace rating to each nurse for each PICC. This was determined by comparing the effectiveness of the nurse to the effectiveness of a nurse with a normal pace. We assigned a pace rating of 1.00 if we felt the pace was ‘normal’, 1.05 or 1.10 if the pace was above normal, or 0.95 or 0.90 if we considered the pace to be below normal. To increase inter-rater reliability, which increases the reliability of assigning the subjective pace rating among observers, we observed the PICC process in pairs and then switched the pairs. Each group member recorded the process individually and gave a rating to each nurse. At the end of the observation each group member compared their rating and recorded times to the other member’s. A consensus was eventually reached about how to assign pace ratings and measure the individual tasks. This rating was multiplied by the observed time and then was used in the final formulation of the time standard to consider the pace of the PICC nurse. Once the inter-rater reliability was optimized, each team member collected data for 24 hours for a total of 96 hours. Data was collected beginning the week of February 21\(^{st}\) through the week of March 21\(^{st}\) during the day shift, 86 data entries were collected with 42 being PICCs inserted successfully.


Because we limited our data collection to only the day shift, we were only able to take a sample of half of the VAS nurses who inserts PICCs. The average experience level of the nine nurse we observed was 2.69 years. The nurse with the most experience has been inserting PICCs for 8.42 years and the nurse with the lease experience has been inserting PICCs for 0.06 years (20 days).

Data Analysis

The times were standardized by multiplying the observed times by the pace rating given to each nurse. The mean and the standard deviation were calculated for each element and each delay. The averages for the steps and delay was summed together to get the average time for the entire PICC process. The variances of all the steps and delays were also summed to get the entire variance of the PICC process. The square root was taken of the variance to get the standard deviation of the entire PICC process. They were calculated using the following equation

\[ \sum \left( \mu_{\text{Step}} + P(o) \times \mu_{\text{Delay}} \right) \]

\[ \sum \sqrt{\left( \sigma^2_{\text{Step}} + P(o) \times \sigma^2_{\text{Delay}} \right)} \]

\[ P(o) \] is the probability of the delay occurring. Utilizing the 83\textsuperscript{rd} percentile we calculated the time standard for the process. This time standard was then entered into the scheduling program created by the Fall 2004 IOE 481 team to optimize nurse staffing.

Table 1: Time for completing multiple PICCs at different percentiles.

<table>
<thead>
<tr>
<th># of PICC</th>
<th>Total percentile (per shift)</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 hour shift: 6 Total Process</td>
<td>85%</td>
<td>7.49</td>
</tr>
<tr>
<td>12 hour shift: 9 Total Process</td>
<td>85%</td>
<td>11.14</td>
</tr>
</tbody>
</table>

Findings and Conclusions

According to the data, the entire PICC process was measured to be 69 minutes without the standard deviation. The standard deviation for the entire PICC process is 15 minutes. Delays increase the total process time by 4 minutes, which accounted for 4% of the total process. Using the 83\textsuperscript{rd} percentile the total time for the PICC process was 84 minutes, which is 45 minutes less than the older time standard of 129 minutes. This means that 83% of the time, the PICC process will be complete within the time standard of 84 minutes. The average length of the PICC insertion with delay, which includes arranging the workstation, preparing the patient for the PICC, inserting the PICC, securing the PICC, and cleaning up the work area, takes an average of 38 minutes. One minute of the total delay is within the PICC insertion steps. The standard deviation for the PICC insertion was 11 minutes. Elements not directly involved in the PICC insertion such as prioritizing the patient, travel time, checking orders and accessing patient
records, explaining procedure to patient and family and obtaining consent and ending documentation, updating VAS website and paging doctor, combined were measured at average 31 minutes. The standard deviation for the incidental work was 10 minutes. Three minutes of the total delay is within the incidental work steps.

In order to calculate the sample size needed, we accessed the UCLA website. We used a population size of 15,000, which is the number of PICCs that are completed per year. A maximum allowable difference of .1 between the actual time standard, and the calculated time standard was used. This was calculated with a confidence interval of 95%, which indicates that the time standard calculation has a 95% chance of being correct when compared to the actual time required to insert a PICC. We used a variance estimate of 1, which gave a needed sample size of 375. With the 86 samples we analyzed, this number does not give a statistically significant time standard. However we consider the 86 samples collected adequate to determine necessary staffing for VAS.

The new time standard our team created was entered into the scheduling program created by the Fall 2004 IOE 481 team. We found that on average the number of required FTE’s needed per day to perform PICCs decreased by approximately 2 FTE’s. Table 2 shows a comparison between the numbers of FTE’s required by the VAS department based off of the old time standards and the new time standard.

Table 2: Comparison is FTE’s

<table>
<thead>
<tr>
<th></th>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thur</th>
<th>Fri</th>
<th>Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average per Day (Old Time Standard)</td>
<td>11</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>15</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Average per Day (New Time Standard)</td>
<td>9</td>
<td>13</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Delta</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 1: Average Step time including Delay

Figure 2: Standard Deviation of Step Time Including Delay
According to the data, the success rate of inserting a PICC was 50%. The probability of the nurse not attempting the PICC is 40%. A nurse was unable to attempt a PICC if the results of lab values (i.e. INR, blood cultures or platelets are still pending, positive lab values, the patient was not in room or the doctor has not written an order for the PICC). The percentage of time the PICC nurse was unable to insert the PICC was 10%. Included in this 10% was the PICC nurse not being able to complete the PICC due to difficulties and calling for assistance.

![Figure 3: PICC Attempt Results](image)

**Recommendations**

**Update Time Standard in Staffing Program**

Upon the insertion of our time standard into the Fall 2004 IOE 481 staffing program, our primary recommendation is for the VAS department uses the program with the updated time standards. This is done to accurately calculate the appropriate staffing levels for the nurses inserting PICCs. Additionally, we recommend that more data collection be completed in order to develop an accurate time standard. We also recommend that the VAS department develop recent and accurate time standards for the other IV lines, because we found a significant difference since the last measurements were completed.
Schedule Patient’s PICC Times

To decrease the time a patient waits to receive a PICC, our team recommendation is to set up appointments for the patient’s to receive their PICC. In order for the patient to be entered into the schedule there must be an electronic and hand written order for the PICC and the lab value results must be available and negative. Because the probability of the PICC nurse not being able to attempt the PICC is 40%, setting up appointments will reduce the numbers of failed attempts by guaranteeing the patient will be in the room and that an order has been placed. The outpatient PICC scheduling process should remain separate and unchanged as a result of implementing these recommendations. Queuing analysis research needs to be done for efficient appointment scheduling.

Floor Access of VAS Website

The floor nurses should be able to access the VAS website to address the problem of no attempts. Currently, the probability of no attempt is 40%. The probability of no attempts can be reduced if the floor nurse can update the website. For example, the nurse can notify VAS of the results of lab values, if the patient was not in room, if the patient does not consent, if the patient changes rooms, or if the doctor has not completed the written order for the PICC. When the floor nurse enters an order in the VAS website, a flag needs to appear and remind the nurse entering the order that a written order for the PICC must also be completed. This will increase the productivity of the nurses because they will not incur the non value added time of traveling to a patient where they are unable to insert the PICC.

Implementation

In order to implement the scheduling recommendation, the required number of PICC nurses per day is needed. This can be obtained from the Fall 2004 IOE 481 staffing program after inserting the time standard of 84 minutes. This program determines the number of nurses required to keep PICC queue length to a minimum. Depending on the percentile used for the time standard, the number of PICC nurses required would change. Next, each PICC should be assigned to one block of time and one PICC nurse until each PICC is accounted for. The PICC nurses would receive their schedule at the beginning of their shift. Any PICCs that cannot be accomplished that day can be accomplished the next day.

For floor nurses to have access to the VAS website, a programming change can be made to the sign in webpage. This new webpage will recognize all nurse’s names and passwords and allow them to change patient information which keeps the VAS office informed of all changes. Additional programming changes will require a dialog box to appear that reminds the nurse to verify that a written order has been completed. This dialog box will appear when a nurse is trying to submit an electronic PICC order.
Appendix A: PICC Process Data Collection Sheet

**PICC Process Data Collection Sheet**

<table>
<thead>
<tr>
<th>Step</th>
<th>Element</th>
<th>Start Point</th>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prioritize Patient</td>
<td>Touch printout of patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Travel time</td>
<td>Start walking to patient room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Check for order accessing patient records</td>
<td>Touch patient chart or computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Explains procedure to patient/family/ obtain consent</td>
<td>Introduce themselves to patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Arranges work area/ open PICC tray</td>
<td>Touch table used for supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Prepares patient for catheter</td>
<td>Touch patient or bed control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Insert the PICC into patient</td>
<td>Pierce patients skin with needle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Secure catheter/ cleans patient</td>
<td>Breaking away the introducer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Cleans work area</td>
<td>Finish writing date/initials on catheter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Complete documentation/ update VAS website/ Page Doctor</td>
<td>Start: Write on flier/ Stop: Page Doc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Problem Encountered/ Affect time of PICC Process**

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**Shift:**  
**PICC Nurse Name:**  
**PICC Nurse Pace Rating (1.10 fast - 0.90 slow):**  
**Recorded By:**  
**CPI #:**
Appendix B: Flowchart of the PICC Process

1. PICC Nurse chooses patient
2. PICC Nurse Check for order/assessing patient’s records
3. PICC Nurse contacts doctor to get order for PICC
4. Does the PICC Nurse get in approval from doctor for PICC
5. Is patient is cleared for PICC and has an order placed?
6. Patient fails to receive PICC
7. PICC Nurse explains procedure to patient/family
8. PICC Nurse obtains written consent from patient
9. Does patient consent to PICC?
10. Yes
11. PICC Nurse arranges work area/open PICC tray
12. PICC Nurse prepares patient for catheter
13. PICC Nurse inserts catheter
14. PICC Nurse uses Navion to trace path of catheter
15. PICC Nurse secures catheter/cleans patient
16. PICC Nurse removes small introducer/insert larger introducer over guide wire
17. PICC Nurse cleans work area
18. Patient successfully received PICC
19. PICC Nurse complete documentation/update VAS website/Page doctor