EXECUTIVE SUMMARY

The Vascular Access Services Team (VAST) at the University of Michigan Hospital (UMH) places approximately 250 PICC lines per month as found in the VAS database. Currently, around 40% of these lines require adjustment. The average cost of an adjustment is $271.62 which does not include the opportunity cost from the patient being discharged sooner. VAST performs around 1392 secondary adjustments per year, resulting in a potential savings of $378,095.04. The purpose of this report is to analyze the PICC placement process, identify reasons for adjustment procedures, and provide recommendations that will increase the first time success rate of primary PICC procedures. These recommendations will result in cost savings and increased customer satisfaction.

To compile this report, our team used the following methodology. First we conducted a literature search and observed a senior VAST member perform a PICC procedure. Next we collected and analyzed two metrics from VAS. Using these metrics we conducted interviews and surveys. The interviews were held with three nurses with a high first time success rate of primary PICC placement, two nurses with low rates, and two nurses in the middle. The surveys were handed out to every VAST member that places PICCs. Using the survey and interview answers, we created a process flow diagram. Then we continued the data analysis phase; stratifying the VAS database on factors such as insertion vein and arm, PICC tip location, and adjustment action. Lastly we calculated the cost of a procedure, and developed conclusions and recommendations.

Some of our key findings include various graphs regarding the current nurse readjustment rates. These key findings vary from which arm the PICC is inserted into to individual nurse PICC success rate on primary placement. We have found that 53% of the time, the 1700 radiologist advises the nurse to pull back the PICC. This recommendation is based on a set of guidelines that were released in January, 2006.

We conclude that the current process flow is not standardized. Through the interviews, our team was able to identify the PICC line measurement is inconsistent among VAST. Further analysis of the surveys shows that there is not a set process for measuring this distance. The lack of measurement consistency leads to incorrect PICC placement.

We recommend that training be changed to explain measurement process clearly, nurse measurement system be standardized so that all nurses measure in the same way, further studies be conducted on new technologies and to further minimize inherent variation, and the nurses be provided with additional resources.

We expect that these changes will reduce the current adjustment rate, decrease the non-value added time for both the patient and the VAST unit, increase patient throughput, improve the quality of patient care, and increase customer satisfaction.
INTRODUCTION

The Vascular Access Services Team (VAST) at the University of Michigan Hospital places approximately 250 Peripheral Intravenous Central Catheter (PICC) lines in adult inpatients per month. A PICC line is a form of intravenous access that can be used for an extended period of time. Of the 250 PICC lines placed by VAST, approximately 40% require secondary adjustment and require the patient to receive repeated chest x-rays.

The VAST team is concerned with the high secondary adjustment rate because adjustments have a profound effect on both the quality and cost of care provided. Due to the high interest in the 40% secondary adjustment rate, we developed the following goals. The first goal of this project was to identify and analyze reasons for the secondary adjustment procedures. The second goal was to recommend ways to decrease or eliminate the need for secondary procedures. The last goal was to increase customer satisfaction by establishing improvements in the current process.

This final report presents our data collection, analysis, and conclusions. We then used this information to recommend improvements to the PICC line process that will reduce or eliminate the need for secondary adjustments.

BACKGROUND

The PICC line process, which connects an intravenous catheter to the heart, is completed for various reasons, including chemotherapy treatments, antibiotic treatments, and total parenteral nutrition. The PICC line is a new technology being used to replace old methods including subclavian lines and internal jugular. The PICC line process is performed by inserting a PICC line into a peripheral vein on the arm. Once inserted into the vein, the line continues up the arm into larger veins and is finally placed in the cavo-atrial junction above the heart.

In the past at the UMH, this procedure was performed in the radiology department; however, recently the VAST department has trained a team of certified nurses to complete this procedure at the bedside. Once the PICC line is placed, a radiologist checks the placement with a chest x-ray. If the x-ray shows a misplaced PICC line, then the nurse adjusts the line or, in the case of extreme error, sends the patient to radiology. Currently, the PICC line process has a 60% rate of initial success. This means 40% of procedures need readjustment and about 12% of those require multiple readjustments or are sent to radiology department.

Readjusting the PICC line has many consequences that the UMH is trying to reduce including cost, time spent on the procedure, and customer satisfaction. The term “customer” is used in Health Care to represent not only the patients, but everyone involved in the hospital including the employees from janitors to management. The purpose of this project was to reduce the readjustment rate of the PICC line procedure.
GOALS AND OBJECTIVES

As previously stated in the project proposal and interim report, to address the key issues of the process, we defined the following primary goals:

- Identify the reasons for secondary procedures and prioritize according to significant impact
- Develop recommendations to decrease or eliminate need for secondary procedures

In achieving these goals we attained secondary goals, which included the following:

- Improve customer satisfaction
- Decrease commodity use
- Increase cost savings
- Increase patient throughput

PROJECT SCOPE

We used the following entities and tools that in the completion of the project:

- Inpatient adults in the University Hospital
- The PICC line placement process
- Financial data
- VAST PICC line data

The following tasks were excluded from the scope of this project:

- Outpatients
- **Patients under the age of 18**
- Other hospital entities
- PICC lines placed in Department of Radiology
- New PICC line technology
- Patient medical information

SUPPORT FROM OPERATING ENTITIES

The Manager of VAST provided ongoing details of the problem, requirements, expectations, needed data, and contact information. She also assisted in scheduling interviews with employees. Furthermore to ensure full cooperation, she acted as liaison between our team and other individuals. Specifically, she assisted in the distribution of surveys.
A member of VAST provided a guided tour of the PICC line process and answered our questions concerning the process.

The VAS Department provided data regarding errors during the primary PICC line procedure and the existing data regarding the entire PICC line process.

Our project coordinator, Dr. Richard Coffey, was our mentor and helped to maintain a professional positive client relationship throughout this project. He also acted as a liaison between our team and our client if we were unable to contact them. Furthermore, he provided us with feedback on our progress and assisted us with keeping the project on schedule.

**METHODOLOGY**

To identify reasons for and to reduce the number of secondary PICC line placement procedures, we first collected available metrics, then analyzed quantitative data, qualitative data from current VAST members, and the cost of an adjustment.

**Literature Search**

The literature search was completed to provide the team members with a broader knowledge of the PICC line procedure and background. We identified sources that explained how the process worked in detail and any potential downfalls that can occur throughout the process. We utilized the internet to research different aspects of the procedure. Wikipedia provided detailed steps and illustrations to show the progression of the procedure. In addition, our client provided us with materials regarding UMH’s adjustment procedure options, the VAS website, and VAS training documents.

**Data Collection**

During our initial data collection, we compiled the existing nurse and patient data regarding the PICC line process from two different databases:

- VAST database
- Secondary adjustment database

The VAST database includes data about adjustment date, site, RN, success, first x-ray reading, 1700 recommendation, action taken, success 2, second x-ray, and a notes section, for up to three adjustments. It also includes a coded patient number to ensure secured patient information. The secondary adjustment database includes data about RN, order date and time, area, room, date and time of completion, failure/transfer status, time of transfer, procedure name, nurse who closed out order, and final status.

**Observation**

Each team member shadowed an experienced VAST nurse for approximately four hours to view the PICC line procedure being performed on a patient. Shadowing the nurses enabled us to view the process and identify any problems that can occur based on the...
patient, during the radiology reading, and while entering the outcome onto the multiple databases that VAST nurses are required to use for each procedure. These databases include the VAST database and secondary adjustment database as mentioned above.

Data Analysis
With the multiple databases collected, our team stratified the data by nurse, arm of insertion, vein of insertion, action of adjustment, and number of adjustments. After finding multiple discrepancies between datasets, through the help of our client we determined to primarily focus our data analysis on the VAST database. Using the VAST database metrics from April through August, our team was able to determine the trend of PICC placements adjustment rate by month. Using these same metrics, we stratified the data based on each individual nurse finding the rate of adjustment for each of the thirty two nurses that have worked in the time period between April and August. These adjustment rates range from 29% to 65%. We used statistical analysis and set above 50% adjustment rate as out of control, then we determined which nurses had adjustment rates outside of the upper control limit. Focusing on the patient, we were able to stratify the data by the insertion vein and arm and compare that with adjustment rate. Further stratifying patient metrics, our team did research to determine which arm has a higher success rate. Our team also looked at the radiologist metrics and determined the percentage of occurrence for different incorrect placements such as in the right atrium, internal jugular, or not being able to see the tip. Proceeding with the radiologist recommendation metrics, we looked at the action taken to reverse these placements such as pulling back, repeating chest x-ray, and exchanging the PICC.

Interviews and Surveys
Our team conducted interviews with seven VAST members. We interviewed three nurses with a high rate of PICC placement, two nurses with low rates, and two nurses with average rates. The purpose of the interviews was to determine whether a discrepancy in procedure causes the need for adjustments and to address any needs for process standardization. See Appendix A for a copy of the interview questions.

For all twenty eight nurses that are currently employed, we conducted a survey to gather a general idea of each nurse’s procedure. This survey was constructed after the interviews so that we could focus on the key findings from these interviews. The survey helped us gain insight into the different ways nurses measure the length of the PICC. See Appendix B for a copy of the survey.

Process Flow Diagram
Our team used information from the interviews and surveys to construct a process flow diagram that identifies problematic areas with regard to secondary adjustments. The process flow diagram identifies the three general areas that a PICC can be placed incorrectly: the internal jugular, too long, or too short. From here, the diagram maps out the different steps taken according to the identified problem.
Cost Analysis
Using the process flow diagram, our team conducted a cost analysis to quantify the cost of a PICC adjustment and a PICC exchange. This analysis took into account the different type of adjustment that needed to be made, whether a new PICC had to be placed, and whether the patient had to be transported to radiology or stayed at the bed.

FINDINGS

From our different methodologies our team was able to analyze many aspects of the PICC process. From these we draw many conclusions that will aid in reducing the amount of adjustments for primary PICC placements.

Monthly Metrics

Figure 1. Month vs. Adjustment Rate

<table>
<thead>
<tr>
<th>Month</th>
<th>Adjustments</th>
<th>Total PICCs</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>102</td>
<td>280</td>
<td>36%</td>
</tr>
<tr>
<td>May</td>
<td>103</td>
<td>249</td>
<td>41%</td>
</tr>
<tr>
<td>June</td>
<td>122</td>
<td>298</td>
<td>41%</td>
</tr>
<tr>
<td>July</td>
<td>137</td>
<td>315</td>
<td>43%</td>
</tr>
<tr>
<td>August</td>
<td>90</td>
<td>217</td>
<td>41%</td>
</tr>
<tr>
<td>Total</td>
<td>554</td>
<td>1359</td>
<td>41%</td>
</tr>
<tr>
<td>Average</td>
<td>116</td>
<td>272</td>
<td>43%</td>
</tr>
<tr>
<td>Median</td>
<td>113</td>
<td>289</td>
<td>41%</td>
</tr>
<tr>
<td>StDev</td>
<td>17</td>
<td>28</td>
<td>3%</td>
</tr>
<tr>
<td>Range</td>
<td>35</td>
<td>66</td>
<td>2%</td>
</tr>
</tbody>
</table>

As the above figure shows, the monthly adjustment rate has high variation. April had the lowest adjustment rate of 36%, whereas July had a very high rate of 43%. The total number of adjustments completed for these two months is 102 and 137 respectively. For all of the data, the median is 112.5 readjustments per month.
The figure above shows each nurse's individual adjustment rate. The variation among nurses is very high, specifically, the rate varies between 29% and 65%. This information is useful in determining those nurses with the low adjustment rate and modifying the PICC placement procedure to follow their strategy thus reducing the amount of adjustments.

Using the statistical analysis method of control charting, we set the upper control limit at 50%. The above chart shows that six of the twenty-eight nurses have adjustment rates that are above the control limit.
Surveys and Interviews
Currently, parts of the training process vary from nurse to nurse while some parts are standardized. Our interviews indicated that most nurses are trained for two weeks by shadowing a more experienced nurse. In addition to the training, all nurses must complete a day of classroom training. After the initial two weeks, each nurse is provided with a mentor who acts as a guide when the new nurse has questions about the procedure. The mentor and the nurse that they are shadowing varies, as well as the techniques that they teach. Additionally, any follow up training must be sought out by the nurse.

From the interviews, our team was able to determine the procedure that the different nurses use. In the interviews we identified general information about which arm the nurse prefers to insert the PICC in as well as which vein to insert the PICC into. The placement of patient seemed to be different among the nurses. Some preferred patients to lay flat while other had patients inclined. The angle at which the arm is placed away from the body varied between 0 and 90 degrees. One of the key findings of our interviews was that each nurse measures the distance from insertion point to final placement differently. The nurses generally measure from the vein insertion point to the shoulder, however the point they use on the shoulder varies among nurses. Next they measure from this point on the shoulder to either the left clavical notch or right clavical notch. Last they measure from the chosen clavical notch to the SVC using either fingers, centimeters, or ribs. By noticing this discrepancy, we focused our survey on this topic.

The survey findings support the interview findings, showing that procedures and measuring processes vary among the nurses. The main issues addressed in the survey results are the different ways that nurses measure the insertion point to final placement of the PICC and the fact that patient anatomies are different and that causes a problem. Appendix C has a detailed listing of the survey free response questions and answers.

Vein Insertion

### Figure 4. Vein Insertion Point vs. Adjustment Rate and Count

<table>
<thead>
<tr>
<th>Adjustment Rate</th>
<th>Adjustment Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Adjustment Rate and Count Graph" /></td>
<td><img src="image" alt="Insertion Point Graph" /></td>
</tr>
</tbody>
</table>

---

Deleted: the
Deleted: is
Deleted: A
Deleted: additional
Deleted: arm
Deleted: between arm and body to a comfortable placement for the patient
Deleted: Our key
Deleted: in
Deleted: the
Deleted: between
Deleted: N
Deleted: See
Deleted: for
Deleted: answers
Formatted: Font: Bold
Formatted: Font: Bold
From the graphs above, we can determine the best insertion place. The left median cubital has the lowest adjustment rate of about 32%, however it is not used very often. In contrast, the right basilic has the highest adjustment rate of about 47% and it is used often. Generally speaking, the median cubital is best for either arm while the basilic vein and cephalic vein is arm dependent. It is important to note that these rates are based on varied number of insertions per vein.

Arm Insertion

**Figure 5. Arm of Insertion vs. Readjustment Rate**

Comparing the left and right arm, it is clear that inserting the PICC into the left arm has a lower adjustment rate than that of the right arm. However, each patient is a different case and must be treated differently. Many patients cannot have their left arm used for a PICC line due to the veins being occupied by other medical treatments and devices or the veins are collapsed or rolling.

Adjustment Analysis

**Figure 6. Pie Graph of Chest X-Ray Readings**
The pie graph and Pareto chart display the various areas where the PICC tip is located after primary placement. 51% of all PICCs requiring adjustment are due to the PICC tip being pushed past the SVC and ending up in the right atrium. This percentage outweighs the other incorrect placements considerably as shown by the Pareto chart. Furthermore, the PICC ends up in the jugular 14% of the time. Finally, 3% of the time the radiologist cannot read the x-ray and an additional x-ray needs to be taken.

**Figure 7. Pareto Chart of Chest X-Ray Readings**

The most incorrectly placed PICCs are inserted too far and lie in the right atrium. This percentage outweighs the other incorrect placements considerably as shown by the Pareto chart. Furthermore, the PICC ends up in the jugular 14% of the time. Finally, 3% of the time the radiologist cannot read the x-ray and an additional x-ray needs to be taken.

**Figure 8. Action Taken During Adjustment**
As you can see above in the pie graph and Pareto chart, 53% of the PICCs are too long and need to be pulled back. 18% of the time the PICC must be advanced. 11% of the time the PICC is able to be advanced while 7% of the time the whole PICC must be exchanged. The Pareto chart outlines that the two most common adjustments result in pulling the PICC back or rethreading the PICC.

**Cost Analysis**

**Table 2. Cost Analysis**

<table>
<thead>
<tr>
<th>Nurse</th>
<th>Nurse time of a secondary adjustment</th>
<th>1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nurse salary per hour</td>
<td>$30.22</td>
</tr>
<tr>
<td></td>
<td>Assume fringe benefit rate</td>
<td>32%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$59.84</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Hourly rate for patient transporter</th>
<th>$13.43</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assume fringe benefit rate</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>Percentage of PICCs that need transportation</td>
<td>63%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$11.17</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radiology: chest x-ray single view</th>
<th>Hospital fee</th>
<th>$132</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physical fee</td>
<td>$33</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$165</strong></td>
</tr>
</tbody>
</table>

| Materials | Percentage of PICCs that need to be exchanged | 31% |
This table outlines the various costs incurred in an adjustment. The nurse and radiology costs are constant. However, for intensive care patients, the cost of transportation is not necessary because the x-ray is performed at the bedside. For patients with a PICC that is not far enough, a new PICC is typically needed. In this case a large cost is incurred in materials. The difference between a PICC that is too short versus too long is over $114.88. The yearly cost of adjustments due to inpatient adults for the University of Michigan Hospital is almost $400,000.

<table>
<thead>
<tr>
<th>PICC Type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple Power PICC</td>
<td>$170</td>
</tr>
<tr>
<td>Percentage of PICCs that are PP PICCs</td>
<td>37.50%</td>
</tr>
<tr>
<td>Standard PICC</td>
<td>$81.81</td>
</tr>
<tr>
<td>Percentage of PICCs that are standard PICCs</td>
<td>62.50%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$35.61</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Breakdown</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost per readjustment</td>
<td>$271.62</td>
</tr>
<tr>
<td>Monthly readjustment cost</td>
<td>$31,507.92</td>
</tr>
<tr>
<td>Yearly readjustment cost</td>
<td>$378,095.04</td>
</tr>
<tr>
<td>Cost of an exchanged PICC</td>
<td>$350.89</td>
</tr>
<tr>
<td>Cost of all other PICC Adjustments</td>
<td>$236.01</td>
</tr>
</tbody>
</table>

CONCLUSIONS

Nurse Variation

For nurses there is a large variation in arm and vein choice. The left arm has a 10% lower rate of adjustment than the right arm. The vein with the highest success rate is the median cubital with a rate of 32% but is not used often. The left basilic vein has the next lowest rate of 35% and is one of the most used.

There is also variation in patient placement during the PICC insertion. Some nurses lay patients flat or at a slight incline to increase blood flow. The angle between the arm and body of the patient also varies. Lastly, movement of the patient’s head also varies.

Measuring processes vary between nurses as well. To measure down from the clavical notch, nurses use fingers, centimeters, or ribs to reach the final placement for the PICC. The number of times a nurse checks their measurement from the start position to final placement also varies anywhere between zero times and four and a half times.

Adjustment Analysis

Of all placements, 51% are in the right atrium and the average pull back distance is 4.1 centimeters. 14% are in the jugular. These can be solved by standardizing patient limb placement. The rest of these placements can be solved with technology which will inhibit the PICC line from entering the jugular. Another 9% are coiled or looped. Technology would also be able to identify this irregularity. The last 18% need to be advanced; this includes pushing the PICC forward and exchanges. Taking into account...
all the actions except rethreading, the average action is to pull the PICC back 2 centimeters.

Cost Analysis

A lot of money can be saved by improving the adjustment rate. The average cost per year of inpatient adult adjustments totals $378,095.04. The easily reversible problems are placements in the jugular and those that are coiled or looped. For those in the jugular, $52,933.31 can be saved and for those that are coiled or looped $34,028.55 will be saved.

The situation of a radiologist not being able to read a chest x-ray costs $7,934.40 per year which can easily be eliminated. For the situations when a radiologist suggests the PICC be advanced for the first adjustment and the second adjustment the total savings for eliminating this will be $6,805.71. The situation when a radiologist suggests to push forward the PICC and for the second adjustment to pull the PICC back the cost is $4,537.14. With all three of these being eliminated the cost savings is $19,277.25.

Process Flow Diagram

Figure 10. Process Flow Diagram
The process flow diagram illustrates the numerous adjustments that can be made. The cost benefit analysis mentioned above addresses all of these different paths to sum up a final cost.

RECOMMENDATIONS

Based on the analysis and interpretation we formulated the following recommendations for reducing the adjustment rate of PICC line procedures and decreasing the non-value added time.

**Process Standardization to Reduce Variation**

In order to reduce variation among the PICC placement procedure, the nurses should standardize the patient placement. The incline of the bed as well as the angle between the body and arm of insertion for the patient should be further studied and given a set of guidelines. Along with placement, the nurses should have guidelines for the specific arms and veins to use. If the patient cannot have the particular arm or vein being used than the guidelines will specify what to use from there.

The measuring procedure also needs to be standardized for the PICC procedure. A set of standard guidelines will provide rules for measuring from the point of insertion to final placement.

**Continuous Improvement**

Continuing to improve the PICC process would involve the study of new technologies to reduce the readjustment rate. To aid the nurses, a quarterly self assessment should be completed and given to the nurses so that each knows their current rate of success and how much improvement he/she needs to make. See Appendix E for an example of an assessment.

**Additional Resources**

We recommend that all VAST nurses are provided with the set of 1700 guidelines for reading x-rays. We believe that making this information available to the nurses would provide for a more cooperative environment. In other words, if the nurse understands why they are adjusting the PICC’s, then they will be happier in complying with the instructions.

**Future Studies**

A common problem that nurses have addressed is the patient anatomy. This should be studied by doing a patient analysis before placing the PICC and looking into the patients medical history for any indications of abnormal anatomy.

As mentioned before, the new technology Viasys will decrease the costs of readjustments by $86,961 per year. Using other new technologies in addition to this will further decrease the readjustment rate.
Last, as the interviews and studies showed, the data entry system is tedious. The same information is being put into three different databases, which causes discrepancies in information when they are not put in consistently. Combining down to one or two systems would make the data more accurate and increase nurse satisfaction.

EXPECTED IMPACT

We expect the recommendations from this point will decrease the adjustment rate of PICC line procedures, thus increasing productivity and efficiency of the VAST unit. Specifically, we expect recommendations to result in:

- Reduced adjustment rate
- Decreased non-value added time for both the patient and the VAST unit
- Increased patient throughput
- Improved quality of patient care
- Increased customer satisfaction

Deleted:

Standardize Nurse Measurement System

In our interviews we found that there are multiple ways in which a nurse measures the length of a PICC and the training process followed. However, since the length of the PICC is the main reason for readjustments, the measuring procedure should be standardized. As part of the training process, a standardized measure should be provided to the new VAST nurses. As part of their training, they should focus on having a nurse work on measurements for a substantial amount of time before placing PICCs. Setting these guidelines will help focus on key problem areas to reduce the problems with measurements. The new measurement system will specify how to measure from the insertion point to the exact shoulder point, this also takes into account the vein to follow. From there the guidelines will specify whether to use fingers, centimeters, or ribs to measure down from the clavical notch to the SVC.

Provide Nurse with Additional Resources

We recommend that all VAST nurses are provided with the set of 1700 guidelines for reading x-rays. We believe that making this information available to the nurses would provide for a more cooperative environment. In other words, if the nurse understands why they are adjusting the PICC’s, then they will be happier in complying with the instructions. (can we add some info from the surveys/interviews about radiologist complaints so this makes sense?)

Change Data Entry System

We recommend that the data entry system should be modified. This way, the charge nurse won’t need to sit and input data. Also, this will increase nurse satisfaction because the nurses currently dislike the time it takes to input data. (should we keep this? It might be more connected to the problems between databases?)

Conduct Further Studies

The scope of this project excluded the Radiology department, therefore we recommend that further studies or senior design projects be conducted in this area. We specifically recommend that the process and tools that the 1700 radiologist uses should be closely analyzed. This includes analyzing the current set of 1700 guidelines used to read the x-rays. The radiologist reading is a problem because 1.2% of the readjustments are due to problems with radiologist reading the x-ray or a "push-pull" scenario. A "push-pull" scenario is defined as multiple adjustments w/...
APPENDIX A. VAST Nurse Interview Questions

Step 1: Explain to the nurses our project, our goals, and why we are interviewing them.

Step 2: Ask the following questions.

1. Please describe the PICC Line process from placement order to when you bring the patient to the X-Ray department.
2. What is the most common difficulty during PICC line placement?
4. Can you explain your PICC line procedural training?
5. Are you aware of any particular devices that could substantially reduce the adjustment rate?
6. What suggestions do you have to help increase the current PICC Line readjustment rate?
7. What’s your experience with the overall rate, your rate? What do you think these numbers are?
8. What location of the hospital do you think has the highest redo rate/ most difficult place to place PICCs based on patient type?
9. What do you think is the primary reason for pull back redoes? (Measurement was too long, patient movement, etc?)
10. Why are they pushed in too far?
APPENDIX B. VAST Nurse Survey

**VAST SURVEY: IOE 481 – Health Systems and Operation Analysis**

Name:_____________________________

Number of Years Experience, in VAS Department: __________ in Nursing: __________

Part 1

1. How many times do you measure the PICC line length before placement?
   - 0 1 2 3 4 5+

2. During the measurement process how many extra centimeters do you add the initial measurement from insertion point to SVC (as a buffer, etc)?
   - 0 1 2 3 4 5+

3. How do you measure down from the right clavical notch?
   - Fingers Ribs Cm Other_______
   - How many?
     - 0 1 2 3 4 5+

4. If an adjustment is necessary, do you tend to error on the long or short side?
   - Long Short
   - How many cm?
     - 0 1 2 3 4 5+
   - Why?________________________________________________________
     ____________________________________________________________________

Part 2

Have you learned any shortcuts or tricks that help you with the process? If so, what?

________________________________________________________________________
________________________________________________________________________

What is the most difficult part of the PICC procedure?

________________________________________________________________________
________________________________________________________________________

Please give any advice that might be helpful:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
APPENDIX C. Qualitative Survey Results

Why are your PICCs long/short?
(RN #s, Answer)
29, 1, 30, 2, 23, 32, 20, 22, 15. Patient anatomies are different. Also, often patients are obese or disabled.
3, 4, 8. I prefer to be too long so that if it’s misplaced, I only need to pull back instead of doing an entire exchange.
30. My PICC’s are long or short due to my measuring technique.

Have you learned any shortcuts or tricks that help you with the process? Explain.

24. I have a consistent technique: vein access followed by threading PICC to SVC
2. I place patient in an upright position to prevent line from taking upward course.
4. When threading introducer over MST wire, I pull down on patient’s skin (below insertion site) to create some tension. This helps to avoid bending the introducer and wire.
20. I stay neat and organized.
22. I trim to my measurement but leave 2 cm on skin. (Many times I am at CA Junction-better long than short)
13. I use an image found on Google as a visual aid. I carry this in my workbook.
31. Keep the patient’s arm at 90 degrees during measurement. Fold the tape measure to prevent it from moving around.
1. Measure from insertion point to right of sternal notch with arm at a 90 degree angle, then add 5 cm. I get the most consistent results.
19, 30. positioning. If I and the patient are comfortable, then the procedure goes better.

What is the most difficult part of the PICC procedure?

2, 15, 3, 28. Venous access, placing guidewire, and threading wire is most difficult.
32, 15, 13. Accurate measuring is difficult.
20. When the catheter will not thread in, try readjusting arm, flushing, and advancement.
22. I have trouble with patients. They want to talk to a doctor.
1. Getting the cart in the room and managing available space is difficult.
8. Elderly patients are unable to keep their arms still.
23. Obtaining written strip order is difficult. Availability of the patient is also difficult.
29. A lot of times the MST wire curls when I try to thread it.
30. Positioning the patient.

Please give any advice that might be helpful:

4, 28. Get the patient in a good position with the vein accessibly before even starting placement. I also take a long time with ultrasound assessment to choose an insertion site.
24. Optimize “set up”, anesthetize well, good ultrasound evaluation and technique (proper angle and probe measurement), don’t quit too soon! Reassess and keep trying.
2. Relax and maintain composure during difficult accesses. Find best position to visualize and access vein in the most optimal manner.
20. Having the arm in a good position for access. Giving yourself room (clearing the clutter) to be able to move the table and patient around to do readjustments.
22. VAS lab
3, 13. The patient must be as flat as possible and arm spread 90 degrees for best results
3. Change the angle of the needle to 30 degrees after contacting the vein
8. For patients with loose connective tissue, put a roll of blanket under their upper arm, as this makes it easier to put the introducer ordilator in smoothly.
15. Be patient with yourself.
23. Don’t second guess your measurements.
31. Have the physician get the consent signed.
1. Measure consistently. I try 3 methods at each point to see if I get consistent measurements.
30. If having difficulty threading, I position the patient towards insertion arm so that arm and chest are pinched.
## APPENDIX B. Quantitative Survey Results

<table>
<thead>
<tr>
<th>Nurse ID</th>
<th>Adj. Rate</th>
<th>Yrs in VAST</th>
<th>Yrs in Nursing</th>
<th># of Times Measured</th>
<th>Buffer cm</th>
<th>Measurement Technique</th>
<th># (measurement)</th>
<th>Long/Short</th>
<th># cm</th>
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Currently approximately these PICCs secondary purpose of this project was identify and analyze reasons for the secondary adjustment procedures, ways to decrease or eliminate the need for secondary procedures, and by improving the current process. O for this project the line process in order to fully understand the entire procedure gathered data from three data
The team that works with the sources and the highest success for the primary PICC placement with rates in the middle.

The team that works with the lowest success for the primary PICC placement with rates in the middle.

We continued an ongoing nurse success rate and insertion vein and arm development, analyzed cost benefit information.
Standardize Nurse Measurement System
In our interviews we found that there are multiple ways in which a nurse measures the length of a PICC and the training process followed. However, since the length of the PICC is the main reason for readjustments, the measuring procedure should be standardized. As part of the training process, a standardized measure should be provided to the new VAST nurses. As part of their training, they should focus on having a nurse work on measurements for a substantial amount of time before placing PICCs. Setting these guidelines will help focus in on key problem areas to reduce the problems with measurements. The new measurement system will specify how to measure from the insertion point to the exact shoulder point, this also takes into account the vein to follow. From there the guidelines will specify whether to use fingers, centimeters, or ribs to measure down from the clavical notch to the SVC.

Provide Nurse with Additional Resources
We recommend that all VAST nurses are provided with the set of 1700 guidelines for reading x-rays. We believe that making this information available to the nurses would provide for a more cooperative environment. In other words, if the nurse understands why they are adjusting the PICC’s, then they will be happier in complying with the instructions. (can we add some info from the surveys/interviews about radiologist complaints so this makes sense?)

Change Data Entry System
We recommend that the data entry system should be modified. This way, the charge nurse won’t need to sit and input data. Also, this will increase nurse satisfaction because the nurses currently dislike the time it takes to input data. (should we keep this? It might be more connected to the problems between databases?)

Conduct Further Studies
The scope of this project excluded the Radiology department, therefore we recommend that further studies or senior design projects be conducted in this area. We specifically recommend that the process and tools that the 1700 radiologist uses should be closely analyzed. This includes analyzing the current set of 1700 guidelines used to read the x-rays. The radiologist reading is a problem because 1.2% of the readjustments are due to problems with radiologist reading the x-ray or a “push-pull” scenario. A “push-pull” scenario is defined as multiple adjustments where a nurse will first push the PICC in further with the next adjustment being to pull it back, and vice versa.

Increase Use of New Technologies
Using new technologies such as Viasys will decrease the overall readjustment rate. Currently there are 21% of the PICCs needing readjustment that are in the left internal junction, the right internal junction or are coiled and looped. The new technology Viasys
is a metal detecting tool that provides an audible signal when the hand held machine is placed over the end of the PICC in the patient. With this technology a nurse will be able to determine if their PICC is in an area other than the chest.