Utilizing Garbology to Analyze Discrepancies between Planned, Documented, and Trashed Surgical Supplies in Hospital Operating Rooms

Final Report

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EXECUTIVE SUMMARY

Background
Michigan Medicine handles approximately 50,000 surgical procedures each year. The OR Informatics Manager estimates that 36,000 of these surgeries happen annually between University Hospital (UH) and C.S. Mott Children’s Hospital (Mott). To obtain accuracy metrics of the documentation process of surgical supplies used during surgeries, the IOE 481 student team performed a garbology study at the request of the OR Informatics Manager and the Operating Supply Chain Manager. Inaccurate documentation of supplies is believed to be an overarching issue at the hospital, which impacts the accuracy of inventory and billing. The purpose of this project was to verify that discrepancies exist between planned, documented, and trashed surgical supplies, and to assess the accuracy of the documentation.

Current Documentation Process
A Doctor Preference Card (DPC) contains a list of supplies that the doctor performing the surgery plans to use. The list is examined by a service lead nurse, and after the list is approved, the list of planned items is passed off to a perioperative technician who gathers the supplies on the list from the inventory cores. Both the approval and gathering processes usually happen the day before the scheduled surgery. On the day of the surgery, the cart of gathered supplies is delivered to the operating room (OR) where a nurse unwraps the items and reorganizes them on a table in the OR. During the operation, a circulating nurse is responsible for documenting what supplies are being used. This list of documented items is sent to billing.

Key Issues
Incorrect documentation causes problems outside of the OR, as well as inefficiencies within the OR. First, inaccurate documentation causes billing errors to patients. This occurs when supplies are used (found in trash) but not documented, or when supplies are documented but not used. Incorrect documentation can also result in inventory errors, such as overstocking or supply deficiencies. If supplies are documented as used during a surgical case, but actually returned to inventory, overstocking can occur. An overstocked supply can lead to products expiring and additional costs. Another problem is shortages in surgical supplies. Nurses must leave during a surgery to retrieve supplies that were not originally brought into the OR. These supplies can be used and not recorded, which leads to less inventory than expected. Overall, these issues create various billing and inventory problems within and outside the ORs.

Methods
The sections below describe the team’s trash collection process and modes of analysis.

Trash Collection
The garbology study lasted three weeks from February 20th, 2017 to March 10th, 2017. A total of ten operating rooms were included in the study, 5 ORs in UH and 5 ORs in Mott. These rooms were specifically chosen for their diversity of services and operations to discover if documentation was a general concern. 113 garbage bags, corresponding to 113 cases, were collected, catalogued, and analyzed.
**Analysis**

To analyze the data, the team used Microsoft Access and SQL to query the information of planned, documented, and trashed supplies by case number and by item number. The team began by analyzing the differences between the DPCs (planned supplies) and supplies found in the trash, and then by analyzing differences between documented supplies and supplies found in the trash. Documentation errors were stratified by several categories including site, service, room, and case size. A cost analysis was also performed, revealing the cost of items that went undocumented, as well as the cost of items that seemingly were not used but were documented. Additional areas of analysis included utilization of circulating nurses, inventory inconsistencies, and DPC accuracy.

**Findings and Conclusions**

Based on the garbology study of 113 cases, it was most common for cases to have 80-89% of the trash match items on the DPC. The average percent of trash matching the DPC was 69.52%. Overall, nurses are retrieving approximately 13 additional items per case, and then returning approximately 10 items to inventory after the case is over. If the assumption is made that each item takes one minute to retrieve, the estimate for the number of hours nurses spend retrieving items each year is approximately 7,700 hours. It appears a significant amount of time is wasted retrieving items that were not originally planned for during surgeries.

The team’s analysis proves that documentation of items is inaccurate in UH and Mott. Regardless of factors like operating room, site, service, or case size, 7.22 items per case failed to be documented. Cost analysis revealed that approximately $8,000 worth of items went undocumented during the 113 cases. When scaled, the lost cost of these undocumented items becomes $2.6 million each year. Conversely, $25,000 worth of items were documented but not found in the trash, which is an estimated $8 million each year. Possible error and overstating exists within the number of items documented but not in the trash because some supply wrappers could have been placed in another trash receptacle not collected in the garbology study. However, the errors in documentation are apparent, and likely cause vast inaccuracies for both inventory and patient billing.

**Recommendations**

Given the breadth of potential solutions and their costs, the team recommends a tiered strategy of implementing three solutions: training, barcode scanning, and an RFID (radio frequency identification) system. The team recommends the hospital assess the impact during each phase of implementation. The first step is to review the current standard of work concerning item documentation, and then offer a training session for nurses and staff. For the second step, the team recommends that the hospital test the barcode scanning solution in a few of the ORs to assess the impact, and then fully implement if successful.

In the long term, the team recommends that the hospital adopt an RFID system to track the items used during surgery. Before implementing RFID, the team also suggests that a cost-benefit analysis be performed for RFID in UH and Mott to better understand the benefits. The expected impact from RFID includes greater accuracy in inventory and billing, and availability of nurses.
INTRODUCTION
The University of Michigan hospital system, recently renamed Michigan Medicine, reports approximately 50,000 surgical cases each year [1]. 36,000 of these surgeries are estimated to happen at University Hospital (UH) and C.S. Mott Children’s Hospital (Mott). For every surgery, two lists are compiled; a list of surgical supplies that are planned for the surgery and a list of supplies that are documented as used during the surgery. Currently, UH and Mott do not have accuracy metrics for the planned supplies and the documented supplies. The OR Informatics Manager and the Operating Supply Chain Manager believe that there are instances when supplies are not being recorded accurately during surgeries. IOE 481 Student Team 12 was asked by these two managers to complete a garbology study. The purpose of the study was to verify that discrepancies exist between planned, documented, and trashed surgical supplies, and to assess the accuracy of the documentation. The term “trashed supplies” describes the verified list of supplies used during in a surgical case (found in the trash). This final report provides the project background and methods, and the team’s analysis, findings, and conclusions of planned versus documented versus trashed items.

BACKGROUND
The background section defines garbology and discusses the current situation involving the planned, documented, and trashed items. The key issues, project scope, and project goals are also addressed.

Garbology
According to Merriam Webster’s dictionary, the formal definition of garbology is “the study of a community or culture by analyzing its waste” [2]. Collecting the waste from operating rooms and recording each trashed item enabled the team to create a list of trashed items to then compare with the list of planned and documented items for each case.

Current Situation
Figure 1, seen below, distinguishes the three types of lists at a high level and relates them to the timeline of a surgery. Both trashed and documented lists are formed in the OR during a surgery. Each type of list is explained in greater detail in the subsequent paragraphs.
Planned Items
The process of tracking surgical supplies begins with a list of planned items for a surgery. This list is called a Doctor Preference Card, or DPC. A nurse reviews the DPC to determine if all the necessary supplies are listed and contain the correct quantities. The nurse can consult with the doctor performing the operation for supply input but also uses prior knowledge to judge if the DPC is ready. This review process typically occurs the day before a surgery is scheduled to occur. The DPC is next handed off to perioperative technicians (PT’s). The PTs collect the supplies listed on the DPC from the inventory stock room and place them onto a cart. A stocked cart is placed in a staging area where it waits until it is brought to the OR for its scheduled operation. Before the patient arrives, the cart of supplies is brought inside the OR. A nurse unwraps all the items from the cart and reorganizes them on a sterilized table to streamline the operation. If an item was unwrapped but did not get used during the operation, it is thrown away at the end of the surgery. To alleviate this waste, there is a type of item on the DPC labeled as PRN, or pro re nata in Latin, which translates to “use when necessary”. PRN items are collected by PT’s during their initial gathering of supplies and are placed on the supply cart. However, PRN items in the OR are not opened, and therefore, may be returned to inventory if unopened.

Documented Items
During an operation, one responsibility of a circulating nurse is to document which supplies are used during surgery. This list of used items is what will be sent to the billing department. The circulating nurse uses a computer inside the operating room to edit the list of items being used. All items that are listed on the DPC, excluding PRN items, are automatically documented as used. However, due to the fluctuating needs of the OR, a case’s DPC might not remain accurate over the course of the surgery and extra items may be brought in. The circulating nurse documents any changes in supplies or quantities during an operation.

Trashed Items
When the stocked cart is brought to the OR, a nurse prepares the supplies for the operation by unwrapping each item and discarding the wrappers into a waste bin designated for non-biohazardous materials. If any additional items are opened during the surgery, i.e. PRN, the item wrappers should end up in the same wrapper waste bin. It is from this wrapper trash that the garbology study verifies what items were actually used during a surgery.

Key Issues
This project focuses on the discrepancies between planned, documented, and trashed surgical supplies. The key issues associated with these discrepancies include the following:

- Nurses leaving the OR to retrieve additional supplies
- Incorrect inventory (overstocks and shortages)
- Inaccurate patient billing

The first key issue, nurses leaving the OR, occurs when a large difference exists between the items listed on the DPC and the items found in the trash. If a large number of items are needed for a surgery but were not on the DPC, the circulating nurse will leave the OR to retrieve the extra items. The nurse might leave the OR to retrieve items multiple times depending on the needs of the surgical team. During this time, the nurse is not in the room to monitor what items are being used, and therefore, cannot document those items.
The other key issues, incorrect inventory and inaccurate patient billing, result from discrepancies between documented items and trashed items. These discrepancies can occur when nurses incorrectly document the items used during a surgical case. The case documentation affects inventory levels because the two systems, case documentation and supply inventory management, are linked together. As supplies are documented as used in an OR case, the inventory level of that supply is decremented. Correctly documenting all items can be challenging because of other responsibilities of the circulating nurse. When the documentation of used items is incorrect, inventory levels and patient billing become inaccurate.

Project Scope
The garbology study was only carried out in the operating rooms listed below.

- University Hospital ORs: 4, 13, 17, 31, 33
- Mott Children’s ORs: 5, 6, 9, 10, 19

These rooms were chosen by the OR Informatics Manager and the Clinical Care Coordinator because of the variety of services provided in the ORs (orthopedic, cardiovascular, etc.). Including two hospitals and multiple services in the study helped to identify if documentation inaccuracy was widespread. Implants, such as screws and rods, were considered out of scope for this project since these items are not found in the trash and are therefore not directly recordable. The team did not drill down into any issues related to staffing, billing, or sterilizing.

Goals and Objectives
After meeting with the OR Informatics Manager and Operating Supply Chain Manager, the student team developed the following goals:

- Deliver accuracy metrics on planned vs. documented vs. trashed supplies
- Develop recommendations to improve the accuracy of documenting supplies in the ORs

To help achieve the goals, the team completed the following objectives:

- Observe an operation
- Collect wrapper waste
- Catalogue garbage
- Create database
- Perform analysis
- Complete literature search

METHODS
The team’s objectives doubled as the methods for this project. This section provides more detail on the team’s OR observations, trash collection, garbology study, and data analysis.

OR Observations
With the assistance of the project coordinator, the team was able to observe two operations in UH for a total of four hours. The team saw the collection of wrappers and was able to witness the environment that a circulating nurse works in, taking note of points in the process that could affect the accuracy of documentation. The team gained a greater understanding of the process from the visual context of planned, documented, and trashed items in the hospital.
**Trash Collection**
The OR Informatics Manager facilitated the trash collection process with hospital staff, introducing orange garbage bags to 10 specified ORs in UH and Mott (referenced in Project Scope). The collection period lasted three weeks beginning on February 20th, 2017 and ending on March 10th, 2017. Nurses were instructed to place packaging and wrapper waste from surgical supplies into the orange bags, and affix a sticker with the case number to the bag. The bags were then delivered to a collection room where the team performed the garbology study.

**Garbology Study**
The team began cataloguing the wrapper waste on February 24th, 2017. The OR Informative Manager and Supply Chain Manager provided a tool that connected the case number to the list of planned and documented items for that case. Overall, the team catalogued 113 cases and 4,498 pieces of trash.

**Data Analysis**
The OR Informatics Manager helped the team create a database table in Microsoft Access. The complete database table listed every item used in each of the 113 cases, as well as the planned, PRN, documented, and trashed item quantities. An example of this database table is seen below in Figure 2.

![Figure 2: Microsoft Access Database Table Example](image)

For stratification purposes, case information, such as type of service (orthopedic, etc.), Operating Room number, and site (UH or Mott), was also integrated into the database. More images of the database table appear in Appendix A.

**FINDINGS AND CONCLUSIONS**
After completing the data collection from the 113 cases, the team stratified the data to look at the two following situations.

1. The differences between planned and trash items (DPC accuracy)
2. The differences between documented and trashed items (documentation accuracy)

These two situations are shown below in Figure 3.
The areas highlighted with the numbers ‘1’ and ‘2’ represent the ideal categories for surgical supplies. The first highlighted area represents items that were both planned for and found in the trash. The second highlighted area represents items that were both documented and found in the trash. When larger quantities of items fall into these categories, the documentation will be more accurate.

**DPC Accuracy**

The first area of analysis focused on how accurately the items found in the trash represented items originally planned for on DPC. The Pareto Chart below in Figure 4 displays the frequency with which certain percentages of trash were represented on the DPC. It was most common for cases to have 80-89% of the trash represented on the DPC. In other words, most frequently in the cases examined, 10% of the items in the trash had to be retrieved from outside of the OR.
Descriptive statistics are summarized below in Table 1 for the percent of trash on the DPC across the 113 cases. Additionally, descriptive statistics are included for the percent of items found in the trash that were not on the DPC and the percent of items that had to be returned to inventory after the surgery (unused PRN items).

Table 1: Descriptive Statistics of Garbology Study

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>Median</th>
</tr>
</thead>
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<tr>
<td>% Trash on DPC</td>
<td>113</td>
<td>69.52%</td>
<td>19.87%</td>
<td>75.00%</td>
</tr>
<tr>
<td>% Add-on Items</td>
<td>113</td>
<td>30.48%</td>
<td>19.87%</td>
<td>25.00%</td>
</tr>
<tr>
<td>% Items Returned</td>
<td>113</td>
<td>16.44%</td>
<td>14.40%</td>
<td>14.29%</td>
</tr>
</tbody>
</table>

As seen in the table above, 69.52% of items found in the trash were also on the DPC. This means that approximately 30.48% of the items used in each case must be retrieved from outside of the OR while the case is in progress. Additionally, an average of 16.44% of all planned items are returned to inventory after the surgical case is completed.

DPC accuracy is an important issue because when a greater number of unplanned items are needed, circulating nurses spends a greater amount of time outside the OR. According to the OR Supply Chain Manager, retrieving items outside the room can cause delays in surgeries and can risk disrupting the sterile environment inside the OR. With the assumption that the circulating nurses leave the room for each item individually, the average number of trips outside of the room per case is approximately 13 trips. Another reason DPC accuracy is significant is because returning PRN items after a case can create mistakes in inventory levels and require staff members to take the time to return the items to their proper locations. On average, approximately 10 items have to be returned after a case is completed.

Documentation Accuracy

The following sections explore the discrepancies between the items documented and the items found in the trash during the garbology study. This analysis correlates to the orange intersection marked with the number ‘2’ in Figure 3.

Undocumented Quantities

The number of supplies that were found in the trash but not documented as used is a key metric for assessing the accuracy between trashed and documented supplies. These ‘extra’ supplies are found in the trash as a result of the surgery deviating from the original plan (DPC) and the circulating nurse not adjusting the list of documented items. In all 113 cases, at least one of the item numbers the team encountered included more items in the trash than were documented. In the 113 cases analyzed, approximately 20% of all item numbers had more items in the trash than what was documented. To clarify, this does not mean that 20% of wrappers found in the trash were not documented, but rather the quantity of an item number found in the trash was larger than the documented quantity for that item number 20% of the time.

For simplicity, the team uses the term “undocumented quantity” for the remaining analyses to describe the total number of items trashed from a case that were not documented. For example, if a case had no discrepancies between documented and trashed quantities, except for one item
number which had 2 documented and 4 trashed, the undocumented quantity for the case would be 2. This is displayed in the first line of Table 2 below.

<table>
<thead>
<tr>
<th>Case Code</th>
<th>Item Num</th>
<th>Plan Qty</th>
<th>PRN Qty</th>
<th>Doc Qty</th>
<th>Trash Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>D8739</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>Y494G</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Example of Undocumented Quantity of 2

The boxplot below in Figure 5 summarizes the undocumented quantities from 113 cases.

Figure 5: Undocumented Quantities for 113 Cases
(N = 113, Mean = 7.22)

Overall, the average number of undocumented items per case was 7.22, and the median value was 6. This means that on average, the team found 7.22 items in the trash that were not documented as having been used.

By Site
First, the team separated the undocumented quantities between the two sites examined in the garbology study: UH and Mott. Figure 6 shows the breakdown of the undocumented quantities.

Figure 6: Undocumented Quantities by Hospital Site
(UH: N = 78, Mean = 9.6 and Mott: N = 35, Mean = 6.15)
Based on Analysis of Variance testing (ANOVA), which tests if two or more means are statistically different from each other, a significant difference did not exist between UH and Mott (see Appendix B). It is important to note that the number of samples varied significantly; 78 cases from UH and 35 cases from Mott. By examining the boxplot above, it is clear that both UH and Mott have problems with undocumented items.

**By Case Size**
Next, the team considered undocumented quantities based on case size, seen below in Figure 7. The sizes of cases were split into six groups based on the number of items that were on the DPC.

Based on ANOVA testing, the team concluded that no significant difference existed between the undocumented quantities based on the size of the case (see Appendix B).

**By OR and Service**
Boxplots and ANOVA tests can be found in Appendix C for undocumented quantities separated by operating room location and by service. Both factors were determined to be insignificant factors of undocumented quantities.

In conclusion, the team found that undocumented quantities are a significant problem, averaging approximately 7 undocumented items per case, and that site, case size, operating room, and service do not have a significant impact on undocumented quantities.

**Missing from Trash Quantities**
Another key metric for assessing the accuracy between documented and trashed supplies is the quantity of items documented by the nurses but not found in the trash. Approximately 29% of all item numbers examined across the 113 cases contained more documented items than items found in the trash. To clarify, the documented quantity was larger than the trashed quantity for an item 29% of the time. In addition, the average quantity of items missing from the trash was approximately 23 items. Figure 8 shows the distribution of the “Missing from Trash Quantities” across the 113 cases.
Figure 8 reveals that documented items missing from the trash varied significantly among the cases studied. The “Missing from Trash Quantity” metric is difficult to assess from the results of a garbology study because the team cannot confirm whether large quantities are due to a documentation error or an instance of the item wrapper being thrown into a non-orange garbage bag. Additionally, The OR Informatics Manager indicated that specific items do not have a wrapper that would end up in the trash. Due to this uncertainty, the team worked with the OR Informatics manager to remove items from the analysis that did not have wrappers. Also, any items documented and not listed on their corresponding DPC were removed at the OR Informatics Manager’s request (assumed error). Furthermore, the team removed outliers by excluding cases that had “Missing from Trash Quantities” more than one standard deviation above the mean. The result was a new average “Missing from Trash Quantity” of approximately 15 items. Given the estimation and uncertainty involved in the garbology study, the team does not recommend using this value as an accurate representation of “Missing from Trash Quantities”. However, a problem still exists with the documentation of unused items.

Cost Analysis
Across the 113 cases examined in the garbology study, approximately $8,000 worth of items were found in the trash that were not documented as used (undocumented items). Based on the estimation of 36,000 surgeries per year at UH and Mott, $2.6 million worth of items go undocumented each year.

On the other hand, approximately $25,000 worth of items were documented but not found in the trash (missing from trash items), which is an estimated $8 million each year. This estimate was calculated after first, removing item numbers that do not have wrappers, second, removing items not listed on their corresponding DPCs, and third, removing cases where the “Missing from Trash Quantity” exceeded more than one standard deviation above the mean. Reasons for excluding specific data are explained in the previous section, Missing from Trash Quantities.
**Correlation between DPC Accuracy and Documentation Accuracy**

The team created scatterplots to assess the correlation between the DPC accuracy (% of trash on the DPC) and documentation errors (both undocumented quantities and missing from trash quantities). Figure 9 shows the quantity of undocumented items for each case and the % of trash on the DPC for each case.

![Figure 9: No Correlation between DPC Accuracy and Undocumented Quantity](image)

(N = 113, Mean Undocumented = 7.22, Mean % Trash on DPC = 69.52%, R-Sq = 23.4%)

The team expected that when trashed items closely aligned with the DPC, the undocumented quantities would be fewer; however, the scatter plot revealed no significant correlation. When comparing the percent of trash on the DPC to the number of items missing from the trash, there was also no significant correlation (see Figure 10).

![Figure 10: No Correlation between DPC Accuracy and Missing from Trash Quantity](image)

(N = 113, Mean Missing from Trash Qty = 22, Mean % Trash on DPC = 69.52%)

The lack of correlation in Figure 9 and Figure 10 shows that when cases have DPCs that match closely to the items actually used (trashed items), there are not necessarily fewer documentation errors.
SUMMARY OF CONCLUSIONS
The student team’s conclusions from the garbology study and analysis are explained below.

DPC Accuracy
Based on the garbology study of 113 cases, it was most common for cases to have 80-89% of the trash match items on the DPC (average of 69.52% over all cases). Overall, nurses are retrieving approximately 13 additional items per case, and then returning approximately 10 items to inventory after the case is over. If the assumption is made that each item takes one minute to retrieve, the estimate for the number of hours nurses spend retrieving items each year is approximately 7,700 hours. It appears a significant amount of time is wasted retrieving items that were not originally planned for during surgeries.

Documentation Accuracy
The team’s analysis proves that documentation of items is inaccurate in UH and Mott. Regardless of factors like operating room, site, service, or case size, 7.22 items per case failed to be documented. Cost analysis revealed that approximately $8,000 worth of items went undocumented during the 113 cases. When scaled, the lost cost of these undocumented items becomes $2.6 million each year. Conversely, $25,000 worth of items were documented but not found in the trash, which is an estimated $8 million each year. Possible error and overstating exists within the number of items documented but not in the trash because some supply wrappers could have been placed in another trash receptacle not collected in the garbology study. However, the errors in documentation are apparent, and likely cause vast inaccuracies for both inventory and patient billing.

LITERATURE SEARCH
The team performed a literature search to explore potential solutions to the documentation accuracy issues. RFID (radio frequency identification) came up as a potential solution for accurately documenting surgical supplies.

How RFID Works
It is important to explain how RFID works in order to show how it would be applied in a medical environment. “In a basic RFID system, tags are attached to all items that are to be tracked. These tags are made from a tiny tag-chip, sometimes called an integrated circuit (IC), that is connected to an antenna. The tag chip contains memory which stores the product's electronic product code (EPC) and other variable information so that it can be read and tracked by RFID readers anywhere” [3]. An RFID system would allow a hospital to track any item marked with an RFID tag.

Advantages of RFID
There are significant advantages to RFID systems in hospitals. According to an article by Ron Shinkman, an editor and journalist with 20 years of experience in healthcare business, RFID is being used by hospitals to track inventory. With this system, “when a supply is removed from the cabinet, inventory tracking software is alerted and each piece's absence is duly noted” [4]. The system tracks when the supplies are used during the surgeries and when they are returned to inventory. This is accomplished with an individual RFID tag on each item. When the items pass through RFID scanners, the software is able to track the location of the items. An added benefit is the ability of the software to identify expired supplies by tracking expiration dates. According
to Shinkman’s article, tagging surgical supplies with RFID tags is expensive; however, “hospitals usually start seeing a return on investment within six to nine months of installation” [4].

**Example of RFID in a Hospital System**

RFID’s effectiveness has been proven successful in other hospitals. One example of RFID’s success is Saint Luke’s Health System in Kansas City, Missouri. St. Luke’s struggled to deal with a wide range of medical procedures and equipment. This tracking issue was attributed to the manually intensive process for managing the supply chain and healthcare professionals lack of logistics experience. St. Luke’s, “needed a next-generation inventory tracking and management system” [5]. To solve this problem, St. Luke’s partnered with a number of medical and technology companies to develop a completely integrated RFID-based inventory management system. This system includes RFID tags, RFID readers, RFID antennas, mobile computers, and an inventory management software provided by Cenbion Medical. The RFID solution’s results were profound. The system allowed St. Luke’s to reduce on-hand inventory from $3.2 million to $2.7 million. In addition, the system streamlined inventory management and allowed St. Luke’s to buy supplies in greater bulk, which has led to significant cost decreases. For example, a 12% discount for a bulk order of pacemakers and defibrillators saved St. Luke’s $127,000. Other advantages of the RFID solution in St. Luke’s include:

- Automatic inventory tracking
- Prevention of stock-outs, supply hoarding, and inventory shrink
- More accurate billing and ordering
- Efficient expiration date management

This RFID solution has already saved St. Luke’s significant sums of money, and they believe the investment was well worth it. Dave Strelow, director of Cardiovascular Lab Services at Saint Luke’s, said, “a decrease of just a half of a percent of [lost time to availability and chargebacks due to inventory problems] is more than enough to cover the cost of this solution” [5]. The real advantage of the RFID solution, however, is its ability to allow healthcare professionals to focus on their patients, and not the supply chain [5].

**POTENTIAL SOLUTIONS**

To decrease the discrepancies between the planned, documented, and trashed items used in the OR’s, the team explored four potential solutions: DPC Adjustment, Training, Barcode Scanning, and RFID. Each solution is discussed in detail in the paragraphs below.

**DPC Adjustment**

One potential solution the student team identified is a DPC adjustment. The clients suggested that item documentation errors may be attributed to inaccurate DPCs, as they can quickly become outdated. Nurses and perioperative technicians have tacit knowledge that allows them to pick and manually adjust inaccurate DPCs. However, turnover among these positions and the wide variety of surgical services served by UH and Mott make it difficult for tacit knowledge to be effective. In addition, the DPCs have an accuracy of approximately 80-89%, meaning that 10% of items used and found in the trash had to be retrieved from outside the OR. By standardizing the DPCs to each surgery, nurses would potentially have fewer items to retrieve from outside the OR and more time to focus on documenting the items. Adjusting the DPCs to
more accurately represent surgical cases could potentially reduce time spent retrieving items outside the OR and solve documentation errors.

However, the team’s analysis showed a lack of correlation between more accurate DPCs and documentation errors. As seen in the scatterplots shown in Figure 9 and Figure 10, DPC accuracy does not correlate to “undocumented” quantities or “missing from trash” quantities, both of which are the types of documentation error identified by this report. Therefore, the team does not recommend the hospital spend time editing the DPCs.

**Training**

Another solution the team explored was ensuring nurses and staff are trained on the standard of work for documenting items. If no clear standard is understood and followed, the team suggests remodeling the standard and organizing a training session for the nurses and staff. Currently, when an item is retrieved and brought to the OR, there is a trend that it will not be documented. When an item is not used, it also needs to be properly adjusted on the documentation list. By emphasizing the standard process and creating awareness, training nurses may improve the documentation accuracy of items in the OR.

**Barcode Scanning**

An intermediate solution to resolve inaccurate documentation is barcode scanning. This solution is relatively easy to implement because all inventory supplies already have barcodes. The only change would happen in the unwrapping process when nurses are prepping supplies in the OR. Scanning each item would automatically add it to the documentation list. Barcode scanning is a common practice in hospitals. Its implementation can be seen at the Veterans Health Administration and Henry Ford Health System for tracking patient medication and lab samples. At Henry Ford Hospital System, the implementation of barcode scanning lab samples reduced errors by 95%. However, the Senior Vice President for Pathology and Laboratory medicine said that “It’s not the bar coding that is the solution; it’s the standardized work flow” [6].

**RFID System**

A third potential solution is to have UH and Mott adopt an RFID system to document items used during surgery. This solution can be purchased from a distributor, or it can be developed in house. Although the initial cost of system would be significant, the elimination of the incorrect documentation would likely have long term beneficial economic impacts that outweigh the initial investment. The RFID system would work by placing an RFID halo sensor around the trash bins in operating rooms. In addition, an RFID tag would be attached to all surgical item packaging. This would allow both UH and Mott to track the location and status of surgical supplies until they are disposed in the trash. The expected impacts of this RFID solution include the following:

- Increased accuracy of inventory and reduction of on-hand inventory
- Increased availability of circulating nurses
- Improved effectiveness of the in-case recording process
- Improved reliability of supplies billed to patient
- Increased ordering efficiency (reduced ordering costs)
RECOMMENDATIONS
Given the breadth of potential solutions and their costs, the team recommends a tiered strategy of implementing three solutions: training, barcode scanning, and an RFID system. The team recommends the hospital assess the impact during each phase of implementation to monitor any improvements in the accuracy of documentation. The first step is to review the current standard of work concerning item documentation, and then offer a training session for nurses and staff. Reinforcing a standard workflow would have the expected impact of increased accuracy in the documentation list, which in turn increases the accuracy of inventory and billing. For the second step, the team recommends that the hospital test the barcode scanning solution in a few of the ORs to assess the impact, and then fully implement if successful.

In the long term, the team recommends UH and Mott invest in an RFID system to track and document items used during surgery. Based on the team’s data analysis, an average of 7.22 items are used during a surgical case, but are not documented as used. Using the estimate of 36,000 cases each year, 259,920 items each year are used but not documented in UH and Mott. An RFID system will eliminate a majority of these errors. Before implementing, the team recommends UH and Mott perform a cost benefit analysis on RFID solutions to assess their feasibility.
REFERENCES


Appendix A - Database Tables

Figure A-1: Case Plan Table

<table>
<thead>
<tr>
<th>ManCatNum</th>
<th>CaseNum</th>
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<th>PRNQty</th>
<th>TotalQty</th>
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Figure A-2: Documented Table

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<td>0703047000</td>
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</tr>
<tr>
<td>1351208</td>
<td>C053D</td>
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<td>1349066</td>
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</tr>
<tr>
<td>1362262</td>
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</tr>
<tr>
<td>1361940</td>
<td>SUT34BDUMA</td>
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</tr>
<tr>
<td>1361940</td>
<td>1978</td>
<td>1</td>
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Figure A-3: Table from Data Collection (TrashQty shows actual usage)

<table>
<thead>
<tr>
<th>CaseNum</th>
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<th>PlanQty</th>
<th>UseQty</th>
<th>TrashQty</th>
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<td>1266018</td>
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<td>3</td>
<td>2</td>
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<td>1</td>
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Figure A-4: Case Demographics

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<td>UH-OR 34</td>
<td>UUHOR</td>
</tr>
<tr>
<td>1295942</td>
<td>STX</td>
<td>UH-OR 17</td>
<td>UUHOR</td>
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<tr>
<td>1296057</td>
<td>PLA</td>
<td>MH-OR 09</td>
<td>UMHOR</td>
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<tr>
<td>1308653</td>
<td>ORTH</td>
<td>UH-OR 34</td>
<td>UUHOR</td>
</tr>
<tr>
<td>1311100</td>
<td>ORTH</td>
<td>UH-OR 33</td>
<td>UUHOR</td>
</tr>
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<td>1312800</td>
<td>PESU</td>
<td>MH-OR 07</td>
<td>UMHOR</td>
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Appendix B - ANOVA Test for Hospital Sites and Case Size

Test for differences in undocumented quantities between hospital sites:

Analysis of Variance

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<th>Adj MS</th>
<th>F-Value</th>
<th>P-Value</th>
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<td>286.9</td>
<td>286.92</td>
<td>5.36</td>
<td>0.022</td>
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<tr>
<td>Error</td>
<td>111</td>
<td>5940.6</td>
<td>53.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
<td>6227.5</td>
<td></td>
<td></td>
<td></td>
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</table>

Model Summary

<table>
<thead>
<tr>
<th>S</th>
<th>R-sq</th>
<th>R-sq(adj)</th>
<th>R-sq(pred)</th>
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</thead>
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<tr>
<td>7.3156</td>
<td>4.61%</td>
<td>3.75%</td>
<td>0.00%</td>
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Means

<table>
<thead>
<tr>
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<th>Mean</th>
<th>StDev</th>
<th>95% CI</th>
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<tr>
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<td>35</td>
<td>9.60</td>
<td>11.35</td>
<td>(7.15, 12.05)</td>
</tr>
<tr>
<td>UUHOR</td>
<td>78</td>
<td>6.154</td>
<td>4.507</td>
<td>(4.512, 7.795)</td>
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Test for differences in undocumented quantities for different case sizes:

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<th>Source</th>
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<tr>
<td>CaseSize</td>
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<td>365.3</td>
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<tr>
<td>Total</td>
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<td>6227.5</td>
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<table>
<thead>
<tr>
<th>CaseSize</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>0 - 19</td>
<td>5</td>
<td>1.600</td>
<td>1.517</td>
<td>(-4.962, 8.162)</td>
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<tr>
<td>100+</td>
<td>7</td>
<td>9.14</td>
<td>8.17</td>
<td>(3.60, 14.69)</td>
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<tr>
<td>20 - 39</td>
<td>20</td>
<td>10.00</td>
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<td>(6.72, 13.28)</td>
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<td>40 - 59</td>
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<tr>
<td>60 - 79</td>
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<td>6.857</td>
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<tr>
<td>80 - 99</td>
<td>11</td>
<td>7.27</td>
<td>5.98</td>
<td>(2.85, 11.70)</td>
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Appendix C - Boxplots and ANOVA for Operating Room and Service

Analysis of Variance

<table>
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<th>Source</th>
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Room N Mean StDev 95% CI
MH-OR 05 6 14.83 13.99 (8.97, 20.70)
MH-OR 06 12 6.00 3.86 (1.85, 10.15)
MH-OR 07 1 15.00 * (0.63, 29.37)
MH-OR 09 6 14.50 22.37 (8.64, 20.36)
MH-OR 10 8 7.63 4.84 (2.55, 12.70)
MH-OR 19 2 6.00 4.24 (-4.16, 16.16)
UH-OR 04 12 6.17 6.89 (2.02, 10.31)
UH-OR 13 20 5.750 3.945 (2.538, 8.962)
UH-OR 17 15 6.533 3.701 (2.824, 10.243)
UH-OR 31 18 7.28 4.81 (3.89, 10.66)
UH-OR 33 8 3.375 2.134 (-1.704, 8.454)
UH-OR 34 5 7.00 3.00 (0.58, 13.42)
Very small sample sizes for most services, so ANOVA testing deemed not appropriate. The services with acceptable sample sizes (NSA, ORTH, and STX) all have similar means and medians for undocumented quantities. Thus, the team cannot conclude that significant differences in undocumented quantities exist between services.