Analysis of the Orthotics & Prosthetics
Materiel Management Process
Programs and Operational Analysis Final Report

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Date: April 16, 2004
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Acknowledgements

We would like to thank all the staff at Orthotics and Prosthetics department for their support and for being greatly cooperative in facilitating information. Special thanks to Anita Liberman-Lampear for her input and feedback, and Carl Abrego for his technical support and facilitation of information. We greatly appreciate the cooperation of all the inventory staff, Jill, Brenda and Vince; and for their patience with our questions and measurements.

We thank all clinicians and staff at the clinic for the time they devoted to our interviews and surveys. Also we would like to thank Mary Lind for her technical writing feedback.

Finally, most special thanks to Prof. Richard Coffey, whose constant help, support and feedback was vital to the shape and form of this project.
Executive Summary

The purpose of this project is to analyze the materiel management process of the Orthotics & Prosthetics (O&P) Department at the University of Michigan Hospitals. The O & P Department has experienced a significant increase in staff and materiel flow, but the inventory management process has not been modified to incorporate the increase. In the past 12 years the annual operational budget has increased from $3 million to $7.4 million and the average patient flow is approximately 1500 patients per month. The main goals of this project are to improve efficiency in the inventory management position, determine the appropriate amount of time needed to be spent on the materiel management process, and improve the traceability of materials throughout the entire process.

Findings

Through our analysis we found that the current inventory system satisfies the necessary requirements of ordering and distributing materials in a timely manner, however, there are many possible areas for improvement. Through our analysis, we found that:

- There is no updated list of the names of the products in inventory, no accurate measurements of the current inventory levels and no updated prices of products in inventory. For example many items are in inventory are not on the inventory list, such as items in the first aisle by Swede-O, Roylan and ARD.
- The database is not currently used in the manner that it was designed; individual product information is not systematically entered into the database. For example the most recent three entries in the “Purchase Orders” button logged into the database were on the following dates: 2/9/04, 9/26/00, and 7/11/00.
- The Inventory Managers’ core required tasks do not total 40 hours per week.
- The inventory area is not organized in a systematic method and roughly 20% of the inventory area is consumed by non-medical devices.
- There is no direct link between patient billing and orders placed.
- The current database is functional and can operate with bar coding, if used as designed.

Conclusions and Recommendations

Based upon the findings above it was concluded that a new system should be implemented to organize the inventory. The new system should have the following specifications:

1. Part traceability - allow clinicians to view the status of their orders so patients can be scheduled back according to the part arrival day.
2. Create a link between patient billing and orders placed - avoids over-ordering, improves audit ability and will prevent possible gaps in the system.
3. Reduce the paperwork - improves efficiency, reduces the space needed for paperwork, and optimizes the time available in the inventory manager position.
4. Track materiel usage – can significantly reduce the stock-out rate and the time spent managing the inventory levels.
5. It has to be easy to use, and all the staff involved should be trained to use it.

In light of these specifications, the system that we recommend includes organizing the physical inventory area in a systematic manner, accurately documenting the name, quantity and price of all products in inventory and implementing the use of a bar code.
scanner to enter and delete items from the database. This system could be implemented in four distinct stages:

Stage 1 – Organize
- Implement the 5S’s
  - Sort – All items not needed in the inventory area are removed
  - Set in Order – Arranging needed items and labeling them
  - Shine – Sweeping Floors, wiping off items, and keeping the inventory area generally clean
  - Standardize – The condition that exists after practicing ‘Shine’
  - Sustain – Habitually and properly maintaining the inventory area according to standards set above
- Work with the Inventory Manager to develop a work schedule in order to organize her tasks, provide feedback of job performance
- Provide cart for Inventory Manager to distribute products with less travel and physical exhaustion

Stage 2 - Document
- Document the name, quantity and price of all products in inventory and enter this data into the Microsoft Access database
- Print product names, quantity and price onto the new inventory card to manage inventory until computerized system is functional

Stage 3 – Database Development
- Purchase four bar code scanners and connect them to the Microsoft Access database. Commercial scanners range from $200 for basic model to $500 for high end portable scanners.
- Update the database by applying bar code information to any item that does not already have a bar code.
- Place bar codes on all products and place bar code scanners in shipping and receiving location, in the inventory location and near patient treatment area

Stage 4 – Standardize Inventory
- Establish inventory levels using given formulas
  - Reorder Point = $\lambda \times \tau$
  - Reorder Quantity = square root\(\left[\frac{2 \times K \times \lambda}{h}\right]\)
- Continue to monitor and improve process

Secondary Recommendations

In order to allow the members of O&P to develop the system that they believe will help them out the most, we also researched other possible systems that could be used to manage the inventory. These systems are listed below along with a brief explanation of the benefits and drawbacks of each system:

Radio Frequency Identification (RFID): Will keep track of items as they leave the inventory, is very easy to use and the computer does all of the work. However, the system is very expensive, the technology is new and is therefore subject to small ‘bugs’.

Crib (locking the inventory storage area): Only a few people will have access to inventory which will solve the issue of keeping track of items as they leave the inventory.
However there will be a moderately high up front cost and personnel do not like the idea of being restricted access to their equipment.

Card (using a manual check card to keep track of inventory): This system is much simpler to use than the color coded card system and it is very inexpensive. However, it is intended only for a short term solution, personnel need to be trained on how to use the system, personnel may not always be rigorous when keeping track of their usages, and it does not adequately solve the issue of keeping track of items as they leave the inventory.
Introduction and Background

Purpose

The purpose of this project is to analyze the materiel management process of the Orthotics & Prosthetics (O&P) Department at the University of Michigan Hospitals in order to improve efficiency and accuracy in inventory management, to determine the appropriate amount of time spent on the materiel management process, and to find the least costly way to manage the inventory.

Goals

The main goals of this project are to:

- Create a database system to increase efficiency, decrease paperwork, and make the entire process more manageable
- Establish a system of traceability of materiel within the O&P Department
- Establish inventory levels to reduce costs and prevent delays in the process
- Determine the amount of staff hours that need to be spent managing the materiel process
- Increase the productivity of the inventory area
- Analyze the current culture within O&P and recommend measures to align the culture with management productivity goals

Background

The main Orthotics and Prosthetics Department location of South Industrial Road has an average patient flow of 1500 patients per month. Staff at O&P has more than doubled in past 12 years; from 17 to 45 employees and the annual operational budget has increased from $3 million to $7.4 million, but the inventory management process has not been modified to incorporate the increase.

The Inventory Manager is responsible for all aspects of the inventory system including ordering parts, distributing the packages that arrive, managing the standing inventory, dealing with any errors in the process as well as overseeing the inventory at five other locations around Ann Arbor.

There have been attempts in the past to improve the process but they have so far not provided an adequate solution. The three most recent attempts to manage the inventory included using a bar code system to track the order flow, manually entering product information into a Microsoft Access database and the current process of using a colored card system designed to prevent inventory stock-outs. For various reasons these solutions did not prove to be as successful as the department had hoped and it is the general consensus that a new method needs to be developed to better manage the inventory.

Methodology

This section describes the methodology that was used to define the current state. The current state of the Inventory Management system was defined using analysis of:

1) Materiel Flow (order quantity, receiving quantity, shipments and returns)
2) Inventory Failure Rate
Figure 1 shows the methods used to acquire this data.

<table>
<thead>
<tr>
<th>Method</th>
<th>Source/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order Quantity</td>
<td>Manual data entry of paper order forms</td>
</tr>
<tr>
<td>Receiving Quantity</td>
<td>Log sheet filled out by inventory manager (Appendix B)</td>
</tr>
<tr>
<td>Materiel Flow</td>
<td>Manual data entry from UPS booklet</td>
</tr>
<tr>
<td>Inventory Failure Rate</td>
<td>Survey of 13 clinicians (Appendix A)</td>
</tr>
<tr>
<td>Flow chart of Orders</td>
<td>Observations and clinician interviews</td>
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<tr>
<td>Clinician Perceptions</td>
<td>Clinician Interviews</td>
</tr>
</tbody>
</table>

*Figure 1: The methodology used to develop our findings.*

To determine if our data was representative of the average level of activity in the clinic we analyzed the patient flow for the months in which we performed our study and compared it to the average patient flow for all other months. As we can see in Figure 2, the month of February was not any different from other months, and that year was also not any different from the activity of other years. Therefore, we conclude that our data is representative of the usual activity level.
Figure 2: The activity of the month, and year, when our data collection was conducted (patterned bars) compared to past months and years. Our data is representative of the usual activity. FY represents Fiscal Year.

Current State

The first step to analyze the inventory management system was to establish an understanding of the current state of operations. Analysis of the current state consisted of interviewing clinicians, forming an overview of the ordering and receiving process, measuring the failure rate of the system and measuring the materiel flow.

Clinician Interviews

To get a fuller understanding of the Inventory Management process and how it affects all members of the department, preliminary interviews were performed with clinicians at O&P. The interviewed were performed on four clinicians: two prosthetists, one orthotist and one pedorthist. These interviews provided a picture of how orders are initiated and how the products are ultimately distributed to patients. The interviews also showed that clinicians were in general not content with the current system. All four clinicians mentioned that the current system for re-ordering out of stock items was not functioning adequately. The main complaints were that they did not completely understand how the system worked and that it required too much time to perform. The clinicians also expressed a desire to clean out the inventory location and remove the items that are no longer currently used or have expired.

Their concern about the lack of traceability and the rate of stock-out because each time they did not receive a piece on time for a patient or there was none in inventory it had a very negative impact on the patient. The clinicians that we interviewed expressed a desire for a new inventory management system that would:

- Inform them if an item is in stock or not
- Decrease stock-out occurrences
• Establish appropriate inventory levels

One practitioner expressed a concern about the ordering culture. It was said that there was a lot of overstocking and lack of cost awareness in their ordering culture. For example, there are some expensive shoes and some cheap shoes, and usually the more expensive are ordered, or more than one pair is ordered and the one the patient doesn’t want can’t be then returned to the manufacturer.

All of the four clinicians that we interviewed were open to use technology in a new system, but they said it would have to be very easy to use and not require too much time.

Overview of Current State

The inventory management system is operated primarily through a manual inventory process. The process is represented in Figure 3 below.

![Figure 3: Overview of ordering and receiving process, with the frequency and time taken.](image)

Based upon the analysis, when everything works properly, the average lead time between ordering and receiving an item is 4 days. The majority of this time is consumed by physically shipping the product to O&P.

Figure 3 shows that the majority of orders placed, 70% are delivered directly to the clinicians. These products are carried to the clinicians by the Inventory Manager and are never placed in inventory. Only 27% of the time the packages are taken up to the inventory location by a member of O&P other than the Inventory Manager and stored. There is no system in place to record when new items are placed in inventory and they
are simply distributed to their designated shelves. Most items have labels on the shelf where the item is stored.

The current inventory system requires someone to place one pink card (shown below) on one of the items that are stored towards the rear of the shelf. The idea is that clinicians will use the items that are towards the front of the shelf, and then when the item with the pink card is used, the clinician is to bring the white card to the Inventory Manager to notify the Inventory Manager that the item needs to be re-ordered. The set of two cards are shown below in Figure 4:

![Current inventory cards](image1)

![Current inventory cards](image2)

Figure 4: Current inventory cards

The current system also requires clinicians to write down by hand the name of a product that they take out of inventory along with the quantity and the date the product was taken. With this sheet, the Inventory Manager is supposed to make the required subtractions from the number of products that are in inventory in the Microsoft Access Database and thereby keep up to date accounts of the amount of items that are in inventory.
Materiel Flow
Figure 5 shows the average materiel flow per day at O&P:

<table>
<thead>
<tr>
<th>Materiel Flow</th>
<th>Order Flow (N* = 126):</th>
<th>9.68 packages/day are ordered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Receiving Flow (N* = 198):</td>
<td>24.75 packages/day are received</td>
</tr>
<tr>
<td></td>
<td>Shipping and Returns Flow (N* = 269):</td>
<td>5.75 packages/day are shipped</td>
</tr>
</tbody>
</table>

(*) N = Sample Size.

*Figure 5: Daily Materiel flow of the O&P Department*

As described on Figure 1, the order flow was collected by going through the order forms in the past three months. The receiving flow was collected by giving the Inventory Manager a login sheet for the packages received a day (see Appendix B). Finally, The Shipping and Returns flow was gathered by counting the entries in the UPS book of packages sent out in the past three months.

**Findings and Analysis**

After the initial findings, the project can be divided into the following target areas:

![Target areas](image)

*Figure 6: Target areas*

The inventory management system is comprised of four primary functions:

- Inventory System – the overall process used to manage the inventory, including order process and materiel flow
- Inventory Area – the location that inventory is stored at O&P including how it is organized, the tidiness of the area, and the products that are stored there
- Inventory Database – the Microsoft Access Database used to track inventory usage and to document current inventory levels as well as the price of all products in inventory
- Inventory Manager – the individual in charge of overseeing and implementing the entire process
Our analysis of the inventory management system resulted in findings related to these specific fields.

**Inventory System**

To measure how well the current inventory process was functioning we prepared a survey (See Appendix A). The surveys revealed the failure frequency, since there is no other record of this occurrence. The surveys were filled out by 13 of the 15 clinicians. From these surveys, we have found that the stock-out rate is twice per month per clinician, and the graph showing the frequency of the answers in the survey is shown on Figure 7. It shows that more than 60% of the clinicians experience stock-out at least once a month. We can also see on Figure 8 the graph showing another type of failure. In this case, failure means the time when the patient comes to the clinic to pick up their prescription and it is not ready for them. This failure happens 9 times a year per clinician, and most clinicians (>90%) say this happens at least once a month.

![How many times did you go up to inventory and did not find the item you were looking for?](image)

*Figure 7: Frequency of answers for Question #2*
Often, when an item is placed on backorder, the clinicians are not notified, and the patient is not re-scheduled according to when their prescription will arrive. The result is that the patient will come in to O&P and not receive the required item. The patient then must reschedule an appointment and come back to O&P when the item is finally received and in stock. As shown in previous analysis, on average, each clinician experienced this situation nine times a year.

The problems with shipping and receiving items occur when items are either on backorder or when the order is not placed correctly.

**Inventory Area**

There is no accurate list of the names of the products in inventory. The only existing list has many products listed that are no longer in the inventory location, such as Aircast X-Large Pneumatic Foam Walker. Also there are many items that are in inventory that are not on the inventory list, such as items in the first aisle by Swede-o, Roylan and ARD.

The inventory area is not organized in a systematic method. The inventory location is managed by a diverse group consisting of various clinicians as well as the Inventory Manager and the Inventory Managers assistant. Essentially, each clinician or group of clinicians is in charge of keeping their area in control.

Many products in inventory are old and some have expired. One product was originally ordered in 1999 and there are ten similar parts that were ordered in 2003. Some of the old products are expired and can no longer be used. Other old products in the inventory location fill up space that could be used for other purposes.
There is a large amount of non-medical devices in the area. In the inventory area were two Christmas trees, seven boxes of holiday supplies, demonstration items for classes, toiletries, old grinding machines and other products that are not used in the operating functions of O&P. These items take up a large amount of space and add to the disarray in the inventory location.

Labels are not placed under all products. Some products are placed in inventory in their original box and no label is put on the shelf below the products.

**Inventory Database**

Currently, the O & P department is using a Microsoft Access Database to store all of its inventory information. When this database is accessed, a screen comes up with seven different buttons as seen below.

```
Purchase Orders
Receiving
Inventory Items

Inventory Adjustments
Miscellaneous Tables
Vendors

Exit
```

*Figure 9: Database User Interface*

Figure 9 represents the graphic user interface for any user trying to receive or manipulate data inside of the database. Each button takes you to a different set of tables corresponding to that button’s title. The only exception to this rule is the “Exit” button which allows a user to exit the program.

According to the current Inventory Manager, only the “Inventory Adjustments” button is used regularly. Also, the data inside of the database is not being regularly updated as only a month’s worth of data can be found on the database at any given time.

As of 4/8/04, the most recent information recorded in the tables under each button, excluding the “Exit” button, is as follows:

- The most recent three entries in the “Purchase Orders” button logged into the database were on the following dates: 2/9/04, 9/26/00, and 7/11/00.
- The last “Receiving” entry was on 7/13/00. Also note that there are only receipts dating between 7/7/00 and 7/13/00 on the record.
There is no information whatsoever in the “Inventory Items” button under the subcategories ‘LastReceipt,’ ‘LastOrder,’ ‘LastAdjustment,’ ‘DateCreated,’ ‘WhoCreated,’ ‘LastModified,’ and ‘WhoModified.’  

- The last entry in the ‘Adjustment date’ subcategory in the “Inventory Adjustments” button was on 4/2/04. On this date, 30 different entries were made. However, the last entry before this date was on 11/19/03.  

- The “Miscellaneous Tables” button simply has 2 entries with no dates attributing to them.  

- The last entry in the ‘New Vendor’ subcategory in the “Vendors” button was in January 2003. Also, there is no information whatsoever under the subcategories ‘LastModified,’ and ‘WhoModified.’

**Inventory Manager**

To determine if another staff member is needed to manage the inventory, we conducted time studies upon the Inventory Manager and established the amount of time that is spent of various aspects of the inventory management system. The results of the time studies are shown in Table 1. We have separated the tasks of the position into three different categories: Core Activities, Infrequent Activities and Miscellaneous Activities.

**Table 1: The Time Study Results**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sample Size</th>
<th>Avg. Time</th>
<th>StDev</th>
<th>Std. Time</th>
<th>Avg. Volume</th>
<th>Estimated Time/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place Orders</td>
<td>9</td>
<td>2.3 min</td>
<td>0.7 min</td>
<td>2.3 min</td>
<td>48.45</td>
<td>1.9 hrs</td>
</tr>
<tr>
<td>Receive Shipments</td>
<td>42</td>
<td>1.9 min</td>
<td>0.9 min</td>
<td>1.9 min</td>
<td>123.75</td>
<td>3.9 hrs</td>
</tr>
<tr>
<td>Deliver to Clinicians</td>
<td>15</td>
<td>0.2 min</td>
<td>0.01 min</td>
<td>0.2 min</td>
<td>21</td>
<td>0.1 hrs</td>
</tr>
<tr>
<td>Shipping</td>
<td>4</td>
<td>7.3 min</td>
<td>1.0 min</td>
<td>7.3 min</td>
<td>6.63</td>
<td>0.8 hrs</td>
</tr>
<tr>
<td>Returning</td>
<td>4</td>
<td>2.3 min</td>
<td>0.9 min</td>
<td>2.3 min</td>
<td>2.65</td>
<td>0.1 hrs</td>
</tr>
<tr>
<td>Mpathways/P-Card</td>
<td>5</td>
<td>10.2 min</td>
<td>1.3 min</td>
<td>10.2 min</td>
<td>5</td>
<td>0.85 hrs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>7.65 hrs</strong></td>
</tr>
</tbody>
</table>

**Infrequent Activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sample Size</th>
<th>Avg. Time</th>
<th>StDev</th>
<th>Std. Time</th>
<th>Avg. Volume</th>
<th>Estimated Time/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Inventory Levels</td>
<td>Estimated</td>
<td>3.5 hrs</td>
<td></td>
<td></td>
<td></td>
<td>0.875 hrs</td>
</tr>
<tr>
<td>Visit other Sites</td>
<td>Estimated</td>
<td>1.5 hrs</td>
<td></td>
<td></td>
<td></td>
<td>0.375 hrs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1.25 hrs</strong></td>
</tr>
</tbody>
</table>

**Miscellaneous Activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sample Size</th>
<th>Avg. Time</th>
<th>StDev</th>
<th>Std. Time</th>
<th>Avg. Volume</th>
<th>Estimated Time/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Meetings</td>
<td>Estimated</td>
<td>30 min</td>
<td></td>
<td></td>
<td></td>
<td>0.5 hrs</td>
</tr>
<tr>
<td>Check Mail</td>
<td>Estimated</td>
<td>10 min</td>
<td></td>
<td></td>
<td></td>
<td>0.83 hrs</td>
</tr>
<tr>
<td>Cleaning Folders</td>
<td>Estimated</td>
<td>10 min</td>
<td></td>
<td></td>
<td></td>
<td>0.83 hrs</td>
</tr>
<tr>
<td>Break</td>
<td>Estimated</td>
<td>15 min</td>
<td></td>
<td></td>
<td></td>
<td>1.25 hrs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>3.41 hrs</strong></td>
</tr>
</tbody>
</table>

Sources:  
1 = Order Folders  
2 = Login Sheet  
3 = Observational  
4 = UPS login book  
5 = Observational

"+20% For Intangibles"  
GRAND TOTAL 14.77 hrs/week
Conclusions

Based upon our findings, we developed conclusions regarding all aspects of the inventory management process.

The current inventory system has been working well enough that no major problems have occurred recently at O&P. Many of the clinicians at O&P act on their own accord to order new items when an item is out of stock: this is called Just In Time ordering (JIT). For example the resident clinician (Jim) is currently monitoring the orthotics products to ensure that they are sorted correctly and always in stock. This system ensures that items are not out of stock for too long of a period of time and that all necessary items are easy to obtain.

The lead time between when an order is placed and when it is received is very short when there is no backorder (>99% of the time). The lead time for this whole process averages only 4 days, of which three days is shipping the product on the ground. Due to the large amount of time between patient visits, in the range of a few weeks, the majority of the time there are no problems with clinicians receiving the orders in time for patients return visit. Also the large standing inventory reduces the probability that a part is not in inventory when it is needed. Finally, roughly 70% of the ordered materials are delivered directly to the clinicians. These items are never placed in the inventory location and this prevents the inventory location from getting far out of control.

An important weakness of the current system is the inability to pass an audit, because there is no link between patient usage and order amount. This is an important issue, because there could be a leak in the system and it would be very hard to notice. It is vital that there is a link established between a product being ordered and the ones delivered or billed to a patient.

Another with the current inventory system is that the current data system cannot provide item usage per time period. Lacking this data, we cannot calculate inventory levels, along with reorder points and reorder quantities. This means that the inventory failure is higher than desired, and overstocked where not needed.

Inventory Area

The physical inventory can be organized in a more efficient manner to allow for shorter time period to locate items, easier documentation of product usage, and to create more free space. The current method of inventory organization makes it difficult to identify out of stock items and to decrease overstocking. The lack of a formal structure allows for parts to be placed in locations that they should not be placed, especially when considering situations when there is a large overstock of an item or when the person placing the item in inventory is short of time. In these instances items may be placed in whatever location looks open, so Orthotics materials may be placed with shoes, thus adding to the current confusing orientation of product storage. In order to have a smooth functioning system, the physical inventory location needs to be cleaned out and organized in a systematic manner. Finally, the non-medical devices consume a large amount of the limited available space and should be placed either in the rear of the inventory location or in an entirely different location.
Inventory Database

There are many things that are lacking from the current inventory system. To be more specific, the inventory system that is currently being implemented has the following drawbacks:

- No accurate lists of the names of the products in inventory
- No measurements of the current inventory levels
- No updated prices of products in inventory
- The database is not currently used in the manner that it was designed
- Item use over time is not being recorded; no existing information relating to product usage rates
- Lack of connection between orders placed, items in inventory, and patient use
- The only information entered into the database is information regarding the monthly levels of products in inventory
- Vendor information is not regularly updated, cross-checked, or changed

In short, the current system is lacking because there is a lack of loop. It has been observed that there is no link in the system between clinician orders and what patients are billed for. This means that if an item became lost, it would be very hard to discover that it was missing. Catching things like this is an important part of an inventory system, because there could be great losses happening and it would be impossible to know. There is also the risk that patients are not being billed appropriately.

The current inventory levels need to be checked and calculated impartially. As of right now, the system in place to keep inventory levels is a set of cards and not the database as originally intended. Also, there are no inventory levels established according to the usage rates of each item. This is also true for the reorder volumes. The current system where people order whatever number of items they feel they will need is not acceptable. This may lead to over or under stocking of an item.

Inventory Manager

Based upon the findings from the time studies shown in Table 1, we conclude that extra staff is not needed to manage the inventory. Also, given the low level of required hours we believe that the Inventory Manager has enough time to perform more tasks than are currently being done. It is our opinion that the Inventory Manager has enough time to restock the miscellaneous items in the patient rooms, spend the adequate amount of time reviewing purchase orders on M - Pathways and maintain the Access database. This conclusion is mainly derived from the time studies done on the Inventory Manager’s core activities, infrequent activities, and other miscellaneous items.

Recommendations

Based upon our conclusions we have developed recommendations for ways in which the inventory management system can be improved. These recommendations consist of the specifications that the ideal inventory management system should achieve and the inventory management system that we believe should be created, along with a four stage process to implement the system. In order to allow the members of O&P to develop the system that they believe will help them out the most, we also researched other possible
systems that could be used to manage the inventory. These systems are listed at the end of the section.

**Ideal Inventory System**

A new inventory system should be implemented to organize the inventory and keep track of what is going through it. This new system should have the following specifications:

1. There should be online part traceability. All clinicians should have access, and should regularly check the status of their orders. This way, patients can be scheduled according to the readiness of their devices.
2. There should be a link between patient billing and orders placed. This avoids over-ordering and avoids a possible leak in the system, where orders are not connected with patient delivery.
3. It should reduce the paperwork. It should improve efficiency, reduce the space required for the needed paperwork, and optimize the time available in the Inventory Manager position.
4. It should keep track of materiel usage. This will allow for calculated predictions that can be made for the appropriate inventory levels. Thus significantly reducing the stock-out rate, and thereby increasing clinician performance. This may even allow for fewer items in inventory, which reduces costs greatly because inventory is 1/3 of the budget.
5. It has to be easy to use, and all the staff involved should be trained to use it.
6. It needs to be automated so minimal effort is required to use the system. Items should be scanned automatically when they come into the system and when they leave. This will ensure that every staff member will use it even if that person is rushed with seeing a patient.
7. There should be an automatic option to calculate inventory levels and reorder quantities. This could even be used to automatically order an item when it’s level gets to the reorder point in the actual inventory without having to go through and manually order.

**Recommendation Outline**

Given the conclusions that have been presented in this report, the subsequent system is recommended. This system, which is separated into four stages, includes the organization of the physical inventory area, documenting the items that are in the inventory, developing an appropriate database to satisfy the needs of the department and the Inventory manager, and standardizing the quantity of items in inventory given the appropriate usage rates.

**Stage 1: Organize**
- Implement the 5S’s (see *Recommendation Details* section)
- Organize the products in inventory in a systematic manner, using the inputs from the CQI committee and the Inventory Manager
- Locate permanent location to store non-medical devices
- Work with the Inventory Manager to develop a work schedule in order to organize her tasks, provide feedback of job performance, and provide means to achieve satisfaction with the completion of projects
- Provide cart for Inventory Manager to distribute products with less travel and physical exhaustion
Stage 2: Document
- Print product names, quantity, and price onto the new inventory card
- Document the name, quantity and price of all products in inventory, and put the information on the existing database

Stage 3: Database Development
- Enter all relevant product data into the Microsoft Access Database, including product names, quantity on hand, price, etc.
- Eliminate redundancies required in entering information in the database
- Connect Microsoft Access database with bar code scanners, referring to the bar coding system that was attempted in the past, to trace product flow
- Place bar codes on all products and place bar code scanners in shipping and receiving locations, in the inventory location and near patient treatment area

Stage 4: Standardize Inventory
- Establish Usage Rates
- Given usage rates, for each product:
  a) Calculate reorder quantity
  b) Calculate reorder point
  c) Calculate inventory level

Recommendation Details

Stage 1: Organize

In order to make the inventory area work more efficiently, we need to implement the “5S for Operation: The Five Pillars of the Visual Workplace” by Hiroyuki Hirano.

In this principle, the word “pillar” is used as a metaphor to mean one of a group of structural elements that together support a structural system. In this case, the five pillars are a supporting system for the improvement of the inventory area. The five pillars are Sort, Set in Order, Shine, Standardize and Sustain. The two most important elements are Sort and Set In Order. The success of improvement activities depends upon these two.

First Pillar: Sort: This means that all items are removed from the workplace that is not needed for current operations. In this case, this includes all non-medical devices, along with every single item that has not been used for more than 2 years old. It is recommended that a salvage value is sought for the item, and if not possible, discarded. Any item that is not used within this period of time is more costly to keep it in shelves than actually throwing it away. Unneeded inventory creates extra inventory-related costs, such as space and management.

Second Pillar: Set in Order: Set in Order can be defined as arranging needed items so that they are easy to use and labeling them so that they are easy to find and put away. This pillar should always be implemented with the first pillar. Once everything is sorted through, only what is necessary remains. Next, it should be made clear where these things belong to so that anyone can immediately understand where to find them and where to return them. In this case, all materiel should be organized in object type by the isles, not by clinician, which is what is currently organized as. Labels should be put up, indicating
the name and the price for each item. A more detailed explanation of these labels is shown later in this report.

Third Pillar: Shine: Shine means sweeping floors, wiping off pieces, and generally making sure that everything in the area stays clean. Shine should be integrated into daily maintenance tasks to combine cleaning checkpoints with maintenance checkpoints.

Fourth Pillar: Standardize: Standardize differs from Sort, Set in Order and Shine. These first three pillars can be thought of as activities, as something we do. Standardize is the method you use to maintain the first three pillars—Sort, Set in Order, and Shine. It is related to each of the three pillars, but it relates more strongly to Shine. It is the condition that exists after we have practiced Shine for a long time.

Fifth Pillar: Sustain: Within the context of the five pillars, Sustain means making a habit of properly maintaining correct procedures. The first four pillars can be implemented without difficulty if the workplace is one where the employees can commit to sustaining these 5S conditions. This is the discipline to maintain the 5S conditions on a daily basis. Even if the 5S’s are done occasionally, without the Sustain pillar the other pillars will not last long.

We believe that these measures will keep the inventory area clean, organized and therefore, more efficient. Such workplace will enjoy high productivity and quality. It is, however, vital that everyone commits to these measures.

Stage 2: Document

Given the 5S’s, we have devised a card system that could be temporary implemented until inventory levels are standardized. This card shows the cost of the piece so that clinicians are aware of the cost and do not over-order. These cards should be placed on the shelves where the actual product is placed. The bottom numbers show the amount of pieces in inventory right now. When a new batch/product is received, the inventory manager should cross off the amounts that have been received. For example, say 25 pieces of this product have been received. The card would look like this:

<table>
<thead>
<tr>
<th>Items in Inventory</th>
<th>ORDERED?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes: ☐</td>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
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<td>29</td>
<td></td>
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<tr>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 10: Inventory card*
When a clinician comes and takes parts, they should note how many are left. For example, if the clinician has taken two parts, then they should mark off the field with the number 23 in it:

<table>
<thead>
<tr>
<th>PRODUCT NAME</th>
<th>Ordered?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items in Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>11 12 13 14 15 16 17 18 19 20</td>
</tr>
<tr>
<td>21 22 23 24 25 26 27 28 29 30</td>
</tr>
</tbody>
</table>

*Figure 11: Inventory card*

When a product has passed their re-order point and the order has been placed, then the box in the upper right corner of the card should be checked. It is recommended that the inventory manager checks these cards every day, to reorder if it is necessary and to check that these cards indeed reflect the number that there actually is in inventory. Eventually, once inventory levels have been established, there should be an indication of the reordering point, so that the inventory manager does not wait until zero if the product is highly used.

*Stage 3: Database Development*

Once the actual inventory area is cleaned out and is running on the temporary inventory card system, a more direct look at the database system can be made. All relevant product data must be entered into the Microsoft Access Database. This includes product names, quantity on hand, cost, vendors, modification dates, receipts, etc.

After all of the information inside of the database system is entered, updated, and cross referenced with the actual inventory in stock and the information coming from vendors, a new system should be considered. We suggest a bar coding system. A bar coding system would work because O & P had once implemented a bar coding system in the past. The only reasons that it is not in place now is because of lack of support from the Inventory Manager and because it “red flagged” some incidents where people were misusing their access to the inventory and this distracted from the implementation process.

Now, with proper training, the Inventory Manager can put her full support behind the new system. Since the database that is currently in place has the ability to print off individual bar codes for each item in inventory, no significant new work will be added. Also, it is highly recommended that the loop be closed. To clarify, when an item comes into the inventory, it needs to be checked off on the database if it leaves the inventory. This will allow for immediate update in the database and it will help to track the rates at which items are being used.
The database should be connected with bar code scanners, referring to the bar coding system that was attempted in the past, to trace product flow. The bar codes must be on all products and we suggest that 4 new bar code scanners are utilized. Three of these should be located in:

1) Shipping and receiving locations,
2) The inventory location, and
3) Near patient treatment areas.

These areas are where most items from the inventory flow through. The fourth bar code scanner should be kept in storage for emergency use, just in case one breaks down. The estimated cost is $200-$500 per scanner.

This will solve the traceability issues within the O&P department itself. To implement this, it may be necessary to contact the original team that programmed the database. If not, there may be some technical issues that come up regarding the practical installation of bar code scanners.

Essentially, the advantages and disadvantages to the proposed bar coding system are as follows:

Advantages:
- Easily implemented using current Microsoft Access Database
- Will solve the issue of keeping track of items as they leave the inventory
- Inexpensive due to previous implementation

Disadvantages:
- System has been implemented in the past and it didn’t work
- Personnel need to be trained to scan all items entering and exiting the system

Stage 4: Standardize Inventory

When all of the above steps are completed, the database should have the ability to keep track of which products are being used over the course of time. After approximately six months, there should be enough data to calculate the usage rates for each item that is stored in inventory. This calculation should be done by the Inventory Manager, and is easily found using the following equation:

\[ \lambda = \frac{D}{t} \]

where:
- \( D \) = number of units demanded
- \( t \) = the time frame that is used to find demand (weeks)

\[ \lambda = D/t = \text{number of units demanded divided by the unit time} = \text{usage rate} \]

**Example:** There are 20 items demanded every two weeks

\[ \text{Usage Rate} = \lambda = \frac{D}{t} = 20/2 = 10 \text{ items per week} \]

Given the usage rates for each item, the Inventory Manager should calculate the reorder quantity, reorder point, and thus the recommended inventory level should be stable.

\[ \lambda = \text{usage rate} = \text{number of units demanded per unit time} \]

\[ \tau = \text{leadtime} = \text{the amount of time it takes a shipment to reach O&P after it has been ordered} \]

\[ K = \text{the fixed cost of ordering} \]

\[ h = \text{the holding cost of the item per unit time} \]
sqrt = square root

Reorder Point = \( \lambda \tau \) = usage rate multiplied by leadtime (Leadtime is the amount of time it takes a shipment to reach O&P after it has been ordered)

Reorder Quantity = \( \sqrt{\frac{2K\lambda}{h}} \) = square root of the following quantity: (2 times the fixed cost of ordering times the number of units demanded per unit time) divided by the holding cost per unit time

**Example:** There are 10 items demanded per week, and after the items are ordered, it takes half a week for them to reach O&P. The fixed cost of ordering the items is $25, and the holding cost in inventory is 50 cents per week.

\[
\text{Reorder Point} = \lambda \tau = 10 \times 0.5 = 5 \text{ items (when the inventory has 5 items left of this particular item, reorder)}
\]

\[
\text{Reorder Quantity} = \sqrt{\frac{2K\lambda}{h}} = \sqrt{\frac{2 \times 25 \times 10}{0.5}} = 31.6 \approx 32 \text{ items (When you reorder this particular item, order 32 items)}
\]

These values will let the Inventory Manager know how much of each item to order when ordering. They will also let the Inventory Manager know when to order, and how much should be in stock at any given time. This knowledge, based on calculations rather than simply guessing, will most likely allow for a smaller inventory than the one that is currently in place. This leads to more room for storage for other items. There will also be less “stock-outs.” This means that there will be much fewer times where a clinician goes to find an item for a patient and it is not in the inventory area.

**Secondary Recommendations**

These recommendations provide some other possible directions that can be taken to gain the same objectives as the originally recommended bar coding system. They were briefly studied and the following information shows our preliminary findings.

**Radio Frequency Identification (RFID):** Will keep track of items as they leave the inventory, is very easy to use and the computer does all of the work. However, the system is very expensive since it is a brand new technology. Also, since the technology is new, it is subject to small ‘bugs.’

Advantages:
- Will solve the issue of keeping track of items as they leave the inventory
- Very easy to use.
- The computer does all of the work

Disadvantages:
- Very expensive (estimated at 2-3 times as much as bar coding)
- The technology is new and is therefore subject to small ‘bugs’

**Crib (locking the inventory storage area):** Only a few people will have access to inventory which will solve the issue of keeping track of items as they leave the inventory. However there will be a moderately high up front cost and personnel do not like the idea of being restricted access to their equipment.

Advantages:
- Only a few people have access to inventory
- Will solve the issue of keeping track of items as they leave the inventory

Disadvantages:
- Moderately high up front cost
- Personnel do not like the idea of being restricted access to their equipment

**Inventory Card (using a manual check card to keep track of inventory):** This system is much simpler to use than the color coded card system and it is very inexpensive. However, it is intended only for a short term solution, personnel need to be trained on how to use the system, personnel may not always be rigorous when keeping track of their usages, and it does not adequately solve the issue of keeping track of items as they leave the inventory.

Advantages:
- Much simpler to use than the color coded card system
- Very inexpensive

Disadvantages:
- Intended only for a short term solution
- Personnel need to be trained on how to use the system
- Personnel may not always be rigorous when keeping track of their usages
- Does not adequately solve the issue of keeping track of items as they leave the inventory
Appendix A – Survey Sample

SURVEY
This survey is very valuable to us. We appreciate your accuracy in the answers. We
would greatly appreciate if you would like to add any comments regarding the inventory
at the back of this page. This survey will remain confidential and will only be analyzed
by the Operations & Analysis research team

-------------------------------------------------------------------------------------------------------

I am a……(circle one)………pedorthist orthotist prosthetist fitter associate

1) Please indicate IN PERCENTAGES the amount of orders you place in each of the
following:
   - make orders through Brenda…(circle one)…………less than 10% of the total
     10%-30%
     30%-50%
     50%-80%
     80%-100%
   - pick up material from the inventory…(circle one)… less than 10% of the total
     10%-30%
     30%-50%
     50%-80%
     80%-100%
   - other (please indicate)______________________

2) How many times PER WEEK did you go to the inventory and found that the item you
were looking for was out of stock?
   (CIRCLE ONE)
   Less than 1 (Please go to question 3) Between 5 and 10
   Between 1 and 2 Between 10 and 20
   Between 2 and 5 More than 20

3) [Answer this ONLY if you have answered “Less than 1” in the previous question]
   How many times PER MONTH did you go to the inventory and found that the item you
   were looking for was out of stock?
   (CIRCLE ONE)
   Less than 1 Between 5 and 10
   Between 1 and 2 Between 10 and 2
   Between 2 and 5 More than 20

4) How many times A MONTH did you order through Brenda and you did not receive
the item on time for delivery to the patient? (due to back ordering or other issues you
were unaware of)
   Less than 1 Between 5 and 10
   Between 1 and 2 Between 10 and 2
   Between 2 and 5 More than 20

THANK YOU FOR YOUR TIME!!!
## Appendix B- Flow Entry Sheet

<table>
<thead>
<tr>
<th>DATE</th>
<th># Packages Received</th>
<th>Of which were for hospital</th>
<th>Of which were for inventory</th>
<th>Of which were for clinicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 22&lt;sup&gt;nd&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>March 23&lt;sup&gt;rd&lt;/sup&gt;</td>
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<td>March 24&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>March 25&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>March 26&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>March 29&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>March 30&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>April 1&lt;sup&gt;st&lt;/sup&gt;</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
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<td></td>
</tr>
</tbody>
</table>