IRMM
INTERNATIONAL REVIEW OF MANAGEMENT AND MARKETING
EJ EconJournals
ISSN: 2146-4405

International Review of Management and Marketing

ISSN: 2146-4405

available at http: www.econjournals.com

International Review of Management and Marketing, 2018, 8(3), 69-74.

Efficient Equipment Management for Biomedical Engineering Department in the Hospital

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ABSTRACT

Biomedical equipment management is a significant concern for safety and worth in the current hospital operations environment. In effect, the practice of an efficient information system will effectually stimulate the managing performance. The drive of this approach is to outline an efficient equipment management that affords for the safe and steadfast operation of medical equipment used in the treatment of patients. In this research work, AlGarhoud Private Hospital's biomedical engineering department, UAE is taken into consideration. This particular establishment is chosen due because it meets the criteria of being a private medical organization that is currently undergoing a revamp in their equipment management system. Collections of data and information dating back from 2010 have been compiled and analyzed. Firstly, the focus has been on asset management. Currently, medical equipment's inventory is managed on Microsoft Excel. Data from 2017 states that there are a total of 900 medical equipment's, and hence reflects its important to manage inventory effectively. Since inventory is getting managed manually, there have been recorded high chances of human error to miss out an important update or maintenance schedule every month. A new software named as enterprise asset management has been recommended to resolve this particular issue.

Keywords: Efficient Equipment Management, Enterprise Asset Management, Inventory Management
JEL Classification: O3

1. INTRODUCTION

The role of the Biomedical Engineering Department in a hospital is to manage the hospital's medical equipment. The goal of biomedical equipment management is to provide electrically safe, calibrated and well-functioning equipment with the purpose of delivering best healthcare for patients and to present the best cost effective manner of maintaining equipment in a hospital. The more effective the management is, the less the chances of inconveniences caused by malfunctioning of equipment will occur. Similarly, the better a hospitals equipment are taken care of, it presents a logical solution from the point of financial, technical and customer-centric feasibility. A biomedical engineer, basically, is an equipment manager, whose job is to provide the end-users or clinical staff with medical equipment.

Technology also enables integration and systems management in a way that contributes to improvements in the level of health indicators. Hospital and clinical administrators are faced with the expectation for return on investment that meets accounting guidelines and financial pressures (David and Jahnke, 2004. p. 73). The appropriate deployment of healthcare technology contributes to the improvement in the quality of healthcare delivered (Sprague, 1988. p. 26).

As rapid changes in the complexity and variety of technological tools and in the measurement of patient care outcomes taking place, it is best to facilitate transfer of such knowledge having well defined body of knowledge. As systems complexity and integration continues to increase, now is the time to demonstrate that the required competencies do contribute to desired outcomes (Yadin, 2008. p. 15).

To facilitate the process, the current state of the hospital's inventory should be assessed and quantified by the clinical engineer and the users with the use of quantified criteria. This process is aided by

the existence of both biomedical equipment and finance capital equipment databases outcomes (Blair, 2002. p. 23).

In National Taiwan University Hospital, a framework of medical equipment management system is used for in-house clinical engineering department. The system was web-based, and it integrated clinical engineering and hospital information system components (Chia-Hung et al., 2010. p. 6054). To face the tough competition environment and complex health care system, all hospitals should take the appropriate operational activities of medical devices such as purchase, contract, repair, and maintenance (Andreas et al., 2009).

There are a set of major and minor issues faced by a biomedical engineering department in the hospital and these are discussed in more elaborate in the coming part.

1.1. Minor Problems

Often, the maintenance labels to indicate the due for service of an equipment is missed. This, although a minor issue, accumulates to present a much larger problem in regards to the maintenance of the highly valuable and sensitive equipment.

Another issue that is problematic is that documents that get filed wrongly. It is an issue of documents not being kept in order and correctly by staff members and their coordination. This issue then gives way for the other minor issue which relates to team coordination and whether personnel are communicating with each other clearly and fulfilling each of their duties instead of assuming that the person previous or after would be filing/labeling the said documents for each equipment.

1.2. Major Problems

The following mentioned are larger issues that are apparent and prevalent within the organization. Errors while managing medical equipment inventory, which is considered to be a significant problem that can result in the equipment being damaged, used incorrectly and causing financial and mental distress to all stakeholders.

Calibrations of equipment can also prove to be of issue due to some of the medical equipment's that cannot be done in a correct and timely manner due to lack of testing tools that are particularly meant for the equipment in question.

1.3. Equipment Inventory Management

1.3.1. Asset management

Technology of health-care is considered a crucial part of health-care industry because it plays a major role in diagnostics, treatment, monitoring and giving therapies to patients. It eventually provides the quality health care that all stakeholders expect. Managing medical equipment's properly and efficiently, ultimately ensures that health care services are presented in a secured and successful manner. For this purpose primarily, it is important to create an inventory for managing medical equipment's. Inventory is basically a working document that is inspected and updated at regular time intervals in order to provide precise information about the said medical asset.

Inventory of medical equipment's evaluates the equipment's that are present in a hospital, and also, provides with details such as model and quantity etc. of medical equipment's. Inventory acts as a base for efficient equipment management since it is also proving the preventive maintenance timetables and keeps records of service calls and recall notices etc. Inventory can also show finance related data that allow for budget evaluations to be done objectively and beneficially. Some of the items that are managed in the Al Garhoud Private hospital are logbooks, instructional and service manuals and CDs, medical equipment files, preventive maintenance schedules and ensuring that equipment's are safe to use. Other than that, spare parts, consumables and accessories of equipment's are also included and monitored. The primary goal of asset management is to enable an organization to meet its service delivery objectives efficiently and effectively, and minimize the risk associated with asset failure.

1.3.2. Maintaining the integrity of the specifications and inventory used in Al Garhoud Private Hospital

Inventory of medical equipment evaluates the equipment that is present in a hospital, and also, provides with details such as model and quantity etc. of medical equipment. Mostly, medical equipment inventories are managed at the organizational level. Small facilities, like healthcare clinics might update the inventories less frequently because in these facilities, the quantity of medical equipment is lesser than what would be expected of a full-fledged hospital (Table 1).

On the other hand, larger facilities have to keep their inventory well updated as it is often the case that they have thousands of medical equipment to be kept a track upon and maintained. By using a Computerized Maintenance Management System, equipment logs to record events associated with a piece of equipment can be created (Whelpton and Cooke, 1990. p. 248).

The type of inventory applied depends on the type, size and culture of an organization. An inventory's length is based on information inserted in it and the role it plays for department as well as the users of the particular facility. There are various medical equipment that need consumables and accessories depending upon the service to be performed. To keep a record of all these items, facilities have a separate inventory.

This inventory includes simple consumables such as white A4 papers and different colored paper, reagents, CTG printing paper to blood tubing sets, ventilator breathing sets, BP cuffs etc. In this inventory, quantity, production and expiration dates of items are added to monitor details and use the consumables or accessories before their respective expiry dates. A well-managed inventory never lets the organization run out of stock, and additionally, it provides crucial budgeting details.

Another inventory is required to manage the record of spare parts and replacement kits required by medical equipment depending on type of service call and manufacturer recommendation. Items should be in stock at all times to maintain good operation of equipment. This inventory includes replacement kits, O-rings, printer heads etc. Some general items are also included, such

Table 1: A sample of the equipment inventory in Al Garhoud private hospital

Included in inventory	Explanation
Equipment Identification number	Specific number for each equipment from which it is identified labeled by organization
Item/Equipment type	Describes the item/equipment. For example ECG machine, MRI machine etc.
Equipment Description	Brief definition and function of medical equipment is inserted
Item/Equipment model number	Specific identification model of medical equipment. For example, Aplio 400 and Aplio 500 are two different models of ultrasound machine
Equipment Manufacturer	Manufacturer's name, contact details and address are added in inventory as required by facility
Serial Number	Identification number of a medical equipment assigned by manufacturer
Location of medical equipment	Location of each medical equipment is specified to show where it is kept in facility
Current status of medical equipment	This column of inventory shows the current state of medical equipment like under service, out of service, waiting for spare parts, beyond repair etc.
Inventory's update record	These dates show when, why and what was updated in inventory last time
Power Needs	Each equipment is having its own needs for power. In the column, power needs are specified. For example 110V, 220V, 380V and 3 phase

as lie screws, bulbs, power cords that are available in stock. This inventory can help to gauge and manage the approximate equipment in stock.

Some other types of inventories can also be used optionally as a support tool to record the issues related to medical equipment. These are as outlined below:

Equipment tools and testing tools inventory - It includes all the general tools such as screw drivers, Allen keys etc. and equipment testing and calibrations tools such as electrical safety test analyzer, NIBP analyzer etc. This inventory endeavors to help the biomedical engineering team to organize their workshop tools and calibration equipment properly.

Hospital and industrial equipment inventory - Services or equipment, such as sterilizers, autoclaves, water purifiers, vacuums, medical gas system etc. also play an essential role in running a hospital smoothly. These items should also be maintained at specific time intervals. Hospital and industrial equipment inventory is comprised of all such items.

Safety equipment inventory - There is also an inventory of safety equipment like fire extinguishers, hoses, fire alarms etc. because even safety equipment needs to be checked at regular intervals of time to make sure that these items can provide safety at the time of disaster.

1.4. Inventory Management in Al Garhoud Private Hospital

An inventory becomes successful only when it is detailed and precise. It is important to maintain and make sure an inventory is kept up to date by making all the necessary alterations or additions as per requirements in a timely, accurate and accountable manner. Inventory can be categorized in three stages:

1.4.1. Initial data collection

For an existing hospital or facility, it is essential to have a medical equipment inventory, and for creating an inventory, it is important to collect all the data related to medical equipment that are available in the facility. For this purpose, many people and groups of people are involved, such as end-users with good knowledge about equipment; biomedical engineers do the main job of building an inventory by visiting the end-users and departments, analyzing all medical equipment physically and noting down important information as per requirements. While making an inventory, the responsible people might also have to look in stores, cupboards etc. to ensure that there are no possibilities left exhausted in the pursuance of a complete inventory. It is also possible that some beyond repair medical equipment can be found during this process and it will present a good opportunity for the concerned department to dispose and look for a new alternative to such equipment.

For a new hospital or facility, it is essential to collect data of inventory before facility gets operational. This will be in favor of the facility to have a full, complete and accurate record of medical equipment from the beginning of operations. After collecting complete data, it is assembled and prepared in the form of document in computers, based on the facility and how it intends to document the inventory.

1.4.2. Information update

Whenever there are changes made related to medical equipment, it is mandatory that it is updated in the concerned inventory. If new equipment is installed, it is added into the inventory before it becomes operational. If medical equipment is on reagent bases, consumable bases or loan bases, it will be added into inventory. Inventory should be assembled in the way that any changes done are indicated clearly such as; change of location, maintenance dates and software up gradation etc.

2. ANNUAL AUDIT/REVIEW

Inventory is checked and evaluated by engineering department or any other responsible person annually. The reason to do so is to keep an audit check on the items and to do corrections of any mistakes, if any are found in World Health Organization (2011). As discussed in II. Equipment Inventory Management, a similar process is repeated in which a team of people work together to check the medical equipment physically and on the system to reconfirm that all the information on the system is accurate. All required changes are noted and edited in the inventory respectively.

2.1. Managing Inventory on Computers

While not recommended, it is fine to use a paper based inventory for smaller facilities as long as they are managed properly, it is certainly recommended that large computerized systems are better and easier to use, in bigger facilities. Computer based inventories

have the ability to combine all the data such as maintenance dates, installation dates, locations etc. all in a single management system.

These computerized inventory management systems are basically the software or worksheets that can be used for efficient inventory management. Software that are available in the market and can also be customized as per organization's requirements. Mostly, for a simple and straight forward inventory, excel worksheets or database software is used to insert and maintain the medical equipment data.

Inventory management systems are also capable of storing the service and repair histories of each equipment in the inventory. In case of any services performed on equipment, it will be updated on the system. After a while, if another person wants to see the data on the same equipment, he/she can see the complete maintenance or service history of the equipment that can assist the person in performing the service of equipment.

Tracking the order of work is also the function of this inventory management system that is computer based. The access to these work orders is with biomedical engineering department since they are the responsible people. Very few computerized systems are designed in such a way that they provide the engineering with notifications of due maintenance dates and checklists of devices.

2.2. Inventory as a Tool

Once an inventory is built, it becomes a very useful and essential tool for biomedical engineering department and the facility itself. In the case of Al Garhoud Private Hospital, the below are the outcomes of the implementation of the inventory system.

2.2.1. Predicting and making budgets

The medical equipment inventory can also assist in predicting different budgets. Present data of equipment's is monitored to observe if and medical equipment needs replacement, or if its life is ended, or it's depreciated, or the budget required for upcoming years followed by the purchase of new medical equipment.

Operating costs, servicing costs, maintenance costs, spare parts costs, yearly, all can be forecasted and future budgets can be planned accordingly. Also, use of spare parts can be monitored; items to be kept in stock can be predicted and entered in budget.

2.2.2. Designing and equipping medical equipment workshop

It is essential to keep a biomedical workshop well equipped with test tools and other required tools to provide effective services for medical equipment. Workshop should also have large space to perform tasks easily. Equipment inventory management system will also provide with the list of test tools and other important tools available in the workshop, required for performing proper services and maintenance of equipment. It will also provide the budget required for calibration, purchase and maintenance of instruments.

It depends on technical requirements of medical equipment that what space and which place it needs for servicing and maintaining and accordingly workshop areas will be divided for work. These divisions might include area for disinfecting equipment, store, test equipment area, technical documentation and manuals area, spare parts and accessories cabinets etc.

Since test and calibration tools are expensive, it is essential to keep the record in the form on inventory to monitor the use of tools to avert from any loss that can happen due to misuse or mishandling. Also, these tools require calibration, due calibration dates will be notified in inventory management system.

2.2.3. Decisions about necessary staff

Data of equipment present in inventory gives the staff an idea about equipment and determines the skills of staff required for maintaining the workflow of inventory. There are many types of medical equipment with different technical specifications, functions and requirements. Depending on the complexity of the medical equipment, knowledge about equipment and skills of staff, a manager assigns the staff for handling the issues that particular equipment.

Clinical staff is also responsible for handling the equipment with care, operating properly, cleaning, disinfecting, shifting (if required) and inform biomedical engineers for service issues. Clinical staff also plays an important role in inventory management by limiting resource settings.

2.2.4. Training requirements

After making an inventory, engineers might face issues like failures, misuse or mishandling of equipment, this happens because of lack of training. So, it is important to provide trainings for biomedical engineers and end-users, both, technical and operational trainings. When new equipment is installed, it is indicated in the inventory. Inventory can also show the training status of equipment, hence, this data can also be updated in inventory to keep a record and trace that all equipment will be used efficiently. This will favor to know; only that staff will use the equipment that is well trained.

2.2.5. Service contracts management

Sometimes, equipment requires service that cannot be done in-house, so, suppliers support will be required to perform such services for medical equipment. Mostly, this is done for big and complex equipment and equipment under warranty. Inventory can assist in explaining when external services are required and can also give the idea about budget required for providing services.

Suppliers can provide services either in clinical departments or by moving equipment to biomedical engineering workshop. It is important for biomedical engineering department to keep a record of what services are performed by suppliers by adding all the information in inventory. Also, biomedical engineering department should receive service report from suppliers, stating what services are performed by them.

2.2.6. Efficient equipment inventory management

It is essential for a facility to keep a maintained and update inventory. Inventory is the base of equipment inventory management. Maintenance done dates and due dates, testing of equipment and inspection at time intervals are indicated in inventory. Facility will also include items such as spare parts and

accessories that don't need regular checks but these items are added mainly for budgeting and tracking quantity. Organizing technical documents is also done in inventory. Properly arranging reports in inventory files provide easy access to reports when required also ensures good quality of technical services.

2.2.7. Ordering spare parts and accessories

Medical equipment inventory can favor to identify the spare parts and accessories that are required to be ordered. Inventory notifies the biomedical engineers if spare parts and accessories quantity is ending due to which services can stop, so that engineers can request to purchase more at right time. Main purpose of inventory of spare parts and accessories is to decide the rates of use and determine the reordering level that will be enough to maintain service until new order is placed and parts are received.

2.2.8. Making replacement and disposal policies

All medical equipment has a particular lifetime after which they need replacement or disposal. History of service of medical equipment is available in inventory if equipment goes beyond repair, out of service or missing etc. The trends that are available on inventory can favor the biomedical engineers to determine the lifespan of medical equipment and its cost effectiveness to let the equipment stay in-service, efficiently. Such type of data available in inventory can help the engineers to generate the policies for disposing or replacing equipment's. Similarly, budgets can also be formed to plan the purchase of new equipment.

2.2.9. Preparing case for medical equipment normalization

Examining medical equipment inventory can favor in normalizing or standardizing medical equipment. Assessing the inventory includes examining costs of accessories and spare parts, percentage of beyond repair equipment, end-users way of operating equipment, engineer's way of maintaining medical equipment due to complexity of equipment, cost of trainings for end-users and engineering staff. Normalizing the equipment will help to reduce costs of trainings so that more individuals can get trained on single type of equipment, reduction of spare parts and accessories cost and lowering the costs of test tools and other tools etc.

From the above mentioned information, it is observed that, inventory is very essential and powerful tool. For managing medical equipment, inventory serves as the base of medical equipment management. Any facility of hospital planning for improvements must have a well updated inventory as the first step. Medical equipment inventory management is the complete responsibility of biomedical engineering department.

In this work, medical equipment inventory of Al Garhoud Private Hospital has been analyzed.

2.3. Biomedical Engineering Department in Al Garhoud Private Hospital

The role of Biomedical Engineering Department in a hospital is to manage the medical equipment. Biomedical engineering department of Al Garhoud Private Hospital provides in-house facilities and services.

Biomedical engineering department is directly connected to patients via medical equipment that favor in diagnostics, lifesaving and curing patients. Biomedical engineering regulation in Al Garhoud Private Hospital is proportionate with the modern technology when it comes to medical equipment. Management does not only refer to repair or maintenance of medical equipment, there are certain roles given below that biomedical engineering department perform in management of medical equipment:

- Classifying medical equipment according to complexity
- Requesting and recommending the purchase of new equipment
- Scheduling planned preventive maintenance and calibrations of medical equipment
- Plan the life cycle and determine the life span of medical equipment
- To suggest up-gradations from time to time with the aim of keeping the equipment up to date as compared to market
- Schedule the medical equipment's operational and service trainings for end-users and biomedical engineering staff
- Request for test tolls and calibration tools for maintaining the medical equipment more efficiently
- Propose normalization of equipment to reduce the costs from maintenance and trainings after procurement
- Decide what spare parts and accessories are to be kept in stock to be used when required for servicing medical equipment.

2.4. Inventory Management at Al Garhoud Private Hospital

Medical Equipment Inventory Management is explained in detail in previous section. Inventory is a list of medical equipment managed by biomedical engineering department. Medical Equipment Inventory Management is explained in detail in previous section. Inventory is a list of medical equipment managed by biomedical engineering department. It is important to keep the inventory updated all the time so as to get proper information about present status of medical equipment.

It is the decision of department to add the information in inventory that is required by them according to protocols. The aim is to have an updated inventory at all times that can provide appropriate current information of all medical equipment. Currently, in Al Garhoud Private Hospital, inventory is getting managed on Microsoft Excel Worksheet.

As observed from Table 2 and 3, from the displayed data, it is clear that errors are occurring every month while editing and updating inventories. This creates a problem for biomedical engineering department in the management of the medical equipment.

Currently, Biomedical Engineering Department is managing the equipment inventory on Microsoft Excel Worksheets. The analysis was performed to observe where exactly the issues faced by Biomedical Engineering Department are centered around. The evidence presented in both the Tables 3 and 3 strongly suggest that, managing medical equipment inventory on excel worksheets are displaying some disadvantages. Due to these manual errors, that occurs while managing medical equipment inventory, the efficiency of biomedical engineering department reduces. For managing such problems, asset management software is

Table 2: A sample summary of data collected from Al Garhoud Private Hospital inventory between 2016 and 2017

Date	Errors percentages (%)
2016	
January, 2016	3
February, 2016	6
March, 2016	8
April, 2016	2
May, 2016	9
June, 2016	4
July, 2016	1
August, 2016	2
September, 2016	5
October, 2016	4
November, 2016	3
December, 2016	1
2017	
January, 2017	2
February, 2017	3
March, 2017	8
April, 2017	2
May, 2017	6
June, 2017	4
July, 2017	3
August, 2017	5
September, 2017	5
October, 2017	4
November, 2017	9
December, 2017	2

Table 3: A sample summary of data collected from Al Garhoud Private Hospital inventory between 2015 and 2017

Errors observed from January to December, 2016 in 5 intervals					
January	2	-	-	-	-
February	204	-	-	-	17
March	63	-	-	-	1
April	35	-	-	-	1
May	29	-	-	-	1
June	2	-	-	-	-
July	7	-	-	-	-
August	36	-	-	-	-
September	6	-	-	-	1
October	7	-	-	-	-
November	10	-	2	-	-
December	38	-	-	-	-
Errors observed from January to December, 2017 in 5 intervals					
January	7	-	-	-	2
February	208	-	-	-	11
March	67	-	1	-	21
April	38	-	-	-	36
May	36	-	-	-	4
June	9	-	2	-	7
July	24	-	-	-	4
August	50	-	-	-	2
September	10	-	1	-	6
October	8	-	-	-	4
November	14	-	2	-	10
December	41	-	-	-	5

recommended to be used by biomedical engineers for medical equipment inventory management. The next part of this paper attempts to provide a solution for the issues that are currently faced by the facility in terms of its current inventory management and the errors that are being presented by it as displayed in the Table 3.

2.4.1. Introduction to asset management

Asset management systems can favor facilities to improve medical equipment management. The optimized medical equipment inventory functions to manage the life cycle of medical equipment, starting from planning until procuring and continued with deploying, tracking equipment's performance, maintenance and disposing. Asset management is medical equipment inventory management in this case. For better inventory management, enterprise asset management (EAM) software can be used.

5. CONCLUSION

For the efficient management of inventory of Al Garhoud Private Hospital, EAM is suggested to be used instead of Microsoft worksheets. EAM is currently being used in well-known hospitals in UAE. These companies and more that are using EAM have reported satisfactory results with the software and have given positive reviews about it. The ratings of EAM are 3.9/5.0, which means it is reliable and suitable for use. Computerized system software is the need of the hour for managing biomedical equipment's. This will save many man-hours and also make the system more efficient.

6. ACKNOWLEDGMENT

Al Garhoud Private Hospital, Dubai, UAE is highly acknowledged by the authors for providing indispensable documents for this research.

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