

Management System of Medical Equipment in Hospitals

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Abstract— In the hospital, the management of medical equipment is a series of activities from budget planning to equipment disposing. The overall activities focus on issues such as quality, safety, performance, cost, and profit. An efficient and effective management system is necessary for supervising these goals. The main problem faced in most of the Lebanese hospitals is the over load that is applied from both paper work and maintenance issues at the same time, resulting in department breakdown and/or limitations. In this paper, we show an equipment service life-cycle model applied in these activities for in-house clinical engineering department, beside an in-house cycle management, in addition to a tool of communication with the other departments in the hospital. Some information systems were built by the management system and the information of management operations in clinical engineering department can be systematically collected and revealed at different life-cycle stages by these systems. Through the management system, we can easily integrate the management activities and improve medical care quality and patient's safety.

Keywords-*Management system;communication;in-house cycle management.*

I. INTRODUCTION

Nowadays, the healthcare sector is indispensable to us in order to maintain a healthy life away from disease, but it is very expensive. Hospitals, private or public, tend to ensure the health service in every region on the Lebanese ground. Various departments are present in each hospital that work together to guarantee the safety of the patient beside the appropriate medication and therapy. Depending on the patient's case, he/she will be transferred to one of the departments and will remain there as long as necessary to complete treatment. Departments within the hospital are divided into therapeutic, diagnostic, and service departments [1]. Every part in the hospital is related to another, thus linked together to form a strong chain to make sure that the patient is better in his stay and nothing is missed in his therapeutic period. Our concern is in the service sector, and especially in the Biomedical Department which is responsible for all the pieces of equipment in the hospital, their history, specifications, failure, and cost. This is very important in order to insure quality health service to the incoming patients.

Working as a biomedical engineer in a hospital requires being able to handle multiple tasks in parallel, such as technical issues and following up with different companies, as well as managing paperwork. Problems are found in the management part which is the result of hundreds or thousands of papers on the engineer's desk each month. Papers consist of maintenance requests, transfer forms, preventive maintenance requests, discard forms, etc.

The work mentioned increases the load on the biomedical engineer who is probably the only one in the department doing everything as a one man show. Paper work take a lot of time and disperses the process of parallelism mentioned previously [2]. On the other hand, each three years, the biomedical engineering department should be prepared with all these necessary data following the Accreditation standards to be submitted to the Ministry of Health. For that, all the requirements mentioned before should be available and well organized at any time.

And here is the importance of having a management system that can control the cycle of this work between the departments and the biomedical department, and a tool that can be used to apply this management system [3].

The main goal of the proposed project is to develop a management system that can organize the work pathway between the main department which is the Biomedical, and the secondary parts which are the hospital departments (Emergency, Operating Room, Intensive Care, etc.). What we mean by a management system is actually a process that is controlled by the biomedical engineer to stay in contact and updated with the secondary departments, which provides an improved quality of healthcare delivered to the patients. The system is ridden by a tool which is a software divided into a server user and active users. The main server/program is the biomedical engineer in the hospital. Active users represent the departments found in the hospital. Users can send maintenance requests, write transfer forms, and apply a request for preventive maintenance or exams for the staff. Each department, when using the program, is restricted to the machines found in this department [4]. On the other hand, the server can manage everything in all the departments due to a database that consist of the history of biomedical equipment. The server can also send recommendations and actions to the requests sent. In addition, the engineer can enter all the data that belongs to each machine which result in a history record of each

equipment from the moment bought reaching the discard phase. Policies, procedures, and instructions of use are also available in the software. Several processes (depreciation value, repeated failure, etc.) will be implemented in the program to help the engineer in some decisions he might take.

Using this tool, the management system can be applied easily upon controlling and gathering all the required data beside tracking equipment, counting repeated failures and taking critical decisions concerning hospital improvement which is directly related to the patient's safety and the quality of the delivered healthcare services.

The following section (section II) will shed lights on structure of the Lebanese hospitals with the biomedical engineering's tasks. Section III will cover the system design and implementation. Results and discussion are stated in section IV. Finally, the conclusion is set in section V.

II. HOSPITALS IN LEBANON

Hospitals in Lebanon are mainly divided into public and private. Each hospital has its own divisions. Departments within the hospital follow one of the three classes: Therapeutic, diagnostic, or service. The Biomedical department is one of the service departments that are not only connected to all the other hospital departments, but also to external parties such as companies and agencies.

The biomedical engineering departments should deliver continuous learning about the proper use of medical equipment to the doctors and nurses; communicate with the vendors, hospital administration, third party payers, and leasing agencies to take the right decision about the cost, technical requirements, reliability, and future planning. On the other hand, biomedical engineering department should communicate with the hospital environment section to take care of waste management, power, cabling, maintenance, and safety.

Also, the department should insure the safety and accepted medical practices to overcome the regulation

agencies. All of these connections are part of the daily tasks of the biomedical department to ensure the quality of healthcare delivered to the patient.

The connections shown in figure 1 are essential to provide the best hospital environment with good equipment management, active department's communication, following defined procedures of purchasing and maintenance, etc., which all result in maximizing healthcare quality and ensuring patient's satisfaction.

All the mentioned tasks beside the paper work form a huge responsibility on the biomedical engineer in the hospital.

Since all these tasks, beside the paper work, are related, it becomes essential to have a computer based management system to facilitate the inter-communication between the biomedical engineering department and all the other departments to save the time consumed on paper work and helps in decision making.

III. SYSTEM DESIGN AND IMPLEMENTATION

A Hospital Management System is a way for making the management inside the hospital paperless. This includes the clinical, back office, and generic management of all activities. It integrates the entire resources of a hospital into one integrated software application. The most important benefits that the biomedical engineering department gains from this management system are: minimizing manpower requirements, instant information retrieval, and timely treatment decisions.

It's a well know fact that there is no common hospital management system applied worldwide [6]. Each country has a certain system applied in some of its hospitals based on the country's conditions and standards from one side, and the hospital's profession, level, and type from the other side.

An existing management system in Michigan is based on dividing the biomedical department and the hospital equipment into several subdivisions [7]. Also, the management system applied in New Delhi defines the maintenance categories, as well as defining the function and the troubleshooting process of various medical equipment [8]. In Kenyan hospitals, a software is developed and installed in each department to identify the equipment fault and reports the possible personnel to handle it [9].

Our management system for the Lebanese hospitals should consist of:

A. Number of Staff:

The number of staff varies according to the number of beds in the hospital as shown in table I.

According to the number of beds within the hospital, the number of staff can be easily calculated such that every 100 beds need one biomedical engineer and one biomedical technician [7] [8].

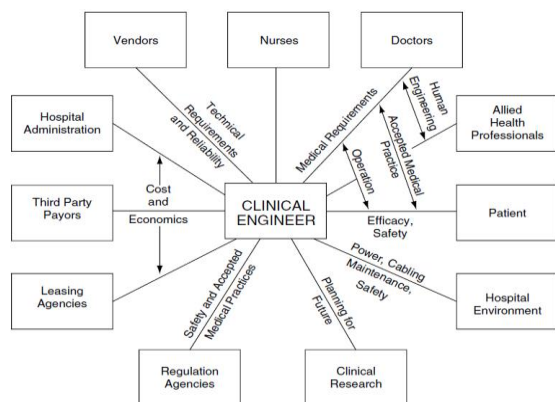


Figure 1. Connections of the biomedical department with inner and outer hospital environment [5].

TABLE I. Number of biomedical engineering staff with the corresponding number of beds.

	0-50 Beds	50-100 Beds	100-150 Beds	150-200 Beds
Biomedical Engineer	1	1	1	2
Biomedical Technician	0	1	2	2

B. Roles and Responsibilities:

- Biomedical Technician:** Different tasks are assigned to the biomedical technician in the biomedical engineering department. He is the biomedical engineer’s assistant, responsible for daily checkup mainly for the life support equipment such as defibrillators, anesthesia machines, etc., to make sure that everything is normal and ready for functioning. Checking the medical gases, such as oxygen, nitrogen, and compressed air to ensure the volume and pressure of each is also one of the biomedical technician’s tasks. On the other hand, the technician should follow up the temperature in some of the departments like Cath Lab, CT scan, MRI, etc... and the level of Reverse Osmosis (RO) water and the corresponding Total Dissolved Substances (TDS) and make sure the normal functioning of the autoclaves as well.
- Biomedical Engineer:** The Biomedical engineer should set the maintenance schedule that is composed of two parts: Planned Preventive Maintenance (PPM), and Corrective Maintenance (CM), to guarantee the efficiency and accuracy beside the normal function of medical equipment in the hospital. Moreover, the engineer is responsible for the stocks that contains the spare parts and stand by items and check for the missing/needed ones to order them. Designing new department, equipment installation, meeting with companies, and new equipment planning are also tasks assigned for the biomedical engineer in the hospital.
- Software:** The software is the tool for applying the hospital management system. It is developed using vb.net language. The software is based on

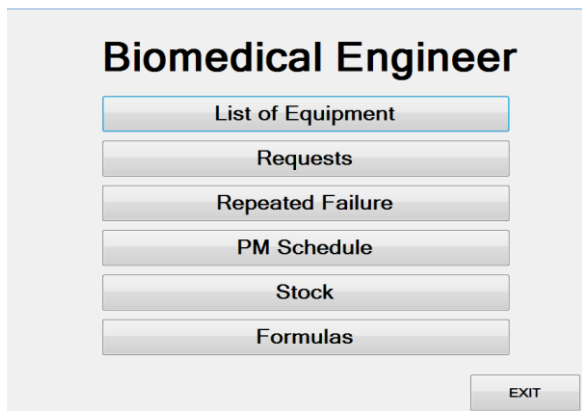


Figure 2. The front page of the administrator’s (Biomedical Department) software.

Administrator-Client Inter-phase [9]. The administrator is the biomedical engineering department, whereas the client may be any other department within the hospital. In figure 2, the front page of the administrator’s software is shown.

The biomedical department represents the head of the management system software. The other departments are the clients in this software. The software consists of:

- List of Equipment:** It lists the medical equipment found in each department with the corresponding details about the location room, serial number, hospital code, model, brand, purchasing date, price, and the availability of the operating manual. Also, a list of the discarded equipment/accessory in each department is available. Figure 3 illustrates the list of equipment found in the ground floor of the hospital with all the corresponding details that can be seen by both the engineering and the relative department.

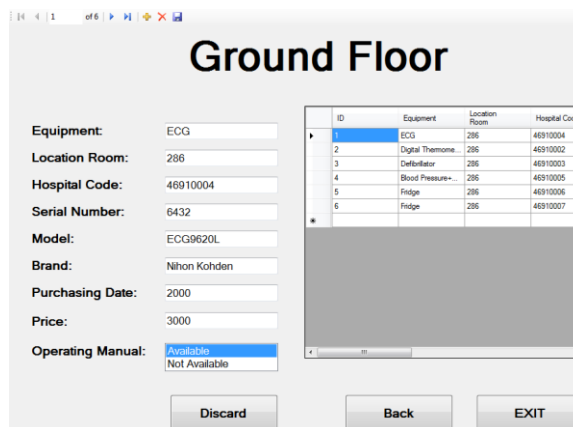


Figure 3. The ground floor's list of equipment software layout.

- Requests:** Requests are divided into maintenance requests and transfer requests. The administrator (Biomedical Department) receives requests sent from any other department. The maintenance request contains all the information about the equipment in addition to the failure date, time, type, description, expected maintenance duration, current status, finish date, and accessories needed. The transfer request consists of all the information about the equipment in addition to time, date, and duration of transfer, and the targeted location beside the reason of transfer.
- PM Schedule:** Figure 4 shows the PM schedule set by the biomedical engineering department. PM schedule is divided into internal (In-house), and external (company) preventive maintenance. The

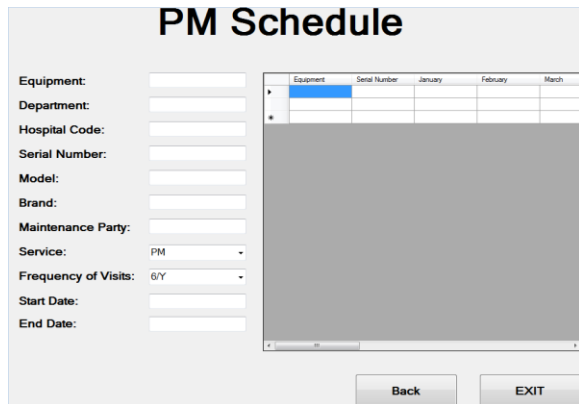


Figure 4. PM schedule layout in the administrator's software page.

schedule also shows the equipment and their corresponding dates of PM in addition to the maintenance party.

- **Stock:** Includes the spare parts/items found in the department and their quantity as shown in figure 5.
- **Repeated Failure:** This part allows the biomedical engineer to search by serial number or date interval to list the number of failures of equipment beside all the needed information. The repeated failure is a clear indicator that gives the biomedical engineer strong evidence and clear statistics about the equipment history, thus helping in taking the appropriate action and highlighting the equipment that should be replaced to guarantee the safety of the patients, as well as increasing the number of patients benefiting from the delivered healthcare.
- **Formulas:** The biomedical engineer can implement any formula that helps him in taking decisions in a more reliable and fast way. Figure 6 shows one of the useful formulas which is the depreciation value [10].
- **Instructions of use:** The page allows the staff in the department to view the instructions of use of all the equipment found in their department. Instructions of use contain details about getting started with the equipment, safely use, cleaning procedure, etc., these details should be clear to all the staff in the department to ensure the best use of the equipment with best results regarding the patient's diagnosis/treatment.
- **Security:** For the administrator software version, a username and password are used to guarantee the data security and private access. On the other hand, the client software version is more flexible to let all the staff access the information needed and send the

requests directly; but any modification requires a username and password.

The biomedical engineer can enter, edit, and delete data about medical equipment in the hospital. He has a full access to the software. However, the clients can only view the instructions of use, send maintenance/transfer requests, and receive feedback from the biomedical department concerning the request sent. The biomedical department receives a notification upon any new request. In return, the client also receives a notification upon any feedback received.

The network security of the software is a part of the overall hospital network security.

IV. RESULTS AND DISCUSSION

The management system and the software were implemented to test the functionality and activity of the overall system. The administrator version was installed on the main computer of the biomedical department. The client version was installed on the computers of all the medical departments. The software's communication is done by using the internal network of the hospital with the help of the information-technology department.

Upon failures in any medical equipment, the department sent a maintenance request. When receiving the notification of a new request, the biomedical engineer checks the software to verify the location of the failed equipment beside a brief description of the failure found, thus, takes the needed action. The engineer in return sends a feedback about the duration of maintenance and fills the missing information in the software to fulfill the data entry step.

The biomedical engineer in his department, and using the software, was able to send/receive data and communicate with the other departments within the hospital. He also checks the PM schedule, as well as following the biomedical stock of spare parts. On the other hand, the department was able to view, add, remove, and edit any

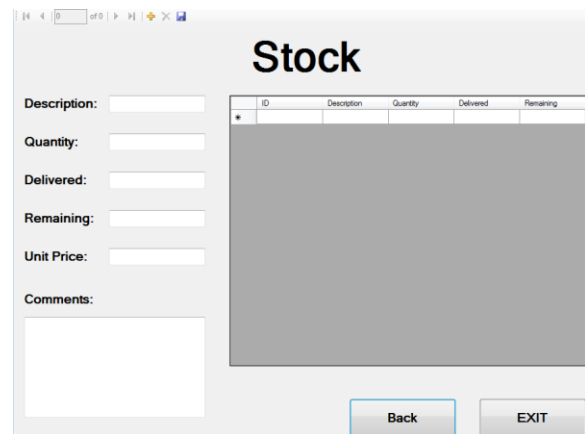


Figure 5. Stock's page with the corresponding details.

Figure 6. Depreciation value is one of the implemented formulas in the software.

equipment with its details using the list of equipment part in the software.

Things were better using the software. Time was saved in a great way with less paper work and reduction of over tasks that were due the responsibilities of the biomedical department.

The most important thing was that everything was ready for the accreditation that is done by the Lebanese Ministry of Health approximately each three years.

As a result, the management system and the software achieved the mentioned tasks and diminish the problem stated at the beginning of this paper in a computerized way based on databases and inter-communication between the biomedical and other hospital departments.

V. CONCLUSION

The implementation of this management system in the Lebanese hospitals can ensure the proper functioning of the biomedical department in the hospital since it saves time, archive data, helps in decision making, and make reviewing the medical equipment history easy. Besides, the system activates the inter-communication between the biomedical department and the other departments, sets the work pathway, and organizes all the data that the biomedical engineer needs.

REFERENCES

- [1] P. Debra Ferenc, *Understanding Hospital Billing and Coding*, Third Edition, 2014J. Clerk Maxwell and *A Treatise on Electricity and Magnetism*, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
- [2] Holleman, L. Warren, Cofta-Woerpel, M. Ludmila, Gritz, and R. Ellen, "Stress and Morale of Academic Biomedical Scientists".

- [3] World Congress on Medical Physics and Biomedical Engineering, Beijing, China, IFMBE Proceedings 2013, Volume 39, May 26-31, 2012, pp 799-802.
- [4] Kevin McGowan, Analytical Sciences, Inc, "Using Visual Basic® to Customize a Set of SAS® reports", Paper 164-27
- [5] Hari Balasubramanian On delays in access to care in American hospitals, Monday, March 17, 2014 M. Young, *The Technical Writer's Handbook*. Mill Valley, CA: University Science, 1989.
- [6] Abdo Jurjus, Focal Point for Health Research MOPH, "Health Research in Lebanon: a country report", Cairo, June 2000
- [7] Jennifer Nolan, Chair, Equipment Management Committee, "The university of Michigan hospital and health centers equipment management plan", 2010
- [8] Ministry of Health and Family Welfare, "Medical Equipment Maintenance Manual", New Delhi, October 2010.
- [9] David Mutia, John Kihium, and Stephen Maranga, "Developing an In-house Computerized Maintenance", Kenya, 2012, No 3, Vol 2.
- [10] Birrittani Sponaugle, JUNE 3, 2014, "Depreciation Expense: Caluculate and Understand Fixed Asset Value".