A Information Management Strategy for In-House Clinical Engineering Department Based on Equipment Service Life-Cycle Model

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Abstract—**In the hospital, the management of medical equipments 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. In this study, we show an equipment service life-cycle model applied in these activities for in-house clinical engineering department. Some information systems were built by the model and the information of management operations in clinical engineering department can be systematic collected and revealed at different life-cycle stages by these systems. Through the model, we can easily integrate the management activities and improve medical care quality and patient's safety. The model will be introduced in the method section and four systems which are medical equipment management system, utilization benefit administrative system, regulatory management system, and emergency management system will be shown in the results section. The framework of this model has worked well in National Taiwan University Hospital.**

Keywords—**information technology, management strategy, medical equipment, life-cycle evaluation mode, clinical engineering**

I. Introduction

An effective medical equipment management is an overall watchdog process from budget planning to disposing, strategy on safety, operation quality, cost, and profits. It must ensure the availability of appropriate equipment used at the right time and in the right place. Many healthcare technology management strategies with a life cycle model have been developed [1-3]. Through systematic planning and optimization in each stage, the management work of medical equipment is more clear and efficient.

In the hospital, the accountable and systemic information system will ensure cost-effective, efficient, and appropriate safety equipment to meet the demands of patient-care. It is important to have the measurable management strategies to monitor and evaluate the existing medical equipment resources [4-6].

The information management system (IMS) is a popular management method to simplify the complex management condition. Its basic structure is combined with network, computer, web server, database, and clear operating procedure. Especially, the web applications become popular increasingly, because they offer more advantages than traditional software did. Whereas the personal computer and web networking is common environment of hospital, the IMS can be easily applied to decrease the waste of operation time in the organization management and to reduce the manpower of consumption through shortening the work flow [7].

An IMS is designed through the conceptual life cycle structure of medical equipment in this thesis. It includes many systems such as Medical Equipment Management System (MEMS), Utilization benefit administrative system (UBAS), Regulatory Management System (RMS), and Emergency Management System (EMS). In the study, we will show the features for each system. IT promote not only on monitoring the status of medical equipments operation on quality and cost-effectiveness, but also enhancing the utility and longevity of the equipments. Through this information, the right people can do the right decision at the right time to give the hospital a realistic picture of feasibility, outcome and findings. To achieve the efficient and effective management in patient safety, maintenance quality, and operating cost-effectiveness, a systematic method is needed to simplify the complex management procedures for the operation management of clinical engineering department (CED) in hospital.

In the method section we will introduce the equipment service life-cycle model and four systems which are MEMS, UBAS, RMS, and EMS will be shown in the results section.

II. METHOD

Our proposed model shown in Fig. 1 includes two major parts that are equipment service life-cycle from planning to disposal and IMS. The information system includes web-based interface, databases, and networks.

M. Long (Ed.): World Congress on Medical Physics and Biomedical Engineering, IFMBE Proceedings 39, pp. 799–802, 2013.
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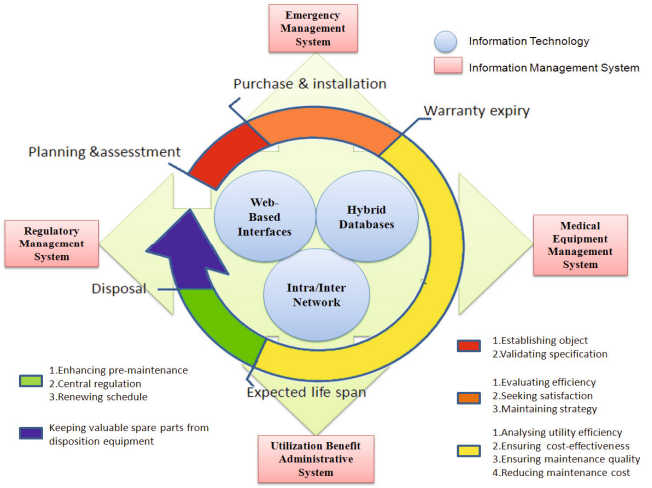

Fig. 1. The system architecture of a web-based medical equipments management model based on equipment service life-cycle

A. Equipment Service Life-cycle

1. First stage: Planning and Assessment

This stage is concerned with the appropriateness of purchasing equipments according to specifications. The main consideration of the purchase goal is whether the medical equipments can reach the expectation in clinical service or the research demand, developing policy of department or hospital. In additions, there are some issues should be aware of, for example, whether the usage volume of operating schedules is reasonable, what is the approximate value of cost-benefit and whether the environmental condition (like water, electricity, air condition, etc.) is suitable. Many factors such as price, the period of life span, safety and other economic issues also should be considered and evaluated.

2. Second stage: Equipment Reassessment before Warranty Expired

This stage is from beginning installation to warranty expiry date (the period of time is about one year). The efficiency evaluation focuses on three aspects, namely operating object, equipment function and the service of suppliers. Principal evaluation items include the followings:

(1) Whether its operation of equipment has achieved the anticipated target?
(2) How much is the revenue and operating cost?
(3) How is the satisfaction (including operating functions, training, and the quality of manufacturer service)?
(4) What is the service type after the warranty expired? in-house or outsourcing?
(5) What is the risk of defect machine (like the possible injury of patients, down time and backup plan and so on)?

3. Third stage: Before the Expected Life Span of Equipment Operation

This stage is the major use period of the equipment. The management must promote maximum benefit, minimize maintenance cost and ensure operating safety with good quality. The benefit of monitoring not only concentrates on the volume and income of the equipment, but also other related areas. This includes the maintenance cost and the quality control for repairing rate, cost, downtime, and fault analysis. According to the analysis results of the above factors, user can adjust and correct inefficient jobs.

4. Forth stage: Out of Expected Life Span of Equipment Operation

This stage deals with equipment that has been in service for some time and some parts have gotten old. Advance maintenance is needed. There are two strategies for reducing the downtime cost, stocking common use parts or proposing a purchase order to replace old equipment. For obsolete equipment with low utilization ratio but it functions are still permissible, the centralized management will approve for providing temporary support usage. This will increase the remaining value for this equipment indirectly.

5. Final stage: Equipment disposal

The disposed equipment could be stocked to provide another on-line equipment service or made use for related teaching or researching.

B. Information Management System (IMS)

The IMS is shown in Fig. 2. This system is divided into four parts: database system, system key users, information system, and web network. It is a comprehensive information platform linked to other systems such as hospital information system (HIS), clinical information system (CIS) and system in the biomedical engineering department.

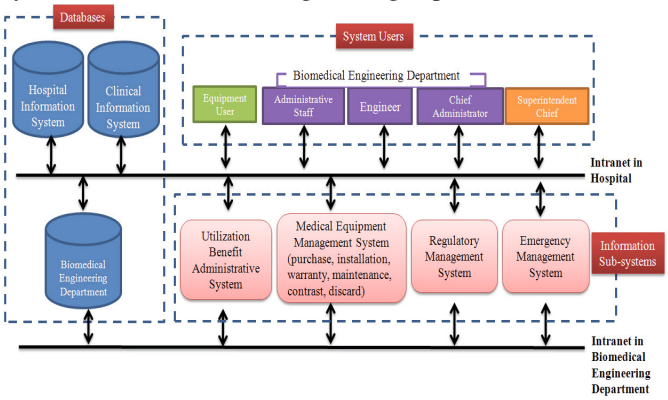

Fig. 2. The structure of web based information system for medical equipment management

1. The Database Systems

- *Database of Hospital Information System (HIS)*

This database contains data from budget, purchasing, and inventory related to medical equipments. These data are from users' input, accounting office, and general affairs office. These basic data are like personal ID information used by other sub-systems. The integrity and validity of data are very important.

- *Database of CED*

This database includes the daily work data related to purchase assessment, accepting check, warranty tracking, repair, maintenance, contract management and discard of medical equipments.

- *Database of Clinical Information System (CIS)*

The database data is a comprehensive and integrated information system designed to manage the administrative, financial and clinical aspects of a hospital related to a patient. The revenues and throughput of the medical equipment can be figured out by the database.

2. System Users

In the IMS, the user interface is rather complicated and is designed to contain many functions for different users. They are described as below:

- *Equipment Users*

To meet the requirements of these users, the collection of data is from budget, purchase demand, operating goal, maintenance demand, and discarding demand of the equipment. Besides, search by keyword such as equipment operation or department is also included.

- *Administrative Staff of CED*

The administrative staffs of *CED* have to input daily operation data into the medical equipment management system (MEMS). These data include dates of accepting the cases, assigning work, user conformation and closing the case. The data are used for monitoring the case' progress and calculating the efficient of engineer work. Therefore, it is important for the validation and completeness of input data.

- *Engineers of CED*

The engineers of *CED* regularly input purchase assessment, repair, and maintenance data into MEMS and retrieve history information from the system.

- *Chief of CED*

The chief of BMED can examine the throughput of engineers and monitor the progress of all cases through the MEMS.

- *Superintendent Chief*

The chief may be the superintendent of hospital or chief of the end users. They are allowed to access the system. The information includes maintenance contents and cost, throughput benefits, and the conditions of regulation in medical equipment.

3. Information Sub-systems

Four information sub-systems are used for monitoring the operating status, quality, cost-effectiveness, utility, and emergency response related to medical equipments. They are described in results section.

III. Results

A. Medical Equipment Management System (MEMS)

MEMS is the major system used by the operation management of *CED*. The system processes large amount of data from basic inventory, routine administration, and outsource management. The inventory data includes property code, device name, user name, using divisions, division's phone number, costs, book values, brands, types and present location. The operating data contain daily working activities such as purchase assessment, installation confirmation, disposal evaluation, and service of correction and maintenance. These records were used for administrating, evaluating staff efficiency, and work force control. Every case acceptance time, finishing time and its related performing contents are major recording data. Moreover, monitoring the outsourcing performance is another important mission for the daily work of *CED*.

Besides data recording, some quality indicators are also built in this system. In the installation stage, through the collected data we can understand the performance of new purchase equipment on its operation, functions, price, service, precision, analysis, stability, performance, technique support, service support, failure rate and extensibility. For operation stage, we can obtain related information such as failure reasons, maintenance cost, saving cost, staff efficiency, delay status, and performance evaluation between different brands of equipments for similar functions [8].

B. Utilization Benefit Administrative System (UBAS)

The end user or the audit department must keep track the utilization benefit of medical equipments. This vital information is converged from CIS, HIS, picture archiving and communication systems (PACS) and MEMS.

Data from CIS includes income, user ID, and used datetime of equipments for clinical diagnosis or therapy such as ultrasound, endoscope, ECG, laser device etc. PACS provides related data on medical image equipments such as CT, MRI, and PET. HIS provides the fixed cost information like spare parts, consumables, man power, and related environment supply cost. MEMS provides the maintenance cost.

There are many devices used for medical research. These devices have no utilization or revenue data from CIS or

PACS. Their visual throughputs include published literatures, notes or letters for related study and research [9].

C. Regulatory Management System (RMS)

RMS focuses on central regulatory management of outdated equipment. The goal of regulation is to promote the utilization benefits of idle or obsolete equipment. Its major function includes two parts. The first part is for the general users to provide related information such as a list of regulated equipments for user to loan and historic recorded data to query. The other for management department includes stock list, request list, data query and historic list [10].

D. Emergency Management System (EMS)

EMS provides a mechanism to manage a large amount of medical equipment affected by a serious disaster or accident happen in the hospital. The mechanism includes a simple pre-operating process and a web-based information system. Through it, the EMS can effectively manage and control damaged medical equipment after an accident. The final goal is to helps hospital recovering to normal as soon as possible. An example of disaster recovery after fire in a hospital can be referred to [11].

To efficiently accomplish the work, a suitable constructing process was proposed, which includes a pre-processing, data management, and information reveal. The pre-processing was to identify, classify, and mark the damaged equipment accordingly. Based on the marks, the administrative staff systematically built the raw data, such as the water number, inventory code, damaged level, position, photographs, etc., for all of the checked medical equipment. These data needed to be combined with the inventory database of HIS to be converted into usable information. Finally, an information system was developed to link the database in order for the related messages to be reported to the related people or department. The information system was developed on a web-based platform. Therefore, everyone could easily access his/her information with the browser using a personal computer, once it was linked to the internet at any time and place.

IV. CONCLUSIONS

Availability of medical equipments has become an important issue of modern health care. But the related management or maintenance is particularly centered on the in-house CED. The growth in capabilities to manage or maintain medical equipment has lagged far behind the rate of deployment of equipment. In addition to traditional operation guideline, the patient safety, operation performance in cost/efficient analysis, and risk evaluation and control are the important issues for using medical equipments. A framework of IMS with an equipment service life-cycle model has been proposed in the paper for assisting in-house CED early to confront the potential risk.

In this thesis, it shows the IMS with an efficient model to get some useful information in operational progress of in-house CED through related systems. This information would effectively help administrators to make correct decision. Besides, the IMS can break the limitation of the space-time block, make the maintenance cost minimum, maximize the income benefit and optimize the operating quality. Moreover, the system will not only reducing the cost of manpower and time wasted in administrative procedures, but also help the hospital for better competition and good care quality.

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