

An Integrated Evaluation for the Performance of Clinical Engineering Department

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Abstract— Performance benchmarking have become a very important component in all successful organizations nowadays that must be used by Clinical Engineering Department (CED) in hospitals. Many researchers identified essential mainstream performance indicators needed to improve the CED's performance. These studies revealed mainstream performance indicators that use the database of a CED to evaluate its performance [1-3]. In this work, we believe that those indicators are insufficient for hospitals. Additional important indicators should be included to improve the evaluation accuracy. Therefore, we added new indicators: technical/maintenance indicators, economic indicators, intrinsic criticality indicators, basic hospital indicators, equipment acquisition, and safety indicators. Data is collected from 10 hospitals that cover different types of healthcare organizations. We developed a software tool that analyses collected data to provide a score for each CED under evaluation. Our results indicate that there is an average gap of 67% between the CEDs' performance and the ideal target. The reasons for the noncompliance are discussed in order to improve performance of CEDs under evaluation.

I. INTRODUCTION

The Clinical Engineer (CE) is involved in many levels in safe, appropriate, and economical use of technology in the health care system. Supported by clinical engineering technicians, the clinical engineer is responsible for areas extending from design and maintenance of hardware to quality control [4]. Hospital-based clinical engineers work on assuring that the medical equipment is effective and safe in operation [5]. Due to the advanced improvement in the field of clinical engineering all over the world; evaluation should be made for CEDs to improve their performance. CED's managers should quantify, evaluate and monitor performance. We should improve the CED efficiency by introducing the right indicators in many fields. We can improve CED effectiveness by monitoring and scoring the selected indicators in order to improve them continuously.

The Egyptian ministry of health department has tried to qualify the CED in hospitals and in spite of this effort, the activity focuses on documentation system and does not take into consideration many factors that have great effect in qualifying the CED. CED in hospitals for the past years have been troubled with creating a standard, substantive performance evaluation benchmarks to measure how well the

department is doing from time to time [1]. Our approach in this work is defining, developing, and selecting additional indicators that describe performance of the CED being more effective.

Benchmarking has been defined as “the process of comparing business practices and performance levels between companies (or divisions) to gain new insights and to identify opportunities for making improvements” [6]. It allows the organization to compare themselves with others, to identify their comparative strengths and weaknesses and to learn how to improve [7].

II. METHODOLOGY

Our objective is to measure CED performance including team and specific individual parameters. Evaluation of the department's performance requires ways to measure it, in order to facilitate objective comparisons and improvements. The first step in our approach is to decide what exactly to evaluate and monitor. Some studies adopted a survey technique as CED directors were asked to select from a list of proposed performance indicators that could be used for performance measurement benchmarking. Their response revealed mainstream performance indicators [1-3]. But the responsibilities of the departments are not limited to these services. Those indicators maybe unfair in measuring the CED performance. Other indicators have to be added and measured in order to evaluate the performance of the other services as well. We use additional important indicators that should be involved to get increased accurate evaluation. The base of our model is choosing indicators that are the same indicators used for the technology replacement plan for medical equipment [8] but with a different scope. These indicators are:

A. Technical / Maintenance Indicators:

To determine the performance of CED staff in maintaining the equipment's technical status in good conditions and safe operation such as making accurate and effective maintenance process, availability of sufficient spare parts and/or tools for repair to reduce the downtime of equipment.

B. Economic Indicators:

The responsibilities in this setting include financial or budgetary management, service contract management and CE service cost as a percentage of CE inventory value.

C. Medical Equipment Acquisition:

The most important standard rules that must be taken in purchasing medical equipment. In Egyptian hospitals, the

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doctor's staff define their needs from the medical equipment and then the CED included in the acquisition process.

D. Criticality Indicators:

Unobvious indicators that may affect the CED performance like technological complexity and the availability of vital equipment.

E. Safety Indicators:

Indicators determine safety such as the presence of documentation, training procedures and alarm systems.

In addition to the above indicators we found out that there are more types of indicators that should be taken into consideration to evaluate the CED performance more accurate as:

F. The Basic Hospital Indicators:

Data such as capacity, utilization, Employee/customer satisfaction and equipment status (age) to get increased accurate and fairer evaluation.

We made interviews with many CED directors and experts from CED consultation foundations to review those indicators and determine which from them can be used to evaluate the performance, we performed the following procedures:

a. The Questionnaire

The most important step of our procedure is the questionnaire that explains the objective and the required data for CED managers to avoid misunderstanding. We designed the questionnaire and put it in balance scorecard format as shown in Table I, which can be used by CED manager to evaluate CED performance and monitor it more easily. The Balanced Score Card (BSC) translates mission and strategy into objectives and measures them [9]. BSC is used to facilitate the business strategy, control behavior, and evaluate past performance [10] so that the organization will identify and respond to success needs and initiate quality improvement.

TABLE I. MAINTENANCE INDICATORS FROM SECTION TWO IN THE QUESTIONNAIRE IN THE BALANCE SCORECARD FORMAT

Indicators	KE indicators	Value	Score
Technical & maintenance	Availability of a sufficient spare parts or tools in the CED		
	The average Downtime of the medical equipment		
	Warranty		
	Service contract		
	No Service contract		
	Executed Preventive maintenance/Planned Preventive maintenance		
	Average response time		
	Inventory Lists		
	Planning Department		
	Percentage of repairs completed within 24 hours and 1 week		
	FTE/number of capital devices		
	Medical equipment management plan.		
	Facilities planning and construction.		
Inventory management			

b. Establishment of Threshold Values for the Indicators

Indicators used need expectations that must be quantified in terms of the indicators result in the establishment of threshold values for the indicators. Indicators combined with threshold values identify the opportunities for improvement.

Monitoring and measuring to determine if an indicator is below or above certain limit depending on the established threshold will provide a flag to whether the process or performance is within acceptable limits or outside so that CED can identify problems to be solved.

c. Scoring Decision:

The next step is giving score to each indicator depending on its threshold in order to give quantified data that can be easily recognized and improved. We use Joint Commission on Accreditation of Healthcare Organizations (JCAHO) scoring system 2009 as shown in Table II.

For some indicators, we modify the scoring system such as the equipment age indicator, which is divided according to its threshold [11] into five levels so that the scoring decisions are changed as shown in Table III.

d. Site Assessment:

Site assessment, documentation, audit review and the interviews used to collect data to give adequate information about the environment of the work of CED which supports the validation of the questionnaire.

This data can be used to give indication and evidence about the correctness and accuracy of the data given by CED directors so that it would verify the data collected by the questionnaire which give the CED performance accurately.

e. Automated Evaluation Tool

We develop a simple tool uses excel sheet as shown in Fig.1 that applies the scoring decision system on the collected data from hospitals to give an evaluation for the CED performance.

The purpose of using this tool is to reduce human errors, provide easiness of evaluation, and recognize indicators that need improvement.

TABLE II. THE SCALE USED IN DOCUMENT AND SITE EVALUATION

Non Compliance	Partial Compliance	Satisfactory Compliance
0	1	2

TABLE III. THE MODIFIED SCALE USED IN DOCUMENT AND SITE EVALUATION

Non Compliance	Partial Compliance	Partial Compliance 1	Partial Compliance 2	Satisfactory Compliance
new	almost new	average	almost old	old
0	1	2	3	4

Indicator	Indicator	Value	Score	Ideal
Technical & maintenance	Availability of a sufficient spare parts or tools	no	0	2
	The average Downtime			
	Warranty	72h	0	2
	Service contract	72h	1	3
	No Service contract	72h	2	4
	Executed Preventive maintenance/ Planned Preventive maintenance (PPM)	50% of PPM	2	3
	Average response time	24	1	2
	Inventory Lists		2	2
	Planning Department		0	2
	Percentage of repairs completed within 24 hours and 1 week	<50%	0	2
	FTE/number of capital devices		0	2
	Medical equipment management plan.	no	0	2
	Facilities planning and construction.	no	0	2
	Inventory management	no	0	2
	Total			7

Figure 1. The developed excel sheet tool that takes the hospital data and gives the evaluation of CE department

III. RESULTS

Fig.1 represent the marks of technical indicators for CED in a hospital for example, the score for some CED indicators is assigned as:

- For the availability of a sufficient spare parts or tools, Inventory management, Facilities planning and Inventory Lists we put scores according to Category “A” in JCAHO scoring system 2009.
- For the average downtime due to failures for equipment in warranty, service contract and no service contract we put scores according to Standard Scored “0” in JCAHO scoring system 2009 with modification. CED work to reduce the down time for equipment in/no service contract more than equipment in warranty, so it takes higher mark.

We collected the data from 10 hospitals and the overall results of CED’s performance score are extracted from the BSC. Fig. 2 shows the average results of the categories of the performance’s indicators points (results) from all hospitals.

We used the following statistical equations in the excel sheet to calculate the hospitals results as:

- The result for each hospital as a percentage of full ideal mark= (Hos. mark/full ideal mark)*100.
- The average results of each category of all hospital's indicators= (sum of categories percentage of Hos. mark/10).
- The CED overall average result= (Hos. mark/10).

The results show that the gap between the CED’s overall performance of existed services and ideal target is 67% as shown in Fig. 3.

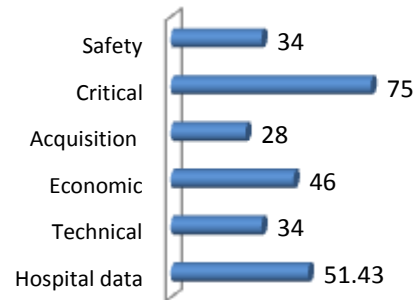


Figure 2. The CED’s performance results for each indicator as a percentage of the ideal state of CE department.

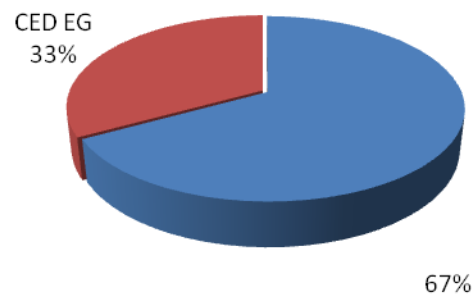


Figure 3. The average CED’s performance in Egypt as a percentage of the ideal

IV. DISCUSSIONS

The average CED performance of the hospitals is quite low (33%) as shown in Fig. 3. By reviewing Fig. 2 we can realize that most indicators that cause this low performance are safety , acquisition, economic, and technical indicators because of the following:

- The safety indicators type which is very important for the safe operation of medical devices for workers and patients is quite low from ideal full mark (only nearly 34%) and the most important reasons for that are:*
 - Most of the clinical engineering departments in hospitals in Egypt don't classify or even record the work orders for equipment failure to define the reasons of these failures and find the solutions to prevent their existence or their reduction.
 - The absence of providing start up procedures or training to the users of medical equipment.
 - Most hospitals don't have any registration for documented failure of equipment or calibration plan except for the equipment in service contracts.
 - Most of the clinical engineering departments don't make any incident investigations or equipment safety checks.

ii. *The Acquisition of medical equipment indicators type which is also quite low from full score mark (nearly 28%).*

The most important reasons for that are the absences of the ideal procedures for procurement of medical equipment.

iii. *Economic indicators type which is also quite low (nearly 46%) and the most important reasons for that are:*

- The CE service costs exceed the total equipment cost.
- The absence of CE Budget that may be devoted to employee training.

iv. *The technical / maintenance indicators which are quite low (nearly 34%) and the most important reasons for that are:*

- The long downtime of medical equipment due to the long administrative routine in Egyptian hospitals taken to make the repair process.
- The absence of spare parts and tools those can be used by The CED's engineers and technicians to repair the medical equipment.
- There is no Planed Preventive Maintenance (PPM) for medical equipment that must be applied on the medical equipment.

We tried to compare our approach with the ways used by other researches in terms of the indicators used and their results as shown in Table IV.

Approach [1] focus on the economic indicators and overlooked other indicators categories such as medical equipment acquisition, other technical indicators, and the safety indicators. Approach [2] overlooked important indicator categories such as the acquisition of medical equipment, other technical indicators, and safety indicators.

TABLE IV. CED PERFORMANCE DUE TO OUR APPROACH AND OTHER APPROACH

Approach	No. of indicators	indicators type	Average performance
Our approach	136	5 Basic hospital data. 13 technical/ maintenance indicators. 12 Economic indicators. Equipment acquisition. Critical indicators. Safety indicators.	33%
Approach [1]	10	8 economic indicators. 2 maintenance indicators.	51%
Approach [2]	18	6 maintenance indicators. Staff learning. Customer indicators. Economic indicators.	47.45%
Approach [3]	16	5 maintenance indicators. Staff indicators. Customer indicators. Procurement.	24.2%

Approach [3] overlooked important indicator categories as the economic, other technical indicators, acquisition of medical equipment and basic hospital data which led to un fair evaluation. Our approach takes in consideration some indicators from these Approaches and involved other types of indicators. The additional indicators help the CED to get fairer and accurate performance evaluation.

V. CONCLUSIONS

Performance measurement of CED in hospitals using these additional indicators such as capacity, utilization, Employee/customer satisfaction, equipment status (age) and indicators used for the technology replacement plan for medical equipment will get increased accurate and more fair performance evaluation. We will be able to find the real reasons of failure and improve performance.

Further analysis may be required to better define the problem of creating a standard and substantive performance evaluation benchmarks and solve it. Researches should be made to find other factors that could affect the CED performance and must take in consideration to evaluate the CED performance accurately.

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