DECISION SUPPORT SYSTEM FOR MEDICAL EQUIPMENT FAILURA ANALYSIS

By

Amira Mahmoud Mohamed Osman

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Biomedical Engineering and Systems

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Under the supervision of

Prof. Dr. Ayman Mohamed El-Deib

Professor of biomedical engineering
Systems and biomedical engineering department
Faculty of Engineering, Cairo University

Dr. Walid Ibrahim Al-atabany

Associate Professor
Systems and biomedical engineering department
Faculty of Engineering, Helwan University

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Approved by the
Examining Committee

Prof. Dr. Ayman Mohamed El-Deib	Thesis Main Advisor
A.Prof. Dr. Walid Ibrahim Al-atabany Biomedical engineering department Faculty of Engineering, Helwan University	Advisor
Prof. Dr. Ahmed Hisham Kandil	Internal Examiner
Prof. Dr. Mohmed Tarek El-Wakkad Biomedical engineering department Faculty of Engineering, Helwan University	External Examiner

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2020

Engineer's Name:	Amira Mahmoud Mohamed Osman
Date of Birth:	1/4/1988
Nationality:	Egyptian
E-mail:	Amira_mahmoud0505@yahoo.com
Phone:	01111682249
Address:	7 Tanta street, Haram, Giza
Registration date:	March, 2013
Awarding Date:	February, 25, 2020
Degree:	Master of science
Department:	System and biomedical engineering
Supervisors:	Prof. Dr. Ayman Mohmed El-Deib (Thesis Main Advisor) Associate Prof. Walid Ibrahim Al-Atabany (Advisor) (Systems and biomedical engineering department, Fcaulty of Engineering, Helwan University)
Examiners:	Prof. Dr. Ahmed Hisham Kandil (Internal examiner) Prof. Dr. Mohmed Tarek El-Wakkad (External examiner) (Systems and biomedical engineering department, Fcaulty of Engineering, Helwan University

Title of Thesis:
Decision support system for medical equipment failure analysis

Key Words:
Medical Equipment; Decision Support System; clinical engineering; Analytic Hierarchy Process.

Summary:
Medical equipment management raises a range of complex problems including those associated with maintenance process. In developing countries, hospitals rarely implement a coherent management plan in medical equipment management. One of the most significant challenges is to distinguish medical equipment that requires repair from those require replacement. A multi-criteria decision-making model, Analytic Hierarchy Process (AHP), is presented to select an optimum maintenance strategy. A set of criteria is employed to calculate a criticality score for each piece of equipment. Therefore, a list of equipment is ranked based on their scores and an optimum threshold is selected to differentiate between maintenance and replacement requirement. Fifty different types of medical equipment located in multiple public hospitals have been used in the validation of the proposed model. Results show that the proposed model can efficiently differentiate the equipment that requires repair and the others that needs to be scrapped.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Amira Mahmoud Mohmed Osman Date: / /2020

Signature:

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Nomenclature

AAMI	The Association for the Advancement of Medical Instrumentation
AHP	Analytical Hierarchy Process
ASHE	The American Society of Hospital Engineering
CEs	Clinical Engineers
CM	Corrective Maintenance
DSS	Decision Support System
ECRI	Emergency Care Research Institute
FTA	Fault Tree Analysis
HTM	Healthcare technology management
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
MCDM	Multi-Criteria Decision Making
MEM	Medical Equipment Management
PM	Preventive Maintenance
QFD	Quality Function Deployment
TJC	The Joint Commission
TSV	Transformed Score Value
WHO	World Health Organization

Abstract

Along life cycle of medical equipment, there are multiple troubles associated with maintenance procedures. In healthcare organizations especially in developing countries, implementation of a consistent management plan is rarely done with limited economic and competent human resources in medical equipment management. Almost decisions in hospitals related to medical equipment management is taken with less analytical, realistic and comprehensive assessment of medical equipment failures. Moreover, decisions are subjectively taken without considering a managerial strategy that depend on unified standards.

Recently, optimization models are developed and widely used to make optimum maintenance decisions. The major target is to categorize the failed medical equipment that needs repairing from those that need scrapping. This situation calls for the implementation of a scheme by which decision making are assigned to equipment based on selective criteria's.

The proposed study considered medical equipment failures as multi-criteria decision-making problem and use Analytic Hierarchy Process to solve it. A set of selective criteria is employed for getting score of criticality for each tested equipment, with reference to literature review and experts' opinions.

Therefore, based on the resulted scores, a list of equipment is classified and an optimal threshold is chosen for differentiation between maintenance and replacement requirement. This situation calls for a novel dynamic approach to the implementation of support system for medical equipment failure analysis in health care organizations. Different classes of medical equipment (50 equipment) placed in multiple public hospitals have been used in building up and assuring validation of the presented model.

The results of our observations reveal that the study can efficiently make reasonable differentiation of the equipment that requires repairing or scrapping. The equipment with criticality score above the selected threshold should be repaired, otherwise the scrapping decision should be taken.

CHAPTER ONE
INTRODUCTION

1.1. Chapter overview:

This chapter covers the health care technology management generally and medical equipment management (MEM) specifically. The chapter introduce the role of medical equipment as the main asset in the hospital. It's evident that there are some challenges of hospitals decisions related to different MEM stages especially in developing countries. The thesis focuses on these problems and their causes.

Therefore, our motivation and objectives are stated to give a supportive solution of medical equipment failures. This chapter also provides an overview of health care technology management, the medical technology support system and the biomedical equipment management. The final section shows the thesis organization. .

1.2 Background

According to the World Health Organization (WHO), the major challenge of biomedical maintenance service in any healthcare organization is to implement a maintenance strategy for the medical equipment. Nowadays, the priority for the managers in such critical areas is reducing the cost of maintenance requirements and the dependency on external parties. Also ensuring that the medical equipment is operating at accepted level of performance with accurate output for patient safety [1]. This will have good impact on healthcare delivery system in maximizing efficiency and availability of the equipment and make efficient controlling on equipment deterioration rate.

This is the first work, to our knowledge, that proposes a decision support procedure to choose the appropriate decision, to choose between repairing and scraping the failed medical equipment in the health care organizations.

General health care largely depends upon technology, especially medical technology. In the complex environment of modern hospital, clinical engineering is concerned primarily with medical equipment managements. There are four major forces that will make a going transition in health care delivery system: Budget, structure, technology, and social expectations. The impact of any one or combination of these forces may change from time to time and control these forces is the optimal management [2].

Over the last fifteen years, ranges from 25% to 50% of all medical equipment in hospitals of the developing countries are unusable, addressed by WHO [1]. Large hospitals in these countries may have roughly more than 2000 pieces of equipment. So the percentage of defected equipment have an effect on the healthcare quality in these countries [3].

1.3 Problem overview

The decision problems arise from many factors that contribute to occurrence. Mainly, there is no objective policies that can control the decision makers for assessment process of medical equipment.

Also the decision making process lacks the scientific and realistic criteria by which the decision makers could make decision successfully from being repaired or scrapped [2].

In addition, there is neither sufficient reliable information system nor appropriate analysis that could enhance the decision making. Inaccurate and inadequate information of inventory or documentation which considered as a criterion of medical equipment repairing or replacement such as all expensed costs, downtime, failure rate and expected life time, etc. This lack of accurate information leads to poor analysis and assessment.