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Computerized Maintenance Management System Design

تصميم نظام ادارة صيانة محوسب

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DEDICATION

This thesis is dedicated to:

The sake of Allah, my Creator and my Master,

My great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life,

My great parents, who never stop giving of themselves in countless ways,

My beloved brothers and sisters who stands by me when things look bleak,

To all my family, the symbol of love and giving,

My friends who encourage and support me,

All the people in my life who touch my heart,

I dedicate this research.

ACKNOWLEGMENT

In the Name of Allah, the Most Merciful, the Most Compassionate all praise be to Allah, the Lord of the worlds; and prayers and peace be upon Mohamed His servant and messenger.

First and foremost, I have to thank my parents for their love and support throughout my life. Thankyou both for giving me strength to reach for the stars and chase my dreams. My sisters and my brothers deserve my wholehearted thanks as well.

I would like to sincerely thank my supervisor Doc. Mohamed Yagoup for his guidance and support throughout this research, also I would like to thank my friend Eng. Ola Salahalden Alfahal in a special way, I express my heartfelt gratefulness for her guide and support that I believe I learned from the best.

To all my friends, thank you for your understanding and encouragement in my many, many moment of crices. Your friendship makes my life wonderfull experience.

Last but not least, deepest thanks go to all people who took part in making this thesis real.

ABSTRACT

The safety and reliability of medical equipment is mandatory. The effective maintenance management of medical technology influences the quality of care delivered and the profitability of healthcare facilities. Equipment may be used on the patients who are unconscious, other types of medical equipment function as life support and their failure may result in the patient's death when the machine is in use. Medical device maintenance in Sudan lacks an objective prioritization system; consequently, the system does not exist nor sensitive to the impact of devices down time on work flow in the healthcare facilities.

The CMMS system has been developed to enable the existing facility's maintenance engineers to improve their maintenance management of the medical equipment.The system would enable the hospitals achieve optimum utilization of hospital equipment and improve the management of medical equipment.

The designed system covers different aspects of equipment management such as maintenance, inventory and can provide reports based on device types or hospital units in the healthcare facilities.

The system evaluated by ten biomedical engineering departments and the result of evaluation proved the achivement of the project objectives. The proposed design simplicity, time efficancy ,reliablity and data safety over the current paper based system make it a helpful tool for the biomedical engineering departments considerd in the evaluation process.

المستخلص

سلامة وموثوقية المعدات الطبية إلزامي. إدارة الصيانة الفعالة للتكنولوجيا الطبية يؤثر على جودة الرعاية المقدمة وربحية مرافق الرعاية الصحية.الجهاز قد يستخدم علي مرضي فاقدين للوعي، وأنواع أخرى تعمل كاجهزة منقذة للحياة وفشلها قد يؤدي إلى وفاة المريض عندما يكون الجهاز قيد الاستخدام. صيانة الأجهزة الطبية في السودان ليس لديها نظام أولويات موضوعي. وبالتالي فإن النظام اما لا وجود له او غير حساس لتأثير فترات توقف الأجهزة عن العمل على سير العمل في مرافق الرعاية الصحية.

وقد تم تطوير نظام ادارة صيانة محوسب لتمكين مهندسي الصيانة في المنشآت الصحية من تحسين إدارتهم لصيانة الاجهزة الطبية. ان هذا النظام سيمكن المستشفيات تحقيق الاستغلال الأمثل لمعدات المستشفيات وتحسين إدارة المعدات الطبية. يغطي النظام المصمم مختلف جوانب إدارة المعدات مثل الصيانة والحصر ويمكن أن يوفرعدد من التقارير حسب أنواع الأجهزة أو وحدات المستشفى في مرافق الرعاية الصحية . تم تقييم النظام من قبل عشرة أقسام هندسة طبية في عشرة مستشفيات بولاية الخرطوم ونتيجة لتقييم اثبتت أن النظام المصمم حقق أهداف البحث. بساطة ,كفاءة ,موثوقية وسلامة البيانات في التصميم المقترح مقارنة بالنظام الورقي الحالي جعلت منه أداة مفيدة لإدارات اقسام الهندسة الطبية التي ساهمت في عملية التقييم.

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LIST OF ABBREVIATIONS

AEM- Alternative Equipment Maintenance

BMETs- Biomedical Equipment Technicians

CBM - Condition Based Maintenance

CM - Corrective Maintenance

CMMS - Computerised Maintenance Management System

D.Report- Device Report

HIS- Hospital Information System

HTM - Healthcare Technology Management

LANs- Local Area Networks

MPI - Maintenance Performance Indicator

Ms Access - Microsoft access

MTBF - Mean time before failure

PDM - Predictive Maintenance

PM - Preventive Maintenance

POs- Purchase Orders

WOs - Work Order

CHAPTER ONE

INTRODUCTION

1.1. General Overview

As health facilities expand and the number of medical devices they depend on to provide quality health care increases, a need to manage health-care technology more effectively and efficiently becomes evident. A computerized maintenance management system (CMMS) is a tool that can improve overall medical equipment management at the facility level. The information included in a CMMS varies depending on the individual situation but always includes the medical equipment inventory and typically includes information such as service history, preventive maintenance procedures, equipment and performance indicators, and costing information [1].

Technology plays a key role in the effective delivery of health care. The selection of appropriate medical technology and the organization of keeping that technology in good working order fall under the remit of health-care technology management (HTM) programs .HTM is often the responsibility of the clinical engineering (or medical equipment) department, which tests, repairs and maintains diagnostic and therapeutic clinical equipment to ensure that it can be used safely and effectively [1].
Computerized maintenance management systems (CMMS) have evolved to provide support to HTM managers to maintain medical equipment and monitor their associated costs automatically.
A CMMS is a software package that contains a computer database of information about an organization's maintenance operations.
In HTM, the CMMS is used to automate the documentation of all activities relating to medical devices, including equipment planning,

inventory management, corrective and preventive maintenance procedures, spare parts control, service contracts, and medical device recalls and alerts. The collected data can be analyzed and used for technology management, quality assurance, work order control and budgeting of medical devices [1].

1.1.1. CMMS Benefites

Keep an inventory of each device in the facility, including the ability to easily add or change the equipment information.

• Keep track of past service events (e.g. IPM, CM, recalls, software updates etc.) and retrieve or print them if needed.

• Store IPM procedures and related information.

• Schedule IPM procedures, change the schedule of IPM procedures and print a summary list of what has been scheduled.

• Print individual IPM forms with the appropriate procedure, the past few service events (for reference), and the expected IPM completion date/ time.

• Record and store the results of the IPM inspection procedures – including tasks that passed or failed, the measurements taken and the acceptable range of measured values.

• Record the CM activity including the problem with the device, time spent in the repair process, a description of the work done and the list of parts used.

• Produce summary reports

•List of parts used to repair equipment over a certain time period [2].

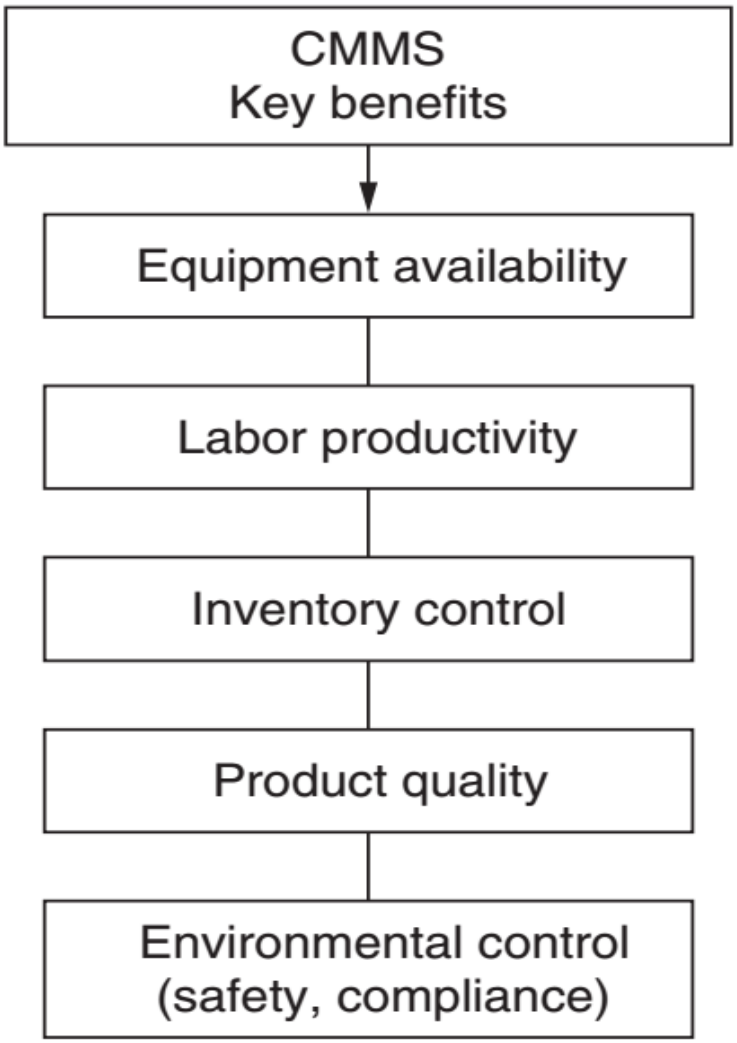

Figure 1.1: CMMS benefits (key elements).

1.1.2. Definitions

Maintenance is a combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function. With technological developments, the responsibility of the maintenance engineers has increased considerably due to over growing complexity and size of industrial organizations. The maintenance actions can be either preventive which are carried out at predetermined intervals or corrective which are carried out after a fault is recognized [4].

A computerized maintenance management system (CMMS) is a computer software program designed to assist in the planning, management, and administrative functions required for effective maintenance. These functions include the generating, planning, and reporting of work orders (WOs); the development of a traceable history; and the recording of parts transactions [3].

1.2 Statement of the Problem

Maintenance professionals are presented with more difficult challenges today than at any previous point. The biggest obstacle of all confronting maintenance professionals is being forced to do more with fewer resources. Maintenance departments must deliver superior service, comply with regulatory requirements and reports.

1.3 Proposed Solution

A computerized system built using microsoft access has been developed to replace a paper based maintenance management system commonly used in biomedical engineering departments.

1.4 Objectives

The primary objective is to design computerized system for managing the inventory and maintenance activities of the biomedical engineering departments in order to achieve this goals

1. A maintenance management system developed
2. A computerized maintenance management system is to be proposed
3. Practical implementation for the proposed design will be done.
4. Performance evaluation for the proposed design by 10 biomedical engineering departments will be done.

1.5 Methodology

In order to obtain the objectives, three phases of work must be fulfilled. The first phase is developing maintenance management system, the

second phase is designing a computerized system and the third phase is evaluation of the system.

1.5.1 Phase one

The common maintenance management formats used in biomedical department collected, analyzed and rearranged

1.5.2 Phase two

The software developed using Microsoft access

1.5.3 Phase three

The designed system has been used by 10 biomedical engineering departments in different hospital and their feedback had been collected in figure (4.12)

1.6 Thesis layout

The research will be reported the whole process and results obtained in four chapters.

Chapter One:

This chapter presents an introduction and general definitions , the problem and main objectives of the design.

Chapter Two:

This chapter presents the previous research background of the CMMS and its development chain through the last fifty years.

Chapter Three:

This chapter explains methods used in the research to obtain the design objectives

Chapter four :

This chapter explains the obtained results and provides a full discussion in order to clarify and express the obtained results.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Role of Clinical Engineering Within the Hospital

Over the years, management organization within hospitals has evolved into a diffuse authority structure that is commonly referred to as the "triad model." The three primary components are the governing board (trustees), hospital administration (CEO and administrative staff), and the medical staff organization [5].

2.2 Equipment Assets Management

An accountable, systemic approach will ensure that cost effective, efficacious ,safe, and appropriate equipment is available to meet the demands of quality patient care. Such an approach requires that existing medical equipment resources be managed and that the resulting management strategies have measurable outputs that are monitored and evaluated. Technology managers/clinical engineers are well positioned to organize and lead this function. It is assumed that cost accounting is managed and monitored by the health care organization's financial group [6].

2.3 Equipment Management Process

Through traditional assets management strategies,medical equipment can be comprehensively managed by clinical engineering personnel. First, the management should consider a full range of strategies for equipment technical support. Plans may include use of a combination of equipment service providers such as manufacturers, third-party service groups, shared services, and hospital-based (in-house) engineers and biomedical equipment technicians (BMETs). All these service providers should be under the general responsibility of the technology manager to ensure

optimal equipment performance through comprehensive and ongoing best-value equipment service. After obtaining a complete hospital medical equipment inventory (noting both original manufacturer and typical service provider),the management should conduct a thorough analysis of hospital accounts payable records for at least the past 2 years, compiling all service reports and preventative maintenance-related costs from all possible sources. The manager then should document in-house and external provider equipment service costs,extent of maintenance coverage for each inventory time, equipment-user operating schedule, quality of maintenance coverage for each item, appropriateness of the service provider, and reasonable maintenance costs. Next, he or she should establish an effective equipment technical support process. With an accurate inventory and best-value service providers identified, service agreements/contracts should be negotiated with external providers using prepared terms and conditions, including a log-in system. There should be an in-house clinical engineering staff ensuring ongoing external provider cost control utilizing several tools. By asking the right technical questions and establishing friendly relationships with staff, the manager will be able to handle service purchase orders (POs) by determining if equipment is worth repairing and obtaining exchange prices for parts. The staff should handle service reports to review them for accuracy and proper use of the log-in system. They also should match invoices with the service reports to verify opportunities and review service histories to look for symptoms such as need for user training, repeated problems, run-on calls billed months apart, or evidence of defective or worn-out equipment. The manager should take responsibility for emergency equipment rentals. Finally, the manager should develop, implement,and monitor all the service performance criteria. To optimize technology management

programs,clinical engineers should bewilling to assume responsibilities for technology planning and management in all related areas. They should develop policies and procedures for their hospital's management program.With life-cycle costs determined for key high-riskor high-costdevices,they should evaluate methods to provide additional cost saving sine quipment operation and maintenance. They should be involved with computer networking systems within the hospital. As computer technology applications increase,the requirements to review technology-related informationin a number of hospital locations will increase. They should determine what environmental conditions and

facility changes are required to accommodate new technologies or changes in standards and guidelines. Lastly,they should use documentation of equipment performance and maintenance costs along with their knowledge of current clinical practices to assist other hospital personnel in determining the best time and process for planning equipment replacement [6].

2.4 Technology Management Activities

A clinical engineering department, through outstanding performance in traditional equipment management, will win its hospital's support and will be asked to be involved in a full range of technology management activities. The department should start an equipment control program that encompasses routine performance testing, inspection, periodic and preventive maintenance, on-demand repair services, incidents investigation, and actions on recalls and hazards. The department should have multidisciplinary involvement in equipment acquisition and replacement decisions, development of new services, and planning of new construction and major renovations, including intensive participation by clinical engineering, materials management, and finance. The

department also should initiate programs for training all users of patient care equipment, quality improvement(QI), as it relates to technology use, and technology-related risk management [6].

2.5 Computer Support

The use of personal computers (PCs) has grown enormously in the past decade. PCs are now commonplace in every facet of hospital operations, including data analysis for research, use as a teaching tool, and many administrative tasks. PCs are also increasingly used as integral parts of local area networks (LANs) and hospital information systems. Because of their technical training and experience with computerized patient record systems and inventory and equipment management programs, many clinical engineers have extended their scope of activities to include personal computer support. In the process, the hospital has accrued several benefits from this involvement of clinical engineering in computer servicing. The first is time: Whenever computers are used in direct clinical applications or in administrative work, downtime is expensive. In-house servicing can provide faster and often more dependable repairs than an outside group can. Second, with in-house service, there is no need to send a computer out for service, thus reducing the possibility that computer equipment will be damaged or lost. Finally, in-house service reduces costs by permitting the hospital to avoid expensive service contracts for computers and peripheral equipment. With all of these benefits, it might seem that every clinical engineering department should carry out computer servicing. However, the picture is not so simple. At the most basic level, the clinical engineering program must be sure that it has the staff, money, and space to do the job well. To assist in making this determination, several questions should be asked: Will computer repair take too much time away from the department's

primary goal of patient care instrumentation? Is there enough money and space to stock needed parts, replacement boards, diagnostic software, and peripheral devices? For those hospitals that do commit the resources needed to support computer repair, clinical engineers have found that their departments can provide these services very efficiently, and they subsequently receive added recognition and visibility within the hospital [5].

2.6 CMMS development chain

It was stated that CMMS software was seen first around 1976. Today it is widely used in manufacturing plants all over the world [8].

A literature survey covering maintenance information technology was conducted in autumn 2003 / spring 2004. The databases used for the survey were Elsevier, Emerald, and IEEE. Following combinations of keywords were used; decision support system, expert system, computerised and information system combined with maintenance, asset management or maintenance management system. An additional search was made in a full text database search tool (ELIN) that integrates a vast number of databases, e.g. Elsevier , Emerald, IEEE, 97 Proquest and Springer, using the same keywords as above, i.e. decision support system, expert system, computerised and information system combined with maintenance, asset management or maintenance management system. A total of 97 articles within the relevant topic were found in this survey. All articles were published in the period 1988 to 2003. Additional reading was made in books about maintenance and computerised maintenance management systems, especially to capture the missing period 1960-1988. The number of articles per year is presented in Table 1. The historical description is divided into three periods, 1960-1992, 1993-1998 and 1999-2003. The amount of articles from each period is found in

Table 1. The periods are representing different stages of maintenance information technology maturity and are consistent with the three phases of corporate IT development; Introduction, Coordination and Integration [7].

Table 0-1: The CMMS development from 1988 to 2003

Year	Number of articles	Period	Number of articles
1988	2		
1989	5	1988-1992	21
1990	5		
1991	5		
1992	4		
1993	7		
1994	5	1993-1998	40
1995	7		
1996	9		
1997	6		
1998	6		
1999	5		
2000	6		
2001	9	1999-2003	36
2002	6		
2003	11		
Total	97		97

Bedewy et al [1989] developed an interactive computer program for maintenance system the purpose of their research was to report the work carried out to design a user friendly shell in order to help maintenance managers in small or medium plants analyze the performance and budget sensitivity to maintenance parameters using small microcomputers.

Various modules selected for the program were: Equipment installation module, Data input module, Data manager module, Data processor module, output information module etc.Wilder [1993] Explained the benefit of CMMS on traditional way of keeping the maintenance record had to be done via some manual method; either in files, chalkboards, desk drawers or wherever else one could write down information. In this age of automation an engineering department has more Sophisticated equipment to maintain and a lot more of it . A properly utilized CMMS can assure management of properly maintaining capital investments on costly plant equipment. Ashayeri [1996] Developed a mixed-integer linear programming model with help of computer to simultaneous plan, the Preventive Maintenance and production in process industry environment, where maintenance planning was extremely important. The model schedules production jobs and Preventive Maintenance jobs, while minimizing cost associated with production, backorders, Corrective Maintenance and Preventive Maintenance. The model takes into account the probability of a breakdown given the last maintenance period. The interactions of different Production and Preventive Maintenance decisions impact on the proper use of available capacity and company profits. Luxhoj et al [1997] Explained the combination of all technical and associated administrative actions intended to retain an item in, or restore it to a state in which it could perform its required function. The trends to „JIT" production and „Agile Manufacturing" maintenance management had become integrated with corporate strategy to ensure the equipment availability, quality products on-time deliveries and competitive pricing. Better linkage between maintenance and production department towards computer based maintenance activities and offered better training by using maintenance trends like Corrective Maintenance, Preventive Maintenance,

Predictive Maintenance and Intelligent Maintenance. Greenough[1999] revealed that despite success in certain areas, maintenance IT systems had weakness which restrict the role of diagnostic information support within a manufacturing environment and described the effectiveness of maintenance system to support activities during machine breakdowns. Tailly [2000] explained that the Computerized Maintenance Management System (CMMS) could be used to increase the efficiency, prevent system failures, minimize unplanned downtime and help to maintain the inventories.

Implementation of CMMS was not only the installation of software but would motivate a change of behavior patterns.

The motive was cost reduction and the objectives were to improve plant efficiency, avoid plant failures, accidental downtime and to meet safety regulations [9]. Sloane et al. [2003] discussed an ongoing medical informatics and business process reengineering research project. The Joint Medical Asset Repository (JMAR) was a relational database system created to integrate very diverse medical supply and medical maintenance management information from the US military services existing heterogeneous database systems. The emerging consensus seemed to be that the JMAR Meta database became an invaluable and efficient tool for managing the heterogeneous information systems and databases [4].

Huo [2003] dealt with Computerized Maintenance Management System and suggest a new way for companies to track equipment, inventory, and propose when and how work orders were to be performed in maintaining those equipment, along with costs for labor, materials and tools. An engineering department of power systems had more sophisticated equipment to maintain. A properly utilized CMMS could assure effective management of costly power plant equipment.

A good CMMS could lead to increased quality, better decision-making and increased efficiency. Donoghue [2004] analyzed the various maintenance management strategies used in International Manufacturing Organizations. Implementation of CMMS in operation provide reduced cost of spares, uptime improvements, increased equipment availability, reduced lead time and reduction in unscheduled maintenance, also it would reduce the wastage and machine would work more efficiently.

Gupta [2006] explained the characteristics of Computerized Maintenance Management System (CMMS) and highlight the need for CMMS in industry, and identify their current deficiencies. CMMS had been designed, developed and customized implemented for a Sugar Industry. CMMS software was worn to reduce total downtime of machines, overall annual maintenance schedule, predict maintenance budget and maintenance policy. The implemented CMMS software used as an effective tool that helps in achieving excellent maintenance. Kans [2007] Investigated the advancement of Maintenance Management System and compare the development of Maintenance Management System with other corporate system by means of literature study of 97 scientific papers and stated that management system had changed the aspects in four categories: (1) from technology to use, (2) from maintenance function to business integration, (3) from reactive to pro-active maintenance and (4) from operative to strategic maintenance considerations. Tumiran [2008] developed a power delivery system to make continuously available of sufficient voltage of satisfactory quality to meet the customer’s need. CMMS software was developed on basis of digitalizing distribution line networks, customer's connection, inventory of the assets and man power CMMS supported by „Geographic Information System“ in conjunction with the reduction of the time needed to restore the system during faults.

CMMS had capability to provide all information about particular equipment as a monitoring parameter and the possibility of altering the equipment's components and spare parts. Ronaldet al [2010] developed the maintenance schedule and Root Cause Analysis based on Computerized Maintenance Management System for a Process Industry. It consists of number of modules like detailed information of equipment, procedures of maintenance tasks, employees, work order and calendar facility etc. CMMS software had been developed in Microsoft Visual Studio .NET. The qualitative analysis using Root Cause Analysis (RCA) helped to create a knowledge base to deal with the problem related to product unreliability by listing out all possible failure causes. Kunduet al [2011] Designed a Computerized Maintenance Management System (CMMS) for a Thermal Power Plant. Researcher analyzed all causes for the failure of Thermal Power Plant Unit. They developed a computer software which had a number of modules like Equipment's detail, Preventive Maintenance (PM) tasks, PM Task Schedule, Employees, Overhaul Schedule, and Critical Issue etc. CMMS software had been developed in Java Server Page. That increased the plant effectiveness and reduced the down time in the plant. Thein et al [2011] explained the implementation of Computerized Maintenance Management System for the Maritime Industry.

CMMS software consists of 5 menus, the facilities management, product engineering management, job management, spare part management and reports. implementing a CMMS software would not only demand an investment in software and computer equipment but also a substantial investment in training, date registration of equipment and its relevant documentation. Fouad et al [2012] developed a Computerized Maintenance Management System for medical devices in Royal Medical

Services. Researchers had investigated the existing CMMS software in Royal Medical Services and then they made a list of their requirements such that a system was conceptually designed and finally an object-oriented model was built based on the conceptual design. The conceptual design was divided into a number of sections such as: System Access, Creating of a work order, Work orders in progress, Look-Ups, Scheduler and Reporting. Selvi [2013] designed a good maintenance system to turn operations into a paperless system and he found that CMMS helps in saving manpower costs, reduces bottlenecks and speed up the processes, all the while keeping operations in check through efficient and cost-effective means. Claverley [2014] Explained the verification of CMMS governed by specific standards and good practice associated with maintenance technique s. Implementation of CMMS correlates causes and effects for defects, planning and scheduling of various jobs. A proper utilized CMMS can assure effective management of costly Power Plant equipment, reduced cost of spares, reduced lead time and better decision making [9].

2.7 Computerized Maintenance Management System

The foundation of the successful clinical engineering program is the computerized maintenance and management system (CMMS). This database will house the information that the clinical engineering staff will use to make informed decisions and recommendations relating to equipment management. Careful selection of a computerized maintenance and management system will permit access to this information using a variety of queries and the ability to format the information in a useful manner. The CMMS also has evolved into an important process tool for organizing the work of the department. Although some clinical engineering systems develop their own CMMS, there is a variety of

products available on the market. Some of these products are designed specifically for clinical engineering and interface with common test equipment; others are more generic service-industry packages that can be adapted to suit the purposes of clinical engineering. At a minimum, the selected CMMS should permit keeping an equipment inventory with a variety of information including a unique numeric identifier, manufacturer, model number, and serial number, and it should have the capability to generate work orders on a scheduled basis and on demand. Other attractive features include the capability to track a parts inventory and parts utilization, financial tracking capability, and payroll functions. Often these various features are arranged in modules that interact with one another. A high degree of integration between modules is a desirable feature of a CMMS. For example, some systems contain a module for definition of device specific preventive maintenance procedures that can be married to specific devices in the inventory module. When a scheduled preventive maintenance work order for that specific device is generated, the appropriate preventive maintenance procedure appears in the work order module screen. Access to the CMMS by the clinical engineering staff is desirable wherever work with equipment is performed. Therefore, transportability of the CMMS into the clinical care environment is also a desirable feature. This can be accomplished through connection to the hospital's backbone—wireless communications—or through upload/download of the database (or some portion) onto portable devices[5].

CHAPTER THREE

METHODOLOGY

3.1 The design overview

The work methodologies include the process and procedures that control work performance and coordinate the flow of information throughout the maintenance department. The existing maintenance management practices (manual or computer-assisted) identified, analyzed, and re-organised to accommodate the capabilities of the maintenance management software. Work scheduling methods, job order dispatching practices, field data collection routines, and information processing routines all be analyzed, redefined and modified to gain Optimum operational efficiency.

The computerized Maintenance Management System (CMMS) Implementation Life Cycle is the related activities required to design, develop, install and improve a complete computerized maintenance system. The CMMS Implementation life cycle is organized into three sequential phases: Need Analysis, System Design, and System evaluation

3.1.1 Need analysis Phase

In this phase the common used paper based maintenance management systems collected, analyzed and reorganized in order to be suitable to be transformed into computerized form

3.1.2 Design construction phase

The program was designed through Microsoft access programming because it is efficient and user friendly tool.

3.1.2.1 Microsoft access

Microsoft Access is a database management system (DBMS) from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software-development tools. It is a member of the Microsoft Office suite of applications, included in the Professional and higher editions or sold separately [10].

3.1.2.2 Microsoft access data base

Database software, such as Access, is designed to be able to manage large lists with millions of entries. Lists are organized as tables of information. A database can consist of a single table, or many tables of information.

In addition to tables, an Access database file contains several different types of database objects like saved queries for organizing data, forms for interacting with the data on screen, reports for printing results and macros and Visual Basic programs for extending the functionality of database applications.

3.1.2.3 The proposed design

There are five forms in this program as in figure (3.1) the ***login*** form consist of three fields, the username and the password field to confirm the entrance authority of the user, and the user rights field to give the user different authorities of the program aspects,the adminstrator can control the authorities depending on the positions and the responsibilities of the users,concerning these differences ,authorizations ranges from having right to remove, modify, add, or open and may have full authorities.

The second form is the ***Main*** form from which the user can sign in and out of the program also from it, the user can backup all the data which is important for the data safety .

The third form is the ***Inventory*** form which is most importat form for the clinical engineer, the first thing the clinical engineer should do is making detailed inventory and that requires large amount of paper, and dificulities also comes with the updating needs. It consists of main and sub form, also it has other button for adding, saving and deleting record.

The inventory form is a main form for the table unit and sub form for the equipment data table and the two forms are connected through the unit field ,The sub form is a connected form.

In the inventory form the unit name enters in the main form and the equipment data of this unit enters in the sub form, so its easy to search any unit and the equipment data of this unit.

The fourth form is the ***Maintenance*** form. It's a main form, it takes the data from the device information table through the inventory form and continuous form. In this form, the maintenance data for specific device is entered and the device searches through unbound textbook

The Fifth form is the ***Notification*** form, This form notifies the engineer when approaching maintenance time depending on queury one.

3.1.2.4 The proposed design reports

The designed system has the capabilitiy of generating report. Reports provide a means of organizing and summarizing data. They are often used to present an overview highlighting main points and trends. A report can be a simple list, a status report or a monthly production report.

3.1.2.4.1 Maintenance report

In this report is all the inventory information, maintenance information and type of maintenance done on the specific device before, the responciple engineer for each maintenance, the date of starting the maintenance and the date of finishing maintenance, the sparepart used for maintenance and the notes wrote by responsible engineer listed.

3.1.2.4.2 Device type report

From this report the engineer will have a clear clue regarding a specific type of equipment, for example if the engineer interested is to know how many suction is in the hospital, where its located and all the inventory information, the D.report will provide it for him.

3.1.2.4.3 Main report

From this report the engineer will have all the inventory by one click,The database include the below modules.

1.Backup module: to backup the program

2.User module: user autherity responsiple

3.Hide module: to hide specific form and access front to protect the prgram

4.Queury module: to notify the engineer when approaching maintenance time

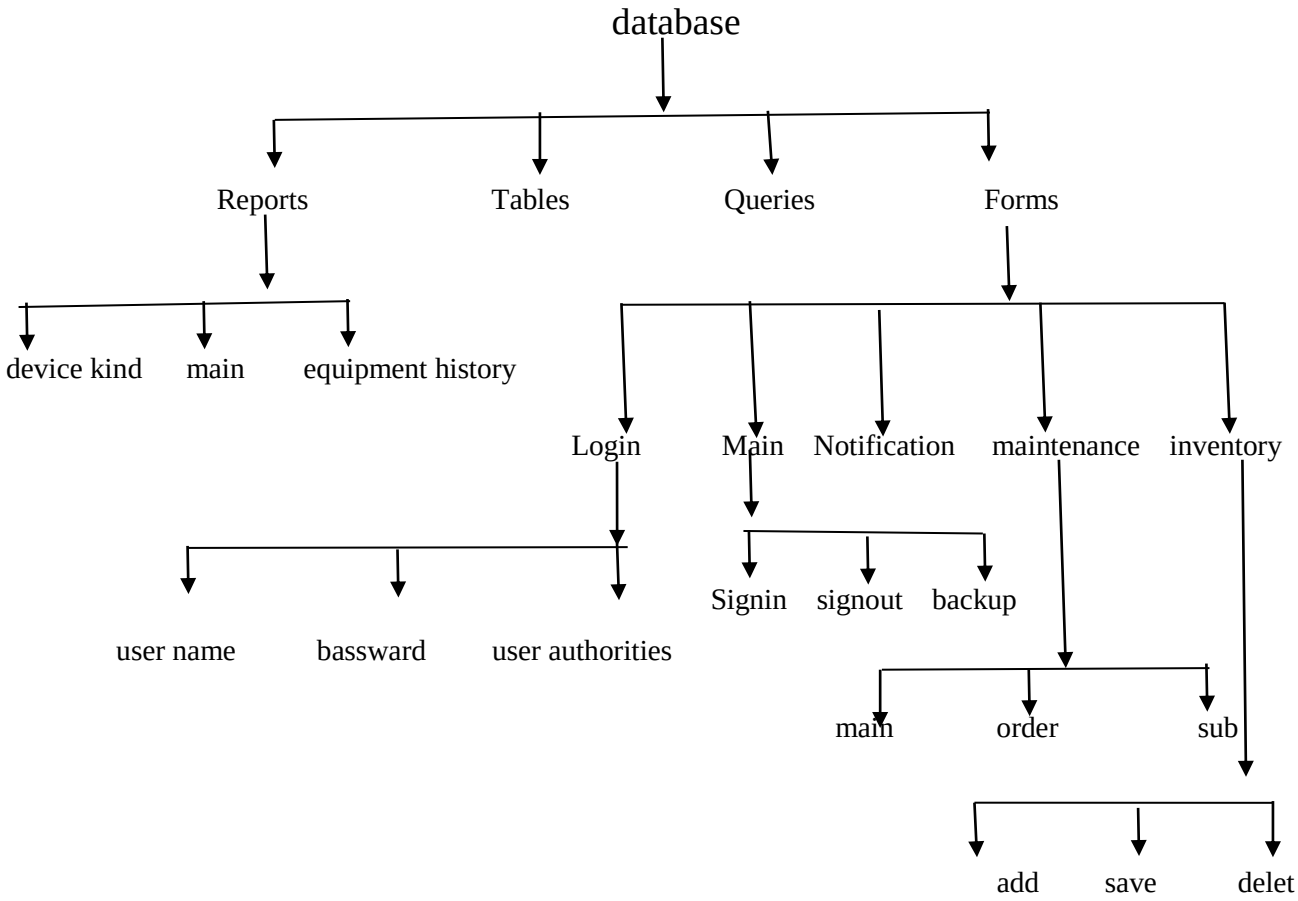

Figure 0.1: The design components

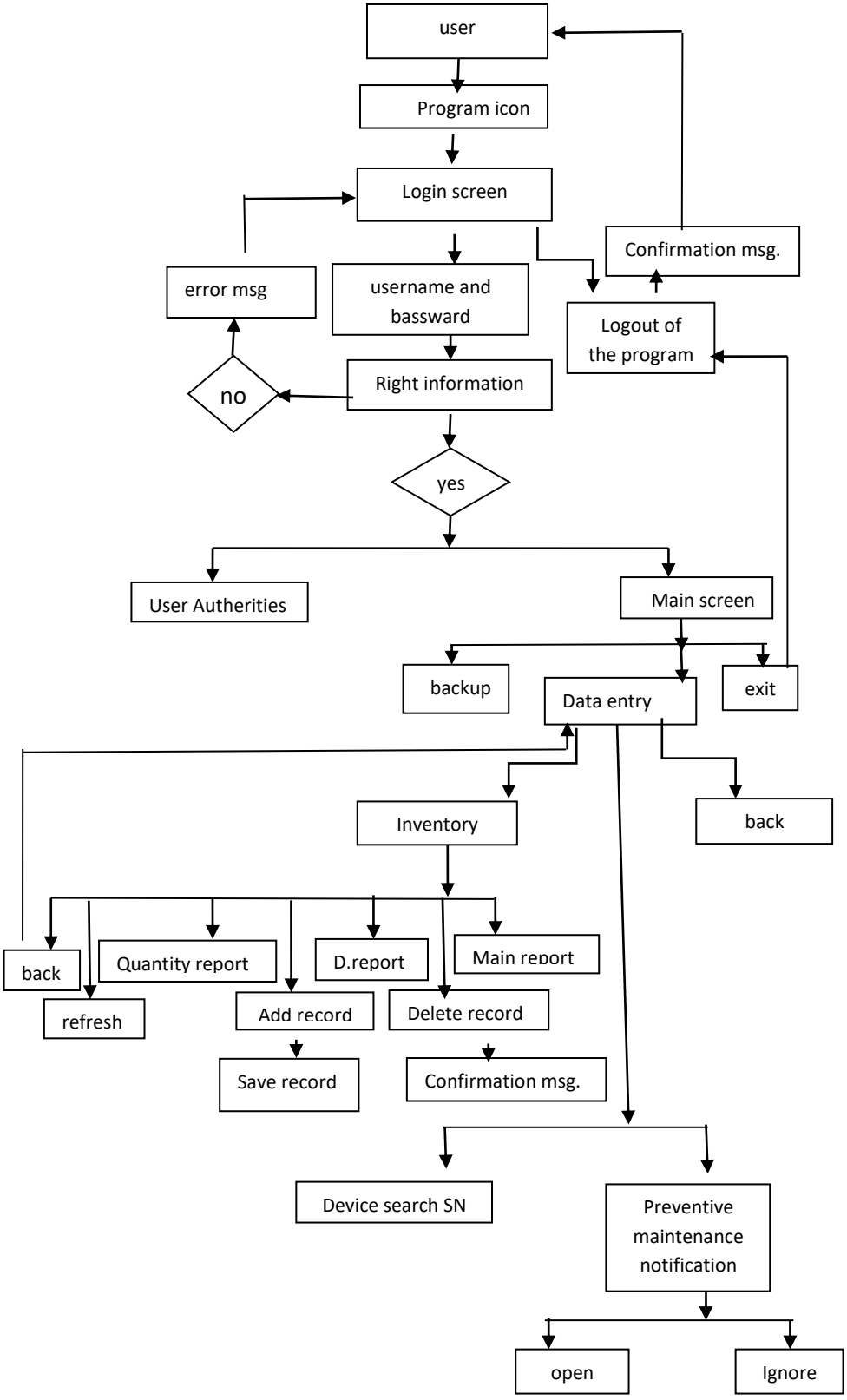

Figure 0.2: The design flowchart

3.1.3 Evaluation phase

In this phase the designed system has been deliverd tot the below ten public hospitals,within khartoum state:

1.khartoim Teaching Hospital

2.Alshaab Hospital

3.Soba Hospital

4.Saadaboleala Hospital

5.Shargalneel Hospital

6.Alamal Hospital

7.Aldayat Hospital

8.Gaafar Ebnof Hospital

9.Makka Hospital

10.Alia Hospital

for evaluation by biomedical engineering departments , and the engineers were asked to fill a survey with their feedback , as in Appendix A. All 10 hospitals had computer devices in the biomedical department, have an inventory system and a paper-base maintenance management system.

The survey covered the advantages of the CMMS over the traditional paper based system such as:

1. The easiness of use
2. The easiness of accessing information

3. The classification of maintenance types and procedures
4. The availability of maintenance history, spare parts replacements and common device malfunctions
5. The decrease of paper and time consumption
6. The continous updates of inventory reports throughout the year instead of the annual reports
7. The decrease of information loss and misplacing
8. The clarity of responsibilities and authorities

Chapter 4

Result and discussion

The development of the computerized maintenance management system for the Sudan hospitals considering the evaluation process was successful. The program was designed through Microsoft access programming because it is user friendly. A considerable number of facility maintenance managers working in the Sudan hospitals have a basic computer skills. It is easier for them to use the in-house, user friendly, simple, does not need special training computerized maintenance management system. The use of complicated computerized system will prove a great challenge on the implementation of the maintenance system to the hospitals.

The process helps to improve the inventory system and also reduce the paper work and loss of data in the maintenance management.

The designed system has been built depending on the real need of the clinical engineers and it pass through evaluation process, the following is gained results and its discussion.

4.1 Login screen

this screen appear when the program icon clicked , it gives the user different choices , the user can return back and close the program or can inter his user name and his password to enter the main screen or the user authorities screen.

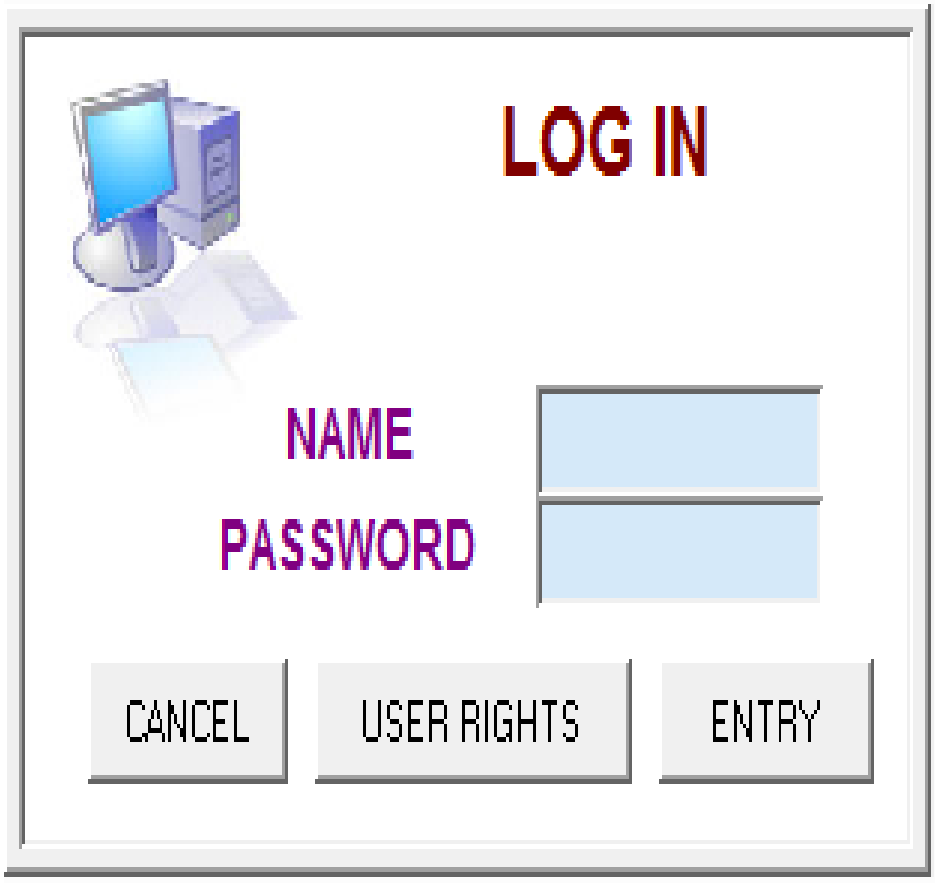

Figure 0.1: The login screen

4.2 User authorities screens

This screen appear when the user rights bottom on the login screen clicked as in figure(3.2), from this screen the adminstrator or the head of biomedical engineering department can control the authorities of the user in the degree of using this program also can proceed to the main screen only if the correct user name and password has been entered.

Figure 0.2: User authorities screen

Figure 0.3: Controlling authorities screen

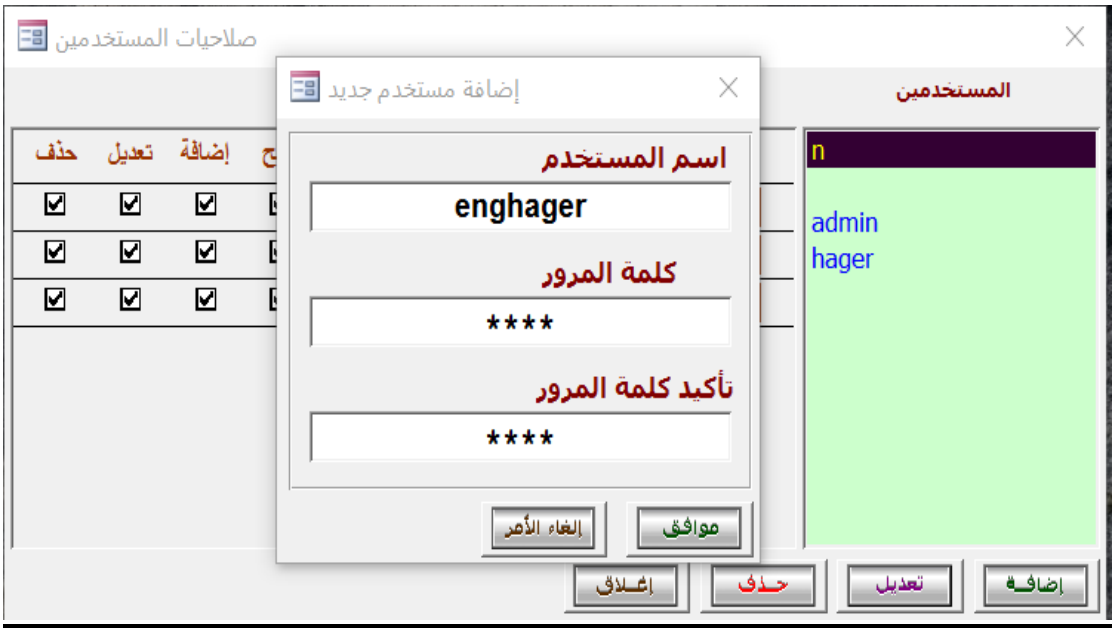

Figure 0.4: Adding new user screen

Figure 0.5: Removing user screen

4.3 Main screen

the main screen appear when the user click the entry button on the login screen , in this screen the hospital name can be identified and also the user can proceed to the data entry screen or backup the system, also can exit from the program by clicking exit button

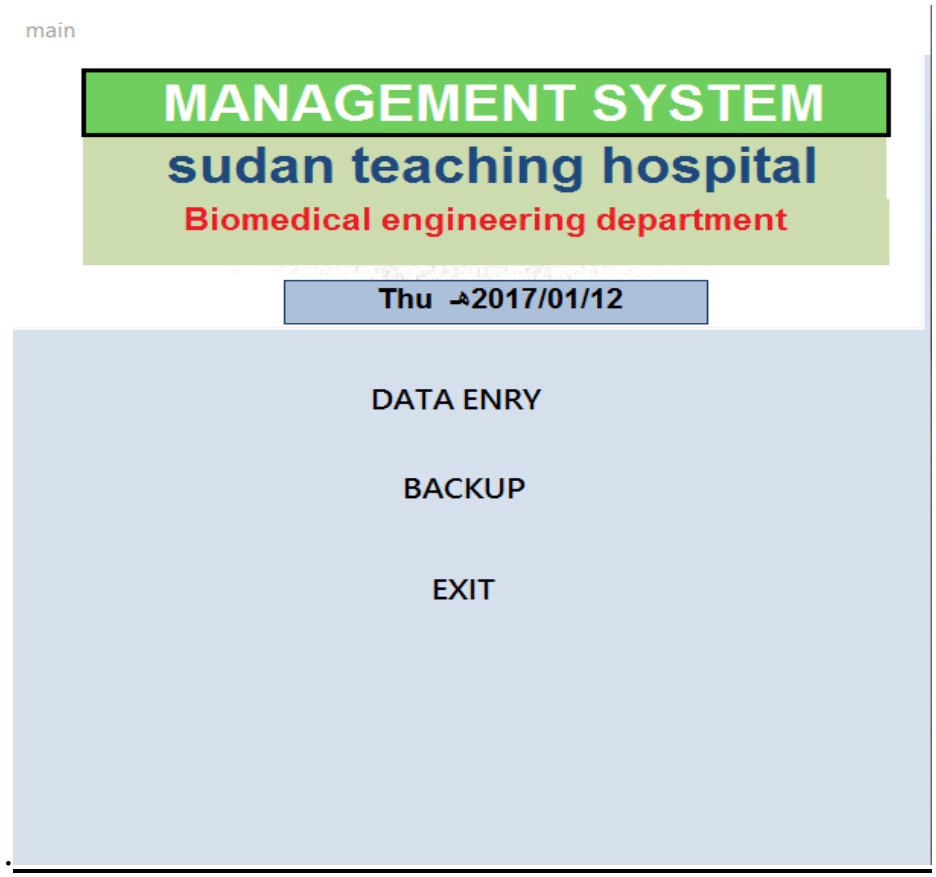

Figure 0.6: Main screen

Figure 0.7: Exit confirmation msg on the main screen

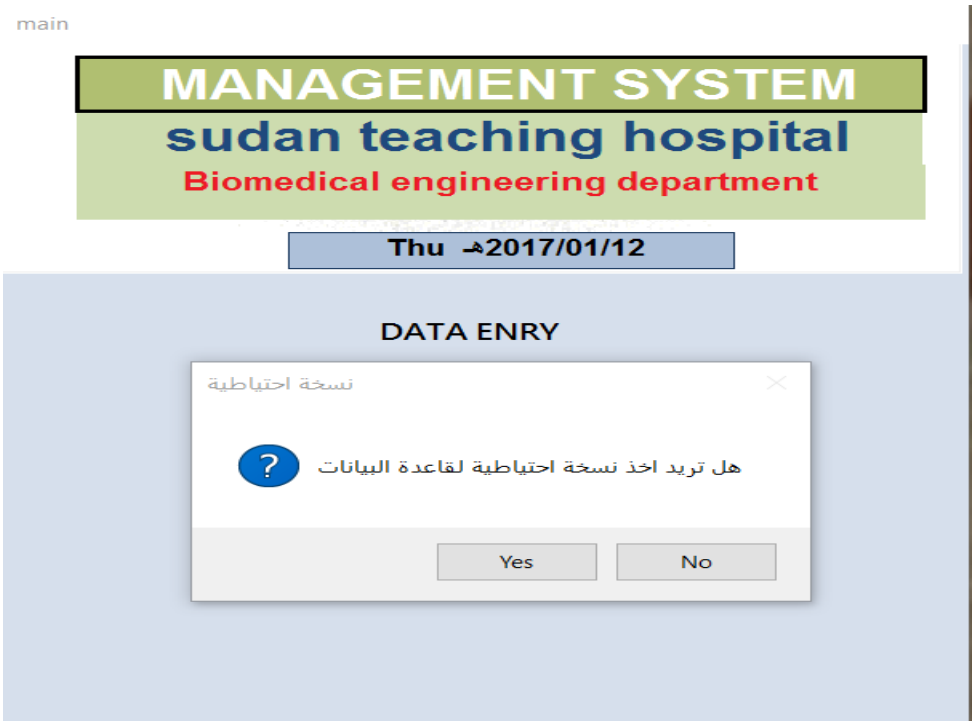

Figure 0.8: backup the system confirmation msg. on the main screen

4.4 Data entry screen

This screen can be considered as maintenance management screen, the device history can be listed by enter the serial number of the specific device in the search field and by clicking the report icon the maintenance history report of this device will be generated, in this screen the current maintenance can be documented, and to reduce the entry time the screen for storing all the data needed frequently has been added to the data entry screen, so for example instead of writing the device name each time the user can simply click the side arrow and the list he made first will appear then can scroll and choose from it, also from the data entry screen the user can proceed to inventory screen

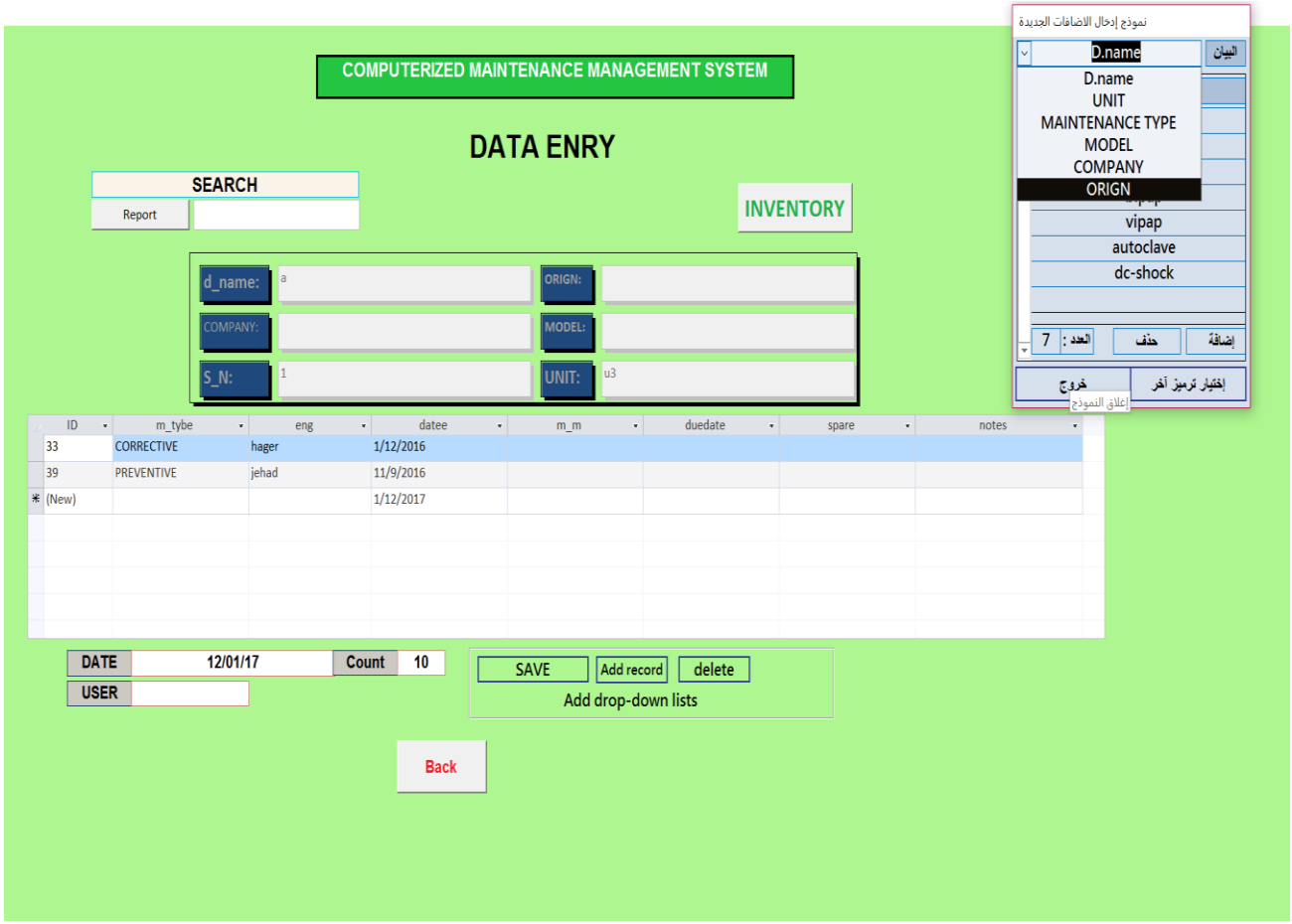

Figure 0.9: Data entry screen

4.5 Inventory screen

A first step in designing an effective equipment management program is initiate inventory records to document all the equipment within the healthcare facilities. Each healthcare organization should:

1. Maintain an inventory of all medical equipment, whether it is leased or owned and whether it is maintained according to manufacturer recommendations or an alternative equipment maintenance (AEM) .

2. Include as part of the inventory a record of maintenance activities.

Using this form the engineer can make detailed inventory, also can generate an envintory report(main report) and device report.

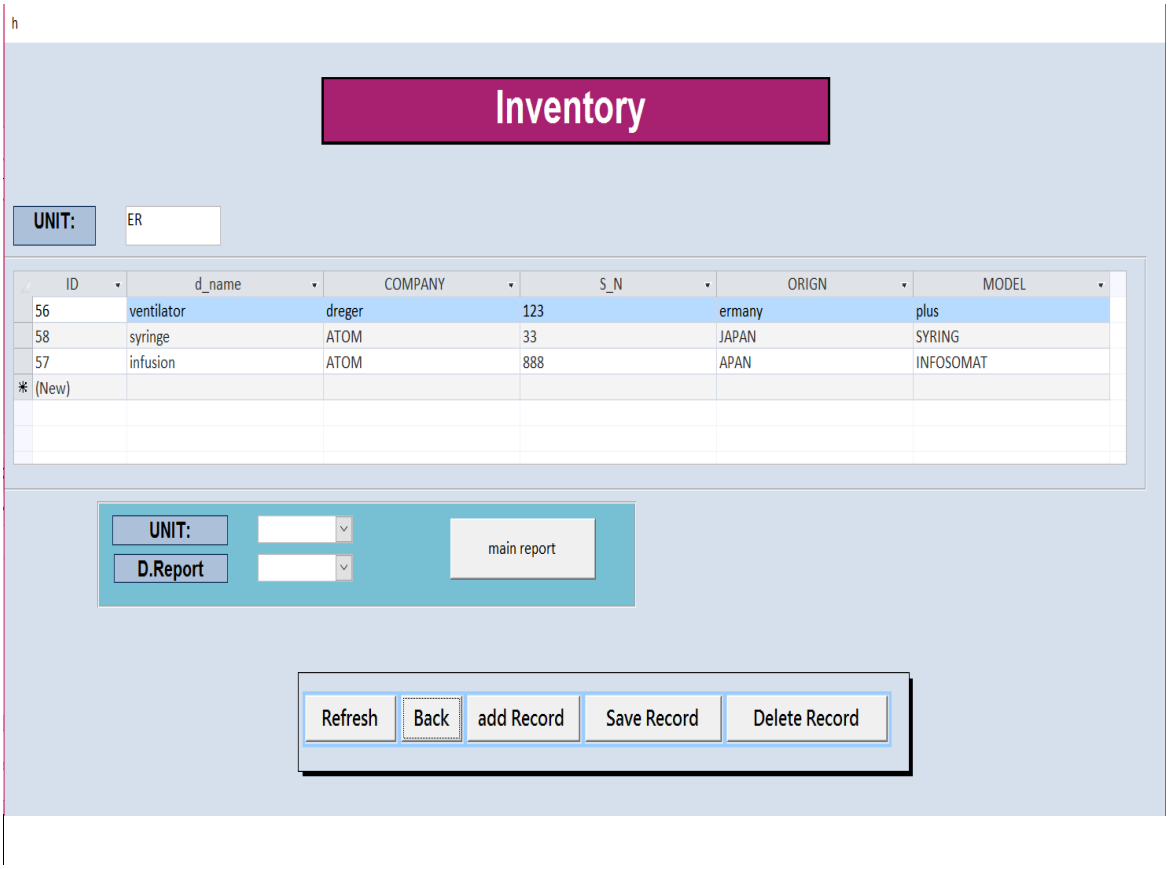

Figure 0.10: Inventory screen

4.6 Maintenance report

High quality service documentation is central to the role of biomedical engineering departments—without good documentation, effective equipment maintenance and repair becomes difficult, or even impossible. All types of medical equipment documentation are important as these are considered an essential part of the equipment [11].

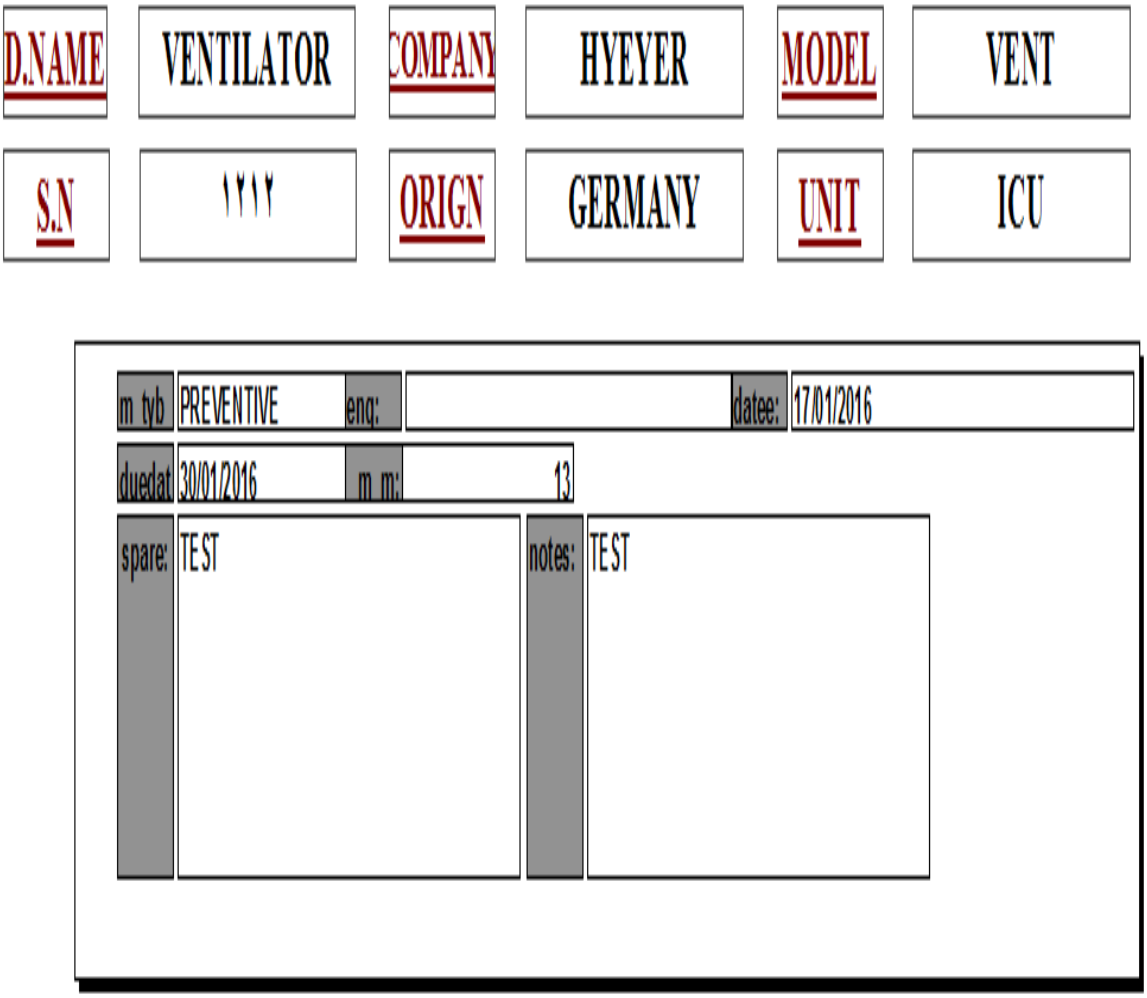

Figure 0.11: Maintenance history report

4.7 Device report

If the engineer interested about specific device for example if the engineer need to know howmany suction avaliable in the hospital and their destribution amonge different departments then all this data is avillable in the device report on the inventory screen

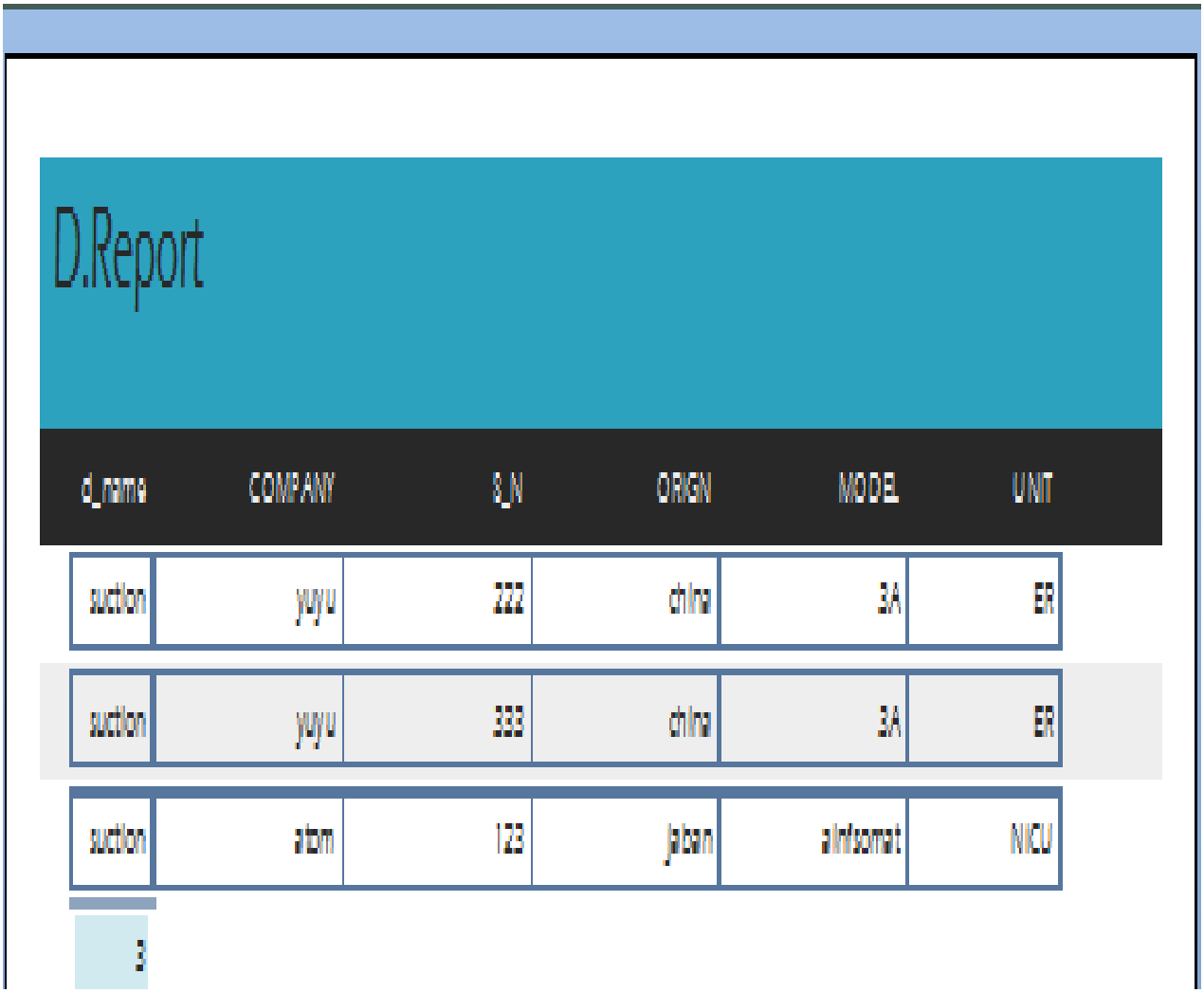

Figure 0.12: Device report

4.8 Main report

Good record keeping is essential for the safe management of medical devices.The records should be maintained within one system wherever possible [12].

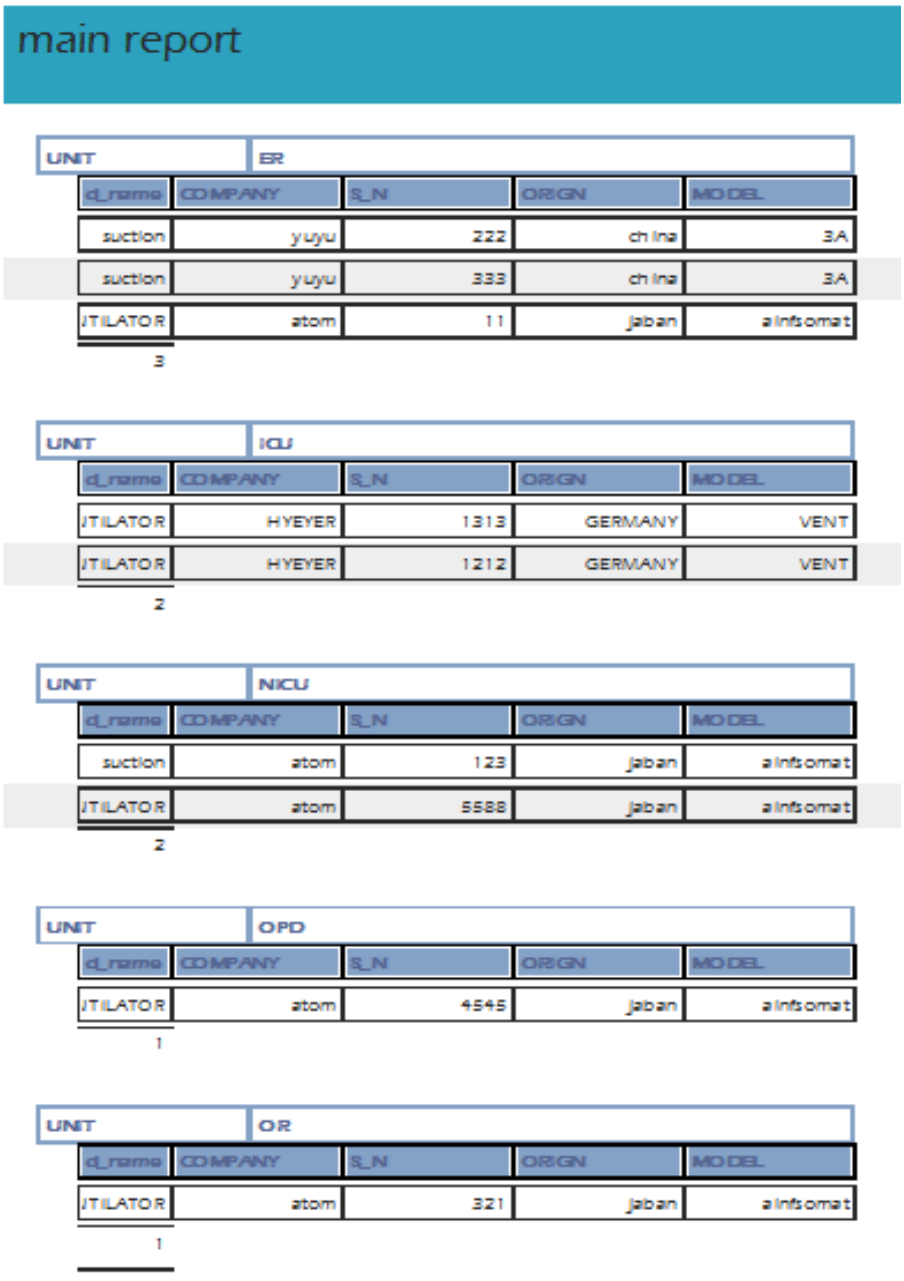

Figure 0.13: Inventory report

4.9 Proposed system evaluation

Bellow is the result of the proposed design evaluation done by 10 biomedical engineering departments

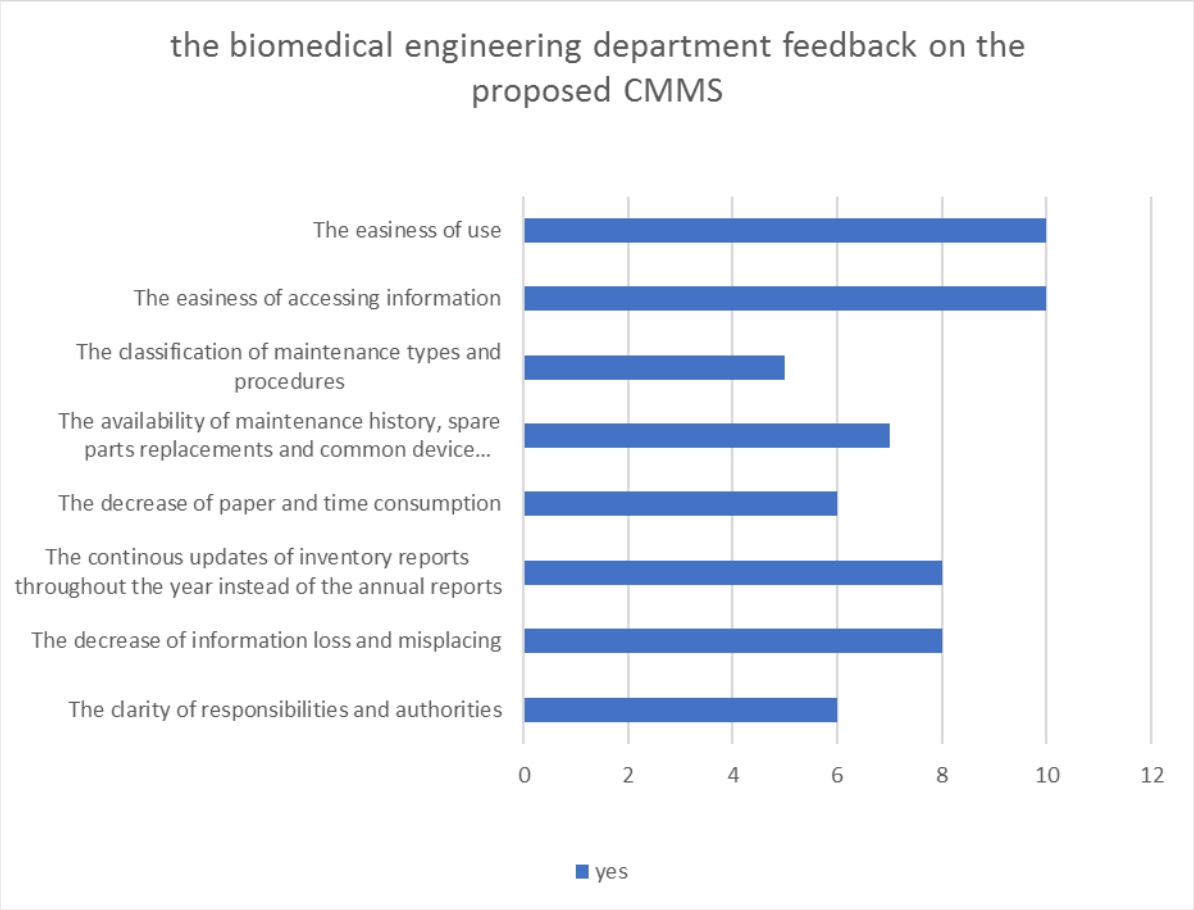

Figure 0.14: Proposed system evaluation

CHAPTER FIFE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The hospitals in Sudan have no quality control system for the repair and preventive maintenance. Technical manuals are not fully utilized when maintaining medical equipment and maintenance not done on the stipulated time frame. Most of the hospitals have computers in the biomedical engineering departments. The implementation of the computer program improves the maintenance practices by increasing the availability of information that lead to solve the faults properly in the shortest duration.

5.2 Recommendations

1. The development of the software program to include a link between the device serial number and all the documents related to it (operation manual, service manual, procurement document...etc.) to facilitate access and save time.
2. Develop CMMS as mobile application that can be installed in the clinical engineer smart phones
3. Developing a CMMS with vendors and manufacturers technical support department link to easiate communication
4. Develop a CMMS with a link to the HIS

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APPENDIX

The conducted servay

The proposed CMMS has which advantages over your current system

1. The easiness of use ☐
2. The easiness of accessing information ☐
3. The classification of maintenance types and procedures ☐
4. The availability of maintenance history, spare parts replacements and common device malfunctions. ☐
5. The decrease of paper and time consumption ☐
6. The continous updates of inventory reports throughout the year instead of the annual reports ☐
7. The decrease of information loss and misplacing ☐
8. The clarity of responsibilities and authorities ☐