



**ST. MARY'S UNIVERSITY COLLEGE
SCHOOL OF GRADUATE STUDIES**

**THE STUDY OF PROCUREMENT, UTILIZATION AND
DISPOSAL OF MEDICAL EQUIPMENT IN THE PUBLIC
HOSPITALS OF ADDIS ABABA, ETHIOPIA**

BY

TESFAYE SEIFU SAHLEDINGEL

FEBRUARY 2013

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**A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY COLLEGE,
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SCHOOL OF GRADUATE STUDIES
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DECLARATION

I, Tesfaye Seifu Sahledingel, hereby submit my MBA Thesis for oral defense, entitled **The Study of Procurement, Utilization and Disposal of Medical Equipment in the Public Hospitals of Addis Ababa, Ethiopia** and truthfully declare that the above thesis is a product of my original research investigation. I further confirm that it has not been submitted either in part or in full for any Degree.

Signed on this day of _____

Tesfaye Seifu

ENDORSEMENT

This thesis has been submitted to St. Mary's University College, School of Graduate Studies for examination with my approval as a university advisor.

Advisor

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ABSTRACT

There are evidences and claims that the management of medical equipment in the public hospitals of Addis Ababa is suffering from a lot of problems related to procurement, utilization and disposal of medical equipment. Some of these problems are procurement of poor quality medical equipment, absence of inventory control system for medical equipment, low performance of medical equipment, absence of disposal practice for unusable medical equipment and low attention given to medical equipment management.

This study has been conducted in order to investigate the policies, practices and status of procurement, utilization, and disposal of medical equipment in the public hospitals of Addis Ababa. A structured questionnaire, interview of key informants and medical equipment inventory were used to collect data from the hospitals. From the collected data combined percentage rating of different functions of medical equipment management and operational performance of medical equipment were calculated. The study indicates combined percentage mean rating of 52%, 36%, 33%, and 12 % for the management of procurement, donation, maintenance and disposal respectively. The operational performance of medical equipment was 66%. The study also indicated non-existence of medical equipment management policies and procedures for selection, procurement, donation, utilization, maintenance, disposal and replacement of medical equipment, in most of the hospitals.

The study concludes that there is very poor management of medical equipment disposal and poor management of maintenance and donation. The management of the procurement is fair but it has significant problems. The performance of medical equipment doesn't have linear relationship with the complexity and standardization of medical equipment.

Hence, all stakeholders of the medical equipment management of the hospital have to pave the way for the better management of the medical equipment through creating favorable environment including laws, policies and procedures and ensuring the implementation of the Ethiopian Hospital Reform Implementation Guideline.

LIST OF ACRONYMS

EHRIG - Ethiopian Hospital Reform Implementation Guideline

FMHACA – Food, Medicine, Health Administration Control Authority

FMOH – Federal Ministry of Health

GTP – Growth and Transformation Plan

PFSA – Pharmaceuticals Fund and Supply Agency

UNOPS - United Nations Office for Project Services

WHO – World Health Organization

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CHAPTER ONE

INTRODUCTION

1.1. Background

Healthcare technology plays an extremely important role in everyday clinical and public health work. If it is properly used, it can contribute to increased life expectancy, enable greater precision for diagnosis, and reduce the time needed for investigations, treatment, and rehabilitation. For these reasons, it is important to take great care when planning and acquiring new medical equipment. Any new equipment which is acquired must be suitable for their purposes and improve access to quality healthcare. It is also important to ensure that the health facilities have the ability and capacity to absorb, support, and use any technologies procured (Temple-Bird, Lenel, Kawohl, & Kaur, 2005b).

The chronic lack of functioning medical equipment is generally regarded as an important contributor to the poor quality of health care delivery in those countries. A number of previous studies, conducted in low- and medium-income economies, indicate that as much as half of the equipment in urban and rural medical institutions is inoperable and not in use. As a result, the efforts of medical and paramedical personnel are seriously impaired (Rommelzwaal, 1997a).

The current health system of Ethiopia follows a three-tier health care delivery system which is characterized by a first level of a district health system comprising a primary hospital (with population coverage of 60,000-100,000 people), health centers (1/15,000-25,000 population) and their satellite health posts (1/3,000-5,000 population) that are connected to each other by a referral system. The second level in the tier is a general hospital with population coverage of 1-1.5 million people; and the third a specialized hospital that covers population of 3.5-5 million (FMOH, 2010a).

Although the core of the Ethiopian health care system is the prevention of diseases, the government has also given due attention to expand hospitals to strengthen the curative health

services. Accordingly, government of Ethiopia planned to increase number of hospitals from 111 to 896 during the Growth and Transformation Plan period (2010/11 – 2014/15) (FMOH, 2010a). As the healthcare delivery continues to expand and improve in Ethiopia, an increase in the number of sophisticated medical equipment is introduced and a system capable of supporting and managing the medical technology must be in place. Hence, management of medical equipment has paramount importance for efficient use of resources in the health sector.

Among others, procurement of medical equipment for the hospitals is one of the major costs for the expansion of the hospitals. Hence, in order to ensure proper provision of health care and to ensure better return on investment; proper acquisition, utilization and disposal of medical equipment are crucial.

Medical equipment management ensures that equipment used in the patients' care is operational, safe, properly configured to meet the mission of the medical treatment facility and continues to function effectively in a good working condition. For example, proper maintenance can extend the life of equipment. This is essential to provide good health services and saving the scarce resources. However, in addition to maintenance, medical equipment management involves other essential activities which ensure that equipment is effectively planned, procured, and operated etc. (Rommelzwaal, 1997a).

Medical equipment is one of the major assets managed by hospitals. The use of medical equipment can influence the quality of care and can also create risks for patients and for staff (Ogembo-Kachieng'a & Ogara, 2004). Poor medical equipment handling and utilization, frequent power surges, the ages of the equipment, lack of operator training, lack of preventive maintenance, lack of spare parts, lack of maintenance capacity, and minimal knowledge regarding sophisticated equipment are factors that contribute to equipment breakdowns (FMOH, 2010b).

Medical equipment management takes place within a context of human, material, structural, organizational and financial resources. Elements of this supporting context are frequently referred to as the health care technical services (Temple-Bird et al., 2005b).

By improving one or more of the managerial activities, or by establishing improved interdependency between those aspects, much can be done to gradually improve the output of the managerial process, which is equipment performance. Hence, this study was conducted in the public hospitals of Addis Ababa to assess the current medical equipment management situation and forward recommendations for the improvement of procurement, utilization and disposal of medical equipment in the hospitals.

1.2. Statements of the Problem

The management of medical equipment in the public hospitals is one of the major areas that are challenging the health care delivery of Ethiopia. The country has guidelines and procedures for the procurement of medical equipment, however, it lacks list of approved medical equipment to guide the procurement. Professionals appeal that the absence of the list of medical equipment and lack of well-established specifications for medical equipment is causing acquisition of medical equipment which is not appropriate for the services of most of the public hospitals found in Addis Ababa. Also, it is claimed that hospitals obtain different models of the same equipment, which may cause difficulty of managing the equipment and increase in cost for spare parts and maintenance.

In Ethiopia the lack of proper management of medical equipment has limited the capacity of health institutions to deliver adequate health care. It is estimated that only 61% of medical equipment found in Ethiopian public hospitals and other facilities is functional at any one time (FMOH, 2010b). Health professionals working in the hospitals claim that significant amount of medical equipment of the hospitals are not operational. Although huge amount of money is spent on the medical equipment, they are not providing the service due to lack of proper maintenance service in the hospitals.

The health sector development program of the country indicates that there is lack of health infrastructure maintenance capacity (FMOH, 2010a). The problem may be the same in all level of the healthcare tier including public hospitals found in Addis Ababa. Since the downtime of medical equipment increases in hospitals where there is lack of maintenance capacity, the interruption of health services also increases.

It is not unusual to hear that public hospitals are not aware of the available medical equipment in their premises. The hospitals lack documentation and proper inventory management system of medical equipment. A study conducted in 170 health facilities of Ethiopia indicated that using logbooks to record history of medical equipment was not widely practiced and the problem was worse in referral hospitals (Engidawork, Gebremariam, & Asres, 2010).

Every equipment has its own life of service. After its life period, medical equipment gets outdated to serve its purpose. Hence, these medical equipment need to be disposed as per the fixed assets disposal guideline of the country. However, there are claims that unusable medical equipment are kept within hospitals without any services. Even though these aged and obsolete medical equipment are maintained, it may be hazardous for the health of patients. Also, keeping outdated and old medical equipment increase storage cost of the hospitals.

In addition to the major functions of medical equipment management, support functions need attention for the success of the management. Among others the availability of qualified professionals for medical equipment management is vital (Ogembo-Kachieng'a, 1999a). The 2010/11 annual report of the health sector development program IV identified lack of trained biomedical engineers in most of the hospitals as one of the challenges in human resources for health (FMOH, 2011). There is a high probability that there is also the same problem is also manifested in Addis Ababa public hospitals.

1.3. Objectives of the Study

1.3.1. General Objective

- To investigate the policies, practices and status of procurement, utilization and disposal management of medical equipment in the public hospitals of Addis Ababa

1.3.2. Specific Objectives

- To identify the policies of acquisition, utilization and disposal of medical equipment in public hospitals
- To analyze the practices of medical equipment acquisition in the hospitals

- To assess the medical equipment inventory management of the hospitals
- To analyze the medical equipment disposal management system of the hospitals
- To assess the human resource, financial resource and logistics support for medical equipment management in the hospitals
- To determine the present operational performance status of medical equipment in the hospitals
- To identify factors contributing to performance of medical equipment in the hospitals

1.4. Research Questions

- What are the policies of the hospitals in the acquisition, utilization and disposal of medical equipment?
- What are the practices of medical equipment procurement in the hospitals?
- What are the practices of medical equipment disposal in the hospitals?
- How does the inventory management of medical equipment of the hospitals function?
- How does the hospital facilitate the management of medical equipment in human, financial and logistics support?
- What is the level of performance of the medical equipment in the hospitals?
- What are the factors contributing to performance of medical equipment in the hospitals?

1.5. Hypotheses

Based on literatures and the statement of the problems, the following hypotheses are made

- Complexity of medical equipment has negative relationship with performance of medical equipment,
- Degree of standardization has positive relationship with performance of medical equipment

1.6. Significance of the Study

The result of the study has the following practical significances for the Federal Ministry of Health, the Pharmaceuticals Fund and Supply Agency; the Food, Medicines, Health

Administration Control Authority (FMHACA), Addis Ababa City Administration Health Bureau and hospitals included in the study, health sector partners and professionals working in the hospitals.

- The FMHACA get acquainted with gaps in the policies and procedures related to regulatory aspect of medical equipment management.
- The PFSA, a major procurement agent for the public sector, be able to get feedback on the medical equipment procurement practices of the agency.
- The Federal Ministry of Health of Ethiopia and Addis Ababa City Administration Health Bureau can use the result of the study for their guidance of medical equipment management in the public hospitals.
- Hospitals' management will have clear picture of the procurement, utilization and disposal management of medical equipment and the recommendation of the study helps them to leverage the implementation of the Ethiopian health reform implementation guideline (EHRIG) on medical equipment management.
- Health sector partners supporting in the provision of medical equipment to the hospitals will have better understanding of the current status of the hospitals to determine on the medical equipment

1.7. Scope of the Study

The study is limited to procurement, utilization and disposal of medical equipment in the public hospitals found in Addis Ababa. The study doesn't include military, police and private hospitals found in Addis Ababa and the newly established Tirunesh Beijing Hospital. The study on the performance of medical equipment focuses on the management of high value and clinically important medical equipment managed by the hospitals.

1.8. Operational Definitions

Recognizing that there are multiple interpretations for the terms listed below, they are defined as follows for the purposes of this thesis.

Standardization of medical equipment: reducing the range of makes and models of equipment available in stock, by purchasing particular or named makes and models.

Complexity of medical equipment: technological sophistication of equipment measured by combination of certain characteristics of equipment grouped in four categories, namely incorporated components, required maintenance and calibration, operator complexity, and auxiliary supplies and connections

Performance of medical equipment: the percentage of a set of equipment in good working order, at the time of survey.

1.9. Limitation of the Study

Medical equipment inventory was not conducted in one of the hospitals, due to absence of compiled data and difficulty of conducting physical inventory in the hospital's setting. As a result, performance of medical equipment was not done for the hospital. Also, models and manufacturers of the medical equipment were not collected from one of the hospitals. Consequently, the degree of standardization of medical equipment was not calculated for the two hospitals. Hence, the relationship between performance and degree of standardization was done only with the eight hospitals data.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Medical equipment forms the core of the any health care institution for the diagnosis, therapy and surgery. Therefore, it is crucial that medical equipment provide accurate information and operate to the optimum limit in order to allow proper diagnosis and ensure patient's safety during therapeutic and surgical interventions. On the other hand, in any health care institution medical equipment consume greatest capital investment. So, it goes without saying that health service provider ought to make the most out of these investments. This can be achieved only when these assets are used efficiently and effectively. Medical equipment management, in broader sense, is the right way to ensure patient's safety and obtain the maximum benefit out of these physical assets of a hospital.

A professional estimate on waste of resources in relation to poor management of medical equipment indicates that purchase of technologically sophisticated equipment for countries which is not used due to lack of skills of operating accounts for 20-40% of the equipment cost. Short life of equipment due to maltreatment by operating and maintenance staff costs 30-80% of life time of the equipment, lack of standardization result in 30-50% extra spare parts cost and down time due to inability to use or repair costs 25-35% cost of the equipment (Malluoppas, 1986).

Medical equipment management defines the organization and coordination of activities that ensure the successful management of equipment related to patient care in the health care facilities. The medical equipment management cycle includes planning and assessment of needs, procurement, training, operation, maintenance, decommissioning and disposal of the equipment (Temple-Bird, Lenel, Kawohl, & Kaur, 2005a)

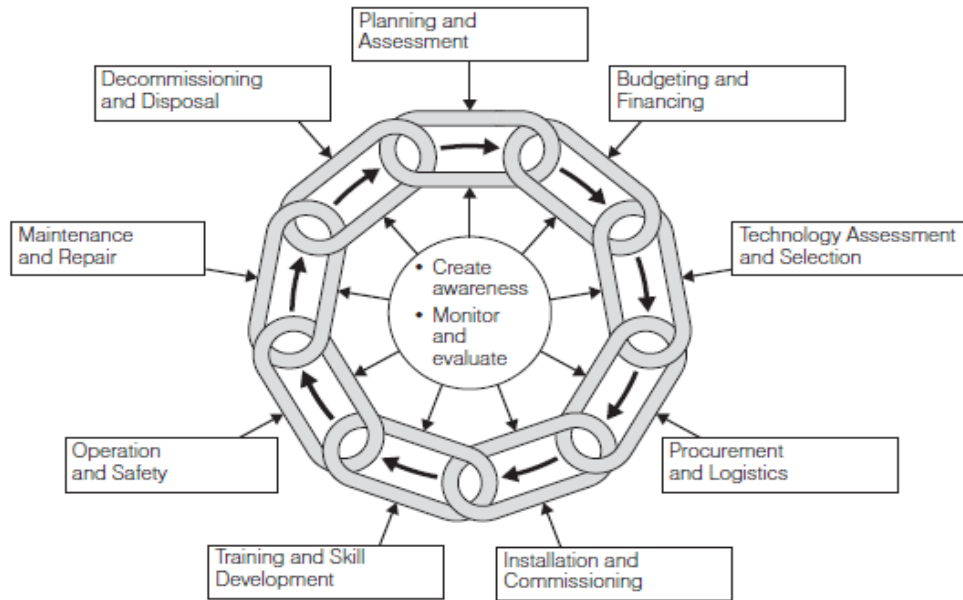


Figure 1: Medical Equipment Management Cycle (Temple-Bird et al., 2005a)

The marginalization of health care equipment issues is likely to change during the next decade not only because of the health care reform processes under way in different countries, but also because of changing environmental issues. These environmental issues include increased litigation by the public due to the incorrect application or non-availability of equipment (Temple-Bird et al., 2005a).

Furthermore, there is likely to be a trend towards diagnostic and therapeutic interventions using increasingly sophisticated equipment and this will force many countries to incorporate higher equipment content in the health care delivery process. These issues, coupled with the fact that health education and modern communications will raise the level of awareness of the populations served about possible health care options, will force many countries to adapt and improve the health care equipment intervention process (Temple-Bird et al., 2005a).

This section will focus on literature review of four of the major elements of the medical equipment cycle which are the fundamental attention of the thesis.

2.1 Procurement of Medical Equipment

Procurement is one of the vital elements of medical equipment management that ensure equitable access of quality medical equipment. UNOPS defines procurement as “the

acquisition of property, plant and/ or equipment, goods, works or services through purchase, hire, lease, rental or exchange” and is taken to include “all actions from planning and forecasting, identification of needs, sourcing and solicitation of offers, evaluation of offers, review and award of contracts, contracting and all phases of contract administration until delivery of the goods, the end of a contract, or the useful life of an asset.” When procurement includes installation and commissioning, the process can be termed “technology incorporation” (UNOPS, 2010).

Hospitals need to have plan for the procurement of medical equipment. During planning the hospitals should consider replacement of obsolete and damaged medical equipment and expansion of services. In order to have better procurement management of medical equipment, the facilities must have well established inventory management (Temple-Bird et al., 2005b).

All equipment should be appropriate to the setting of the hospitals, be of assured quality and safety, be affordable and cost-effective, be easily used and maintained, conform to existing policies, plans and guidelines. These selection criteria should then be used during the procurement process, when hospitals evaluate and decide between different offers from suppliers (Temple-Bird et al., 2005b).

The EHRIG recommends all hospitals to prepare five years purchase plan with consideration of medical equipment development plan. medical equipment. It also indicates the considerations to be made during the procurement of medical equipment including appropriateness to the setting of the hospital, quality and safety, affordability and cost, and ease of utilization and maintenance (FMOH, 2010b).

Once the reason for procuring equipment is known, it is important to determine the types of equipment that are suitable. In order to make the best use of scarce resources, hospitals should be able to procure medical equipment of high importance. Since the market of medical equipment provides ample of options, it is not easy task to select medical equipment.

The equipment planning and procurement process should be based on national equipment lists. In many countries, the Ministry of Health has developed guidelines or standard lists of equipment for all levels of the health system. In Ethiopia, FMHACA is in the process of developing list of medical equipment; however some hospitals have their own list of medical equipment. A standard list is essentially a model list of equipment, based on the type of health services a facility is expected to carry out (Temple-Bird et al., 2005b).

The EHRIG dictates each hospital to have model medical equipment list that describe the ideal number and types of equipment required by the hospital. The list is determined by the essential health service package which is developed by a multi-disciplinary team (FMOH, 2010b).

Medical equipment can be procured in three ways: purchasing, receiving donation and hiring. In purchasing, the hospital buys the medical equipment using funds from government. In donation, the pieces of equipment are chosen and supplied free of charge by non-governmental organizations, charities, individuals, and private businesses. This can range from gifts of small quantities of items to substantial equipment procurement projects. Leasing, renting, – may be an alternative to outright purchase of equipment for or hiring those with limited budgets or cash flow problems (Temple-Bird et al., 2005b).

Wrongly procured equipment is normally the beginning of maintenance problems, often rendering the equipment non-functional. According to a study, lack of equipment standardization, poor management information system, poor logistics of spare parts and lack of ongoing training compound the problems of maintenance for technical personnel and users. This concurs with the study by the World Bank (1993), which concluded that standardization could simplify management and maintenance and reduce inventory costs (Ogembo-Kachieng'a, 1999b).

Well managed equipment procurement can save both time and money, as a result of the shorter time required to train operating personnel and to install and commission equipment, lower frequency of breakdowns and accompanying inconvenience, shorter equipment down-

time, smaller expenditure for parts and maintenance, and fewer preventive maintenance requirements (Temple-Bird et al., 2005b).

The provision of modern health care is heavily dependent on technology, which includes health care equipment. Because of economic constraints, the health sectors of many developing countries have to rely considerably on donations of equipment. Most of the developing countries acquire most of their medical equipment by donation. The studies show that as much as 96% of medical equipment in developing countries is donated (MOHSW, 2008). Among the donated medical equipment, about 40% of medical equipment in the developing world is out of services (Dzwonczyk & Riha, 2012).

In the Sub-Saharan Africa region, up to 70 per cent of equipment lies idle due to mismanagement of the technology acquisition process, lack of user-training and lack of effective technical support. These facts have clear consequence for health outcomes in these countries with the patients suffering from lack of accurate diagnostic or adequate treatment. Large amounts of unused donated equipment in storage put a marked stress on facilities funds (MOHSW, 2008).

The most important principles for health care equipment donations are: the medical equipment should benefit the recipient to the maximum extent possible, a donation should be given with due respect for the wishes of the recipient and their authority within the health system, and must be in conformity with existing government policies and administrative systems at the recipient end, if an item does not meet quality standards in the donor country, it is unacceptable as a donation and there should be effective communication between the donor, the recipient authority and, whenever possible, the end-user, before, during and after the donation (WHO, 2000).

Donation of medical equipment has remained a debatable issue in Africa. Despite charitable intentions of the donors, hospitals rarely benefit from donated equipment due to a variety of factors (Halbwachs & Issakov, 1994). It has been concluded that even when donated equipment meets local requirements, very little of it ever becomes operational, for reasons - including missing or damaged parts, lack of disposable inputs and of user and service manuals, and problems with power supply (World Bank, 1993). Another World Bank study

concluded that the greatest obstacle to improving health technology in Africa was "technology philanthropy" - the uncoordinated donation of equipment to African countries by foreign agencies and charities (World Bank, 1995) .

WHO (2000), recommends that there should be policy to manage procurement of medical equipment in countries.

Ethiopia has drug donation guideline which is deemed to manage the donation of medicines, medical supplies and medical equipment. Since the guideline is prepared with special emphasis to medicines, it fails to address the management related to medical equipment (DACA, 1996).

According to a study on effectiveness of medical equipment donation, which has taken inventory reports of sixteen developing countries' hospitals from 1986 to 2010, in Ethiopia 39% of the donated medical equipment are out of service in 2008 (Perry & Malkin, 2011).

The EHRIG recommends preparation of policy on receipt of donated medical equipment by medical equipment committee in their respective hospital. The guideline provides tips on the conditions under which the donated items will be accepted. Some of the conditions mentioned include good working order of the equipment, need of the hospital, availability of instruction manual in English, availability of supplies, consumables and spare parts in Ethiopia. Also, the guideline recommends consideration of provision of training and availability of maintenance experts (FMOH, 2010b).

2.2 Operation of Medical Equipment

Operation of equipment is defined as “using the correct physical methods to get the equipment to work. In order to do this successfully, the user needs to know the specific operating characteristics of a machine, the operational procedures that make the machine work, how to use its various functions, how to make it perform its customary cycles and routines, how to change the bulb, paper roll, batteries, etc.” (Temple-Bird, Lenel, Kawohl, & Kaur, 2005c).

The equipment manufacturer's user manual is often the best source of information for operation of medical equipment. Other sources include a wide range of reference material written resources from staff training sessions and experienced colleagues.

Staff may feel confident about how to operate equipment, but it is imperative that they also know the correct 'application' for the equipment. Staff needs to be able to apply their taught procedures correctly, and to employ the correct methods of application so that equipment is used to its fullest capacity (Temple-Bird et al., 2005c).

Staff needs to be trained in order to fully appreciate when and how to use equipment. They need to know when different features will be employed for different patients or uses, the range of assistance a machine can offer them, how to alter the relationship between the machine and the patient, or sample, for different purposes and the different procedures to pursue for different disorders or treatments (Temple-Bird et al., 2005c).

2.2.1 Operational Performance of Medical Equipment

As indicated earlier, a large proportion of the existing stock of equipment in health facilities is not operational. The health care literature provides numerous examples of the poor performance of medical equipment in developing countries. It is estimated, for example, that in Brazil 20 to 40 percent of the \$2 billion to \$3 billion worth of public sector medical equipment is not functioning (World Bank, 1993). It has been estimated that 60 percent of the equipment in medical units in a typical third world country is not usable (McKie, 1990). It was indicated that the problem of poor operational performance of equipment is more evident in public sector health facilities and less severe in privately owned medical institutions (McKie, 1987).

A study in 12 hospitals of Sri Lanka indicated that overall average equipment performance for all the hospitals included in the study found to be 58%, which means that 42% of the stock of equipment in the public sector hospitals is unusable for some reason or other (Dasanayaka, 2006). In other study it has been reported that Yemen, Ghana and Costa Rica

had 54.2%, 66.8% and 86.4 equipment performances in the year respectively (Remmelzwaal, 1997a) .

2.2.2 Factors Contributing to Variation in Operational Performance

In a study it has been noticed that for the hospitals in Yemen and Ghana, the performance of the medical equipment is related to the degree of complexity of the equipment (Remmelzwaal, 1997a). In those countries relatively more problems are encountered for equipment of medium and high complexity than for the more simple and robust equipment. By contrast, in Costa Rica, equipment performance appears to be more or less independent of technological complexity (Remmelzwaal, 1997a). The Costa Ricans somehow manage to cope equally efficiently with equipment of all levels of technological complexity.

A study in Sri Lanka depicted that there is a weaker relationships between the degree of standardization and equipment performance. However, the engineers and officials in the Bio-Medical Engineering Division responsible for maintenance in all the study hospitals of Sri Lanka mentioned that a high degree of standardization of medical equipment in general is desirable because of the possible spare parts and consumable management problems a highly heterogeneous set of medical equipment (Dasanayaka, 2006).

2.3 Maintenance of Medical Equipment

According to one estimate, only 10– 30% of donated equipment becomes operational in developing countries (WHO, 2010) . Reasons for unused equipment include mismanagement in the technology acquisition process, lack of user training and lack of effective technical support.

Maintenance is required for all types of medical equipment. This requires a broad spectrum of skills to cover areas such as medical electronics, electro-medical systems, carpentry, plumbing, bricklaying, electrical installations, mechanics, refrigeration, automotive work, and technical management. The range of skills present in medical equipment management of the health facilities depends on the type of health service providers working in the health

facility, and the other maintenance arrangements available in the country (Temple-Bird, Lenel, Kawohl, & Kaur, 2005d).

The life expectancy of medical equipment depends on the type of equipment and the type of technology it contains. For example, five years might be the typical life for an ECG monitor, ten years for a suction pump, 15 years for an operating table, and 20 years for an electricity generator. All equipment is made up of various parts – moving and non-moving, active and passive. At any time during the life of the equipment, these parts can fail due to wear and tear. Thus, it is very important to give regular attention to the equipment through planned preventive maintenance (PPM) and corrective maintenance (Temple-Bird et al., 2005d).

Medical equipment maintenance can be done internally or externally. A number of investigations have shown that, of the equipment problems reported, about one-third arise from operator problems one-third arise from minor, easy-to-solve technical problems and only one-third require more serious fault-finding procedures and special knowledge of the equipment. So at least two-thirds (and maybe as much as 80%) of the problems could be corrected by properly trained equipment users. Hence, at most, there are one-third of the problems which require specially trained maintenance personnel (Temple-Bird et al., 2005d).

PPM is important because it enables the maintenance department to catch any problems before they become crises, prevent breakdowns, save money, as PPM is cheaper than repairs following breakdowns, make sure that equipment is fully operational, guarantee accuracy and reliability, increase the availability of equipment and reduce down-time, extend the life-span of equipment, reduce equipment running costs, ensure the equipment is safe, for patients, users, and maintenance staff (Hans Halbwachs, 1989).

Maintenance not only has a positive impact on the safety and effectiveness of healthcare technology, but also has two important economic benefits: It increases the lifetime of equipment and thus helps to save scarce investment resources; it enhances the demand for health services. Demand for services availability is crucial of functioning healthcare technology (Mutia, Kihui, & Maranga, 2012).

Introducing an element of standardization for healthcare technology will help to limit the wide variety of makes and models of equipment acquired by the health facilities. By concentrating on a smaller range for each equipment type, technical, procedural, and training skills will increase and costs and logistical requirements of the facilities will decrease (Temple-Bird et al., 2005d).

Equipment standardization would lead to the establishment of an instrumentation infrastructure based on robust testing platforms of high quality and performance; allow for cost saving on equipment and reagent procurement based on economies of scale and, therefore, sustainable cost-effective laboratory services; allow the establishment of an efficient and responsive service and maintenance infrastructure; limit overreliance on single platforms and vulnerability to supply bottlenecks; and permit instruments and reagents to be shared during breakdowns or stock shortages (Massambu & Christina, 2009).

In many countries, machine breakdown is a common challenge to delivering testing services. If individual laboratories are procuring only one piece of equipment, they do not have the negotiation power of a network of laboratories that is procuring a large number of the same machines. Thus, having machines of the same kind and centralizing the procurement functions will allow the program to negotiate better service and maintenance contracts with manufacturers, distributors, or both. In some countries, having a larger number of one type of equipment has allowed ministries of health to negotiate maintenance contracts with the purchase of reagents. Given that nonfunctional equipment is a major bottleneck to laboratory service delivery, the negotiation of service as part of the commodity contract is critical to the success of the laboratory program (USAID|DELIVER, 2010).

The introduction of planned maintenance scheme requires careful planning and prioritization of activities. Ambitious arrangement of preventive maintenance discourages staff and overburden the system. The following are important steps to be considered in PPM: get approval of the policy makers on the scheme, train staff on technical procedures, provide maintenance facilities, establish inventory system, determine priority areas of maintenance,

get appropriate manuals, ensure appropriate time for the maintenance activity and develop inspection service schedule (Hans Halbwachs, 1989).

In a study of medical equipment management of Kenya and South Africa, 90 % of the equipment management specialists indicated health care equipment maintenance is a problem. The study also depicted that the problem is severe in larger hospitals (Ogembo-Kachieng'a & Ogara, 2004).

Some of the key issues for an effective equipment maintenance system are: qualification of technical staff, financial provision for maintenance, maintenance facilities, maintenance contracts, transport, technical library, documentation and equipment inventory.

The maintenance programme must strive for accurate records of both the total list of equipment requiring maintenance as well as an accurate accounting of the specific work completed. Another important aspect of equipment control and tracking is keeping accurate records of locations of equipment to facilitate quick location of equipment for procedures. If attention is given to keeping accurate records and information, many hours can be saved in trying to locate equipment that was recently removed from service, disposed of, put in storage or was moved to a different department (WHO, 2011).

Keeping database information updated is an ongoing task, which is well worth the effort when striving for good programme management. These data are typically contained in work order records that provide documentation of every maintenance task performed on the device. As a result, the inventory database will contain the entire technical and financial history for each device in the inventory (WHO, 2011).

2.4 Disposal of Medical Equipment

When a piece of equipment comes to the end of its life, a decommissioning, disposal, and replacement process must take place. “Decommissioning is the process of condemning equipment when it is no longer safe, or of use, and taking it out of service. This process is sometimes known as ‘boarding’ because, originally, government bodies called ‘Boards of

Survey' were responsible for carrying out this task for government property" (Temple-Bird et al., 2005d).

As it has been mentioned above, all equipment has its own lifetime. Reconditioned equipment has a shorter lifetime than equipment bought from new. Once equipment reaches the end of its life, no amount of intervention will help; it just needs to be replaced if the service it provides is to continue.

To understand how equipment depreciates, it is necessary to know the likely 'life' of your equipment. It depends on the rate of use of the equipment, how many back-up units you have, how the equipment is handled, how well the equipment is cared for and cleaned, how well the equipment is serviced and how often, the initial quality of the equipment and the physical environment and climate that the equipment is used in (Temple-Bird et al., 2005b).

Ideally, condemned equipment is only disposed of once the official condemning process has occurred. However, if this does not happen regularly, the health facility cannot afford to become disappointed with old and scrap items, and should start a process of cannibalizing the equipment in order to reduce the impact of the stockpile and to gain as much use as possible from the old items. Also, hazardous components should be properly disposed as per agreed up on procedures.

The EHRIG recommends establishment of disposal committee to oversee the disposal of all fixed assets that are no longer required by the hospitals, including medical equipment. Also, the hospital should have management approved policy on disposal (FMOH, 2010b).

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

The following research design and methods were used to address the objectives of the study.

3.1 Research Design

Multiple techniques of study were adopted using qualitative and quantitative methods, which comprise of interviews through structured questionnaires, self-administered questionnaire, physical inventory of medical equipment and direct observations of practices of medical equipment management. The following are details of the research design.

3.1.1. Study on Medical Equipment Management System

Pre tested questionnaires were distributed to ten key informants, biomedical engineers/technicians in the hospitals. The questionnaire comprised of statements which explain the procurement, utilization and disposal practices of hospitals and they were rated by the technicians from 0 to 5. The weighting of each question was answered as 0 - Very poor: 0%, 1 - Poor: 20%, 2 - Fair: 40%, 3 - Good: 60%, 4 - Very good: 80%, and 5 - Excellent: 100% and it was analyzed as indicated in the data analysis.

In addition to the above quantitative method of studying the medical equipment management system; biomedical technicians of the hospitals, pharmacy case team heads of the hospitals and procurement directorate director of the PFSA were interviewed to understand explanations on the current practices of the hospitals on the procurement, utilization and procurement of medical equipment. Also, forty primary users of medical equipment drawn one from the laboratory, x-ray, operation room and intensive care units of each of the hospitals were provided with questionnaires on the maintenance management of the hospitals.

3.1.2. Study on Medical Equipment Performance

There are variety ways of assessing performance of a stock of medical equipment, which indicates the operational effectiveness of medical equipment. In this study, numerical method

which simply takes equipment performance as the percentage of a set of equipment in good working order, at the time of survey was employed. In other words, it indicates the proportion of the number of units of equipment in health facilities, which is in good working order and ready to deliver its intended services in a safe and reliable manner (Remmelzwaal, 1997b).

3.1.3. Study on Factors Affecting Performance of the Medical Equipment

In this study the two major factors hypothesized to affect the performance of medical equipment were dealt to identify their relationship with complexity of medical equipment and degree of equipment standardization.

i. Complexity of medical equipment

Studies suggest that the technological sophistication of equipment is a major reason for poor operational performance (Remmelzwaal, 1997b). In order to proof this hypothesis, an investigation was carried out into a possible relationship between the degree of technological sophistication of medical equipment and its operational performance, under a given set of circumstances. Technical complexity of categories of equipment was defined in terms of a combination of certain characteristics grouped in four categories, namely (a) Incorporated components, (b) Required maintenance and calibration, (c) Operator complexity, and (d) Auxiliary supplies and connections (Remmelzwaal, 1997b).

A medical equipment engineer working in one of the hospitals was invited to assign scores, on a numeric scale (1-10), to each category of equipment (Appendix E). The relationship between the complexity and the performance of medical equipment were analyzed.

ii. Degree of equipment standardization

Previous studies have suggested that the lack of equipment standardization, in terms of the heterogeneity in brands and models, invariably leads to poor performance of equipment.

The degree of standardization is defined as being a function of two variables, namely the manufacturer and the model of the equipment:

$$STD = \left(1 - \frac{(MOD-1) + (MAN-1)}{2(QTY-1)}\right)$$

Where,

STD = degree of standardization

QTY = the number of equipment items sampled from a hospital

MOD = the number of different models in that set of equipment

MAN = the number of different manufacturers for that set of equipment

(Remmelzwaal, 1997b)

Calculating the degree of standardization in this way was produced a number between 0 and 1, indicating the degree of standardization (Remmelzwaal, 1997b).

3.2. Population and Sampling Techniques

All public health hospitals except Tirunesh Bejing hospital found in Addis Ababa namely Ras Desta Damitew, Zewditu, Minelik II, Yekatit 12, and Gandhi Memorial Hospitals, which are managed by Addis Ababa City Administration health bureau; ALERT hospital, St Paul Hospital Millennium college, Amanuel mental specialized hospital, St Peter's TB specialized hospital which are managed by the Federal Ministry of Health and Black Lion hospital which is managed by Federal Ministry of Education were included in the study. Tirunesh Bejing hospital was excluded from the study because of the low experience of the hospital in medical equipment management.

Medical equipment to be included in the study were determined prior to data collection in consultation with users of medical equipment with criteria of high monetary value and importance for medical services. In the medical system management system study, subject matter experts on medical equipment management which are 10 biomedical engineers/technicians and 10 pharmacy case team heads were involved in the study.

3.3. Types of Data and Tools/Instruments of Data Collection

In the study of the medical equipment management system, biomedical engineers/technicians were provided with structured questionnaires to rate the parameters which describe the practices of the hospitals on medical equipment management (Appendix A). Also, all relevant biomedical engineers/technicians and pharmacy case team heads of the facilities and directorate director of procurement at PFSA were interviewed to identify the root causes of the status of medical equipment management in the hospitals (Appendix B). In addition, self-administered questionnaire used to collect opinion of primary users of medical equipment to triangulate other findings (Appendix C).

In the study of performance of medical equipment, the annexed medical equipment inventory tool (Appendix D) was used to collect the functionality status of medical equipment through direct observation, document review, and interview with relevant staff of the hospitals.

To study the factors that affect performance of medical equipment, relevant information were collected with the above mentioned tool through observation of medical equipment operations, interview of relevant staff and critical review of documents on different models and manufacturers of equipment available in the hospitals and their quantity.

3.4. Procedures of Data Collection

The data for all the studies were collected from 24 Dec 2012 to 8 Feb 2013. The structured questionnaires on medical equipment management of the hospitals were distributed to the technicians and primary users of medical equipment by the principal investigator and the filled questionnaires were collected on the spot. The semi-structured interview with the technicians, pharmacy case team heads and procurement directorate director of PFSA were administered by the principal investigator and the responses were noted on the questionnaire.

In the study of the performance of medical equipment, two biomedical technicians working in the regional health bureau were oriented on the medical equipment inventory form by the principal investigator and they have collected all available information from documents and direct observation to the medical equipment.

3.5. Methods of Data Analysis

In the medical equipment management system study, the results were entered into the SPSS and frequency and descriptive statistics were used to analyze the data. Also, combined percentage of each of the major parameters was calculated as:

Combined % of the parameter =

$$\frac{\sum_{i=1}^{n=10}(\text{Sum of rating of questions on the parameter})}{(5n * \text{number of questions in the parameter})} * 100$$

Where n= number of respondents

Parameter = Procurement, donation, maintenance and disposal management

In the study of performance of medical equipment, using the data collected using the aforementioned method, the performance of medical equipment was calculated as,

Equipment performance = (Number of functional equipment in the set of selected equipment in the hospital * 100)/Total Number of selected equipment in the hospital) (Rommelzwaal, 1997b). This indicates % of medical equipment which are functional at the time of the study.

In the study of factors that affect medical equipment performance, the relationship between complexity and performance, the weight assigned to different characteristics of the medical equipment were computed to get total score of complexity for each of medical equipment.

Complexity score calculated as: 0.4(Score of maintenance and calibration) + 0.3(Score of incorporated components) + 0.2(Score of operator complexity) + 0.1(Score of auxiliary supplies and connections) (Rommelzwaal, 1997b).

After computing the complexity score, correlation between the complexity and performance was analyzed.

In the study of degree of standardization, calculation of degree of standardization gives values between 0 and 1. If the value approaches to 1 it indicates that there is high level of standardization and as the value approaches to 0, there is less standardization. Finally, the relationship between standardization and performance was analyzed using correlation.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1. Medical Equipment Management System

4.1.1.1. Policies and procedures for the management of medical equipment

As per the EHRIG, all hospitals should have medical equipment management committee to prepare policies, guidelines and procedures on major components of medical equipment management. According to the study, only six of the ten hospitals have established medical equipment management committee responsible to oversee the management of medical equipment activities in the hospitals.

Only 4 of the hospitals have list of medical equipment selected for the hospitals' use. None of them do have specifications of medical equipment used in their hospital. However, the respondent from Black Lion Hospital indicated that they have a plan to use the specification of medical equipment developed by FMHACA. The FMHACA's list of medical equipment and minimum requirement of the medical equipment is almost ready for use.

Except Amanuel Mental Specialized Hospital, all of the hospitals don't have donation, disposal and servicing policies to direct the management of medical equipment in the hospitals. Table 1 indicates summary of availability of medical equipment management policies, procedures and guidelines.

Table 1: Availability of policies and procedures for the management of medical equipment in the public hospitals of Addis Ababa

S.No	Policies/ Guidelines/ Plan	Black Lion	St Paul	Zewditu	Yekatit 12	Minelik II	Amanuel	Alert Hospital	Gandhi	St Peter	Ras Desta
1	Selection guideline	0	0	0	0	0	1	0	0	0	0
2	Procurement guideline	0	0	0	0	0	1	0	0	0	0
3	Specification of ME	0	0	0	0	0	0	0	0	0	0
4	List of medical equipment	0	1	1	0	0	0	1	0	1	0
5	Policies and procedures for acquisition	0	0	0	0	0	1	0	0	0	0
6	Policies and procedures for donation	0	0	0	0	0	1	0	0	0	0
7	Plan for replacement of obsolete	0	0	0	0	0	0	0	0	1	0
8	Leasing procedures	0	0	0	0	0	0	0	0	0	0
9	Servicing policies and procedures	0	0	0	0	0	1	0	0	0	0
10	Disposal policies and procedures	0	0	1	0	0	1	0	0	0	0

Key: Yes -1 No -0

4.1.1.2. Procurement of Medical Equipment

In the public hospitals of Addis Ababa, procurement of medical equipment is managed by the hospital's pharmaceutical procurement unit, i.e. the pharmacy unit. The hospitals procure medical equipment using different methods of procurement. As per the proclamation on drug fund and pharmaceuticals supply, all these hospitals procure the equipment directly from the PFSA (FDRE, 2007). If PFSA doesn't have stock of the equipment, the hospitals transfer their budget to the agency and the agency procures the equipment using international competitive bid or the agency gives them stock out certificate to allow hospitals to procure medical equipment from the private sector.

Poor quality of medical equipment is mentioned as one of the challenges in relation with procurement of medical equipment. The reason stated for this is lack of standardization of medical equipment in the country. The procurement guideline of the government favors open competition among all vendors who provide medical equipment registered by the FMHACA. The PFSA claims that the agency treats all medical equipment suppliers equally. All procurements handled by the agency are governed by the proclamation of the Ethiopian government on procurement (The Federal Democratic Republic of Ethiopia, 2009).

Late delivery of medical equipment by the PFSA is also raised as a major challenge for the hospitals. One of the hospitals mentioned that, although PFSA promised to procure the products in 6 months it took 3 years for PFSA to deliver the products. A respondent from PFSA claim that there are different factors that contribute to late delivery of the products. Among others, identification of right suppliers, getting import permit and ensuring qualities are major reasons for delays. However, the agency is managing procurement of medical equipment in a better short lead time than ever.

All of the hospitals use purchasing and donation as a procurement modality for medical equipment. None of the hospitals use leasing as an alternative to acquire medical equipment. There is also no evidence that there is supply of medical equipment through leasing in the country.

The study indicates that the combined percentages mean ratings for the public hospitals' procurement system was 52 per cent, which varies from 18% in Yekatit 12 to 82% in Amanuel hospital (Figure 2).

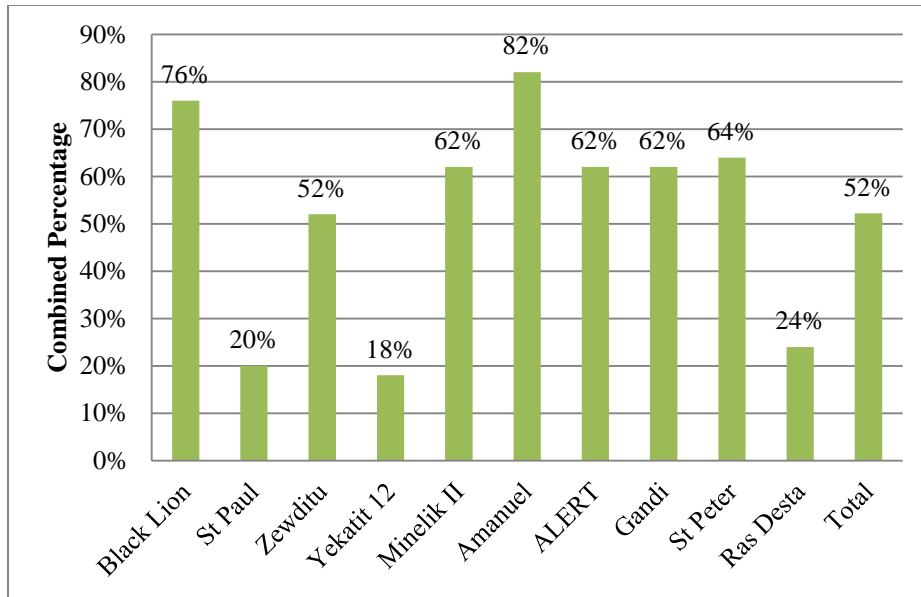


Figure 2: Procurement of medical equipment management in the public hospitals of Addis Ababa

The combined measure includes parameters like medical equipment development plan, replacement plan of medical equipment, involvement of biomedical technicians in the procurement of medical equipment etc. Table 2 indicates the rating of different components of the medical procurement management system.

According to the respondents, the hospitals' procurement practice is good in consideration of the hospital setting, consideration of ease of maintenance and cost and affordability. About 60% of the hospitals' consideration of ease of maintenance is rated by biomedical technicians as the highest.

Table 2: Description of different components of procurement management of the public hospitals in Addis Ababa

S. No	Parameter	Rating (0-5)				
		N	Minimum	Maximum	Mean	Std. Deviation
1	The hospital has clear direction as when to replace medical equipment	10	0.00	4.00	1.6000	1.42984
2	The tender committee gives attention to the decision of technical team/ the tender committee has the expertise on medical equipment management	10	0.00	5.00	3.4000	2.06559
3	The procurement of ME considers appropriateness to the setting of the hospital	10	1.00	5.00	3.7000	1.76698
4	The procurement of ME considers ease of utilization and maintenance	10	0.00	5.00	3.3000	2.26323
5	The procurement of ME considers cost and affordability	10	2.00	5.00	4.6000	0.96609
6	The hospital is good in negotiating with the vendors in setting warranties	10	0.00	5.00	2.7000	1.94651
7	The hospital has good medical equipment procurement service contract management	10	1.00	5.00	3.0000	1.69967

The study also depicted the involvement of different stakeholders in two major functions related to procurement: the preparation of specification and evaluation of tenders. The structured interview indicated that the responsibility of these two functions vary from hospital to hospital. The actors on the preparation of specifications range from involvement of relevant technical staff to involvement of Science and technology engineers (Table 3).

In 60% of the facilities, the biomedical engineering unit is highly involved in the preparation of specification of medical equipment for their procurement.

According to the respondents of the interview, one of the major challenges of procurement of is absence of medical equipment specification. The country doesn't have specification of the equipment and the hospitals lack capacity to prepare the specification. As it is indicated in table 3, in most of the hospitals the specifications are prepared by the procurement unit and primary users of the medical equipment. In few of the hospitals, they involve the biomedical engineering unit in the preparation of specifications. The respondents also questioned that the hospitals don't have adequate number of well-trained engineers to do so.

Table 3: Procurement related responsibilities in the public hospitals of Addis Ababa

S. No	Name of the hospital	Responsible body for specification preparation	Responsible body for tender evaluation
1	Black Lion	Bio medical engineering unit and technical staff from relevant departments	Tender committee and technical staff from relevant departments
2	St Paul	Pharmacy unit + Bio medical Engineering unit and technical staff from relevant departments	Tender Committee
3	Zewditu	Technical staff from relevant departments	Tender committee
4	Yekatit 12	Procurement unit and technical staff from relevant departments (PFSA uses its own specification)	Tender committee and technical staff from relevant departments + Pharmacy unit
5	Minelik II	Biomedical Engineering unit and technical staff from relevant departments	Technical committee
6	Amanuel	Technical staff from relevant departments	Tender committee and technical staff from relevant departments + Pharmacy unit
7	ALERT	Biomedical Engineering unit and technical staff from relevant departments	Tender committee
8	Gandi	Biomedical Engineering unit and technical staff from relevant departments	Technical committee
9	St Peter	Science and Technology Metrology unit	Tender committee and technical staff from relevant departments
10	Ras Desta Damtew	Technical staff from relevant departments	Pharmacy unit and technical staff from relevant departments

4.1.1.3. Donation of Medical Equipment to the Hospitals

The combined percentages mean ratings for the public hospitals management of medical equipment donation was 36 per cent, with the minimum of 22% for Ras Desta and maximum of 73% for Black Lion hospital (Figure 3).

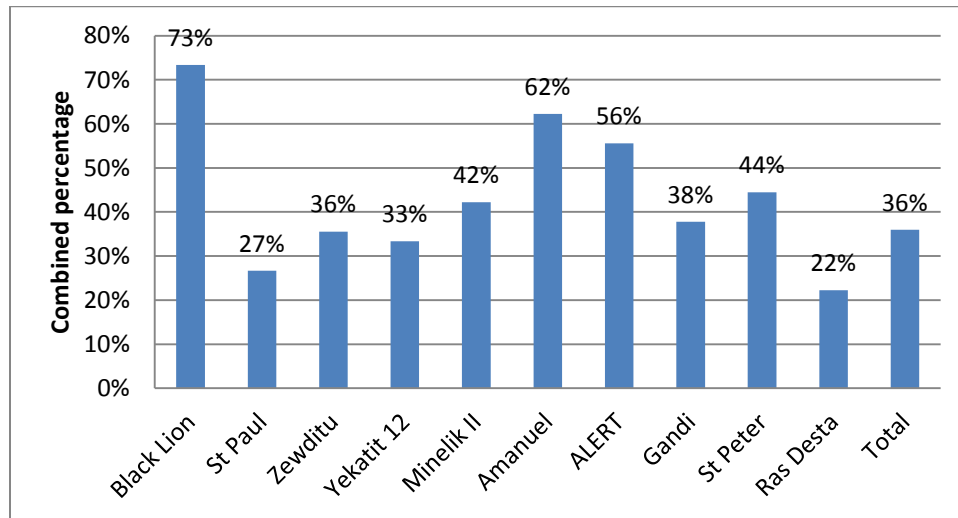


Figure 3: Management of Donation of medical equipment in the public hospitals of Addis Ababa

Some of the components of the combined measures of donation of medical equipment are the benefit of donated medical equipment, ensuring availability of accessories & spare parts, refusal of accepting donated medical equipment that doesn't satisfy the need of the hospitals, involvement of the hospitals in the donation process etc. (Table 4).

This study indicates that 20% of the respondents rated the benefit of donated medical equipment to the hospitals as excellent, 60% of the respondents rated as good. On the other hand, 10% of the respondents valued as poor and 10% as very poor.

Only 20% of the respondents rated excellent for the involvement of the hospital in all stages of the donation management. 40% of the respondents valued as good and very good in equal proportion. 40% are valued below fair comprised of 30% very poor and 10% poor.

60% of the respondents rated very poor for “donation of medical equipment is based on the development plan of the hospitals”.

Table 4: Description of different components of medical equipment donation of the public hospitals in Addis Ababa

S.No.	Parameters	N	Rating (0-5)			
			Minimum	Maximum	Mean	Std. Deviation
1	Most of the donated medical equipment are beneficial to the hospital	10	2.00	5.00	3.4000	.96609
2	The hospital accepts donation after ensuring availability of accessories, spare parts and consumables.	10	.00	5.00	2.4000	1.64655
3	The hospital follows the normal process of acceptance of ME as in the case of purchases	10	.00	5.00	2.4000	2.06559
4	The hospital refuses donation of ME that doesn't satisfy the requirement of the hospital	10	.00	5.00	.8000	1.75119
5	Donations are made based on the request of the hospital	10	2.00	5.00	3.1000	.99443
6	Donations conform with the ME development plan of the hospital	10	.00	3.00	1.0000	1.33333
7	The hospital involves in all stages of donation of ME	10	.00	5.00	2.1000	1.91195
8	The donors provide/ arrange all relevant services to the hospital	10	1.00	4.00	2.0000	1.05409
9	The hospital gets spare parts and consumables for the sustainable operation of the machines	10	.00	5.00	2.3000	1.56702

4.1.1.4. Maintenance of Medical Equipment

The combined percentages mean ratings for public hospitals medical equipment maintenance management was 33 per cent. The minimum is 18% in ALERT hospital and maximum of 68% in Black Lion hospital (Figure 4).

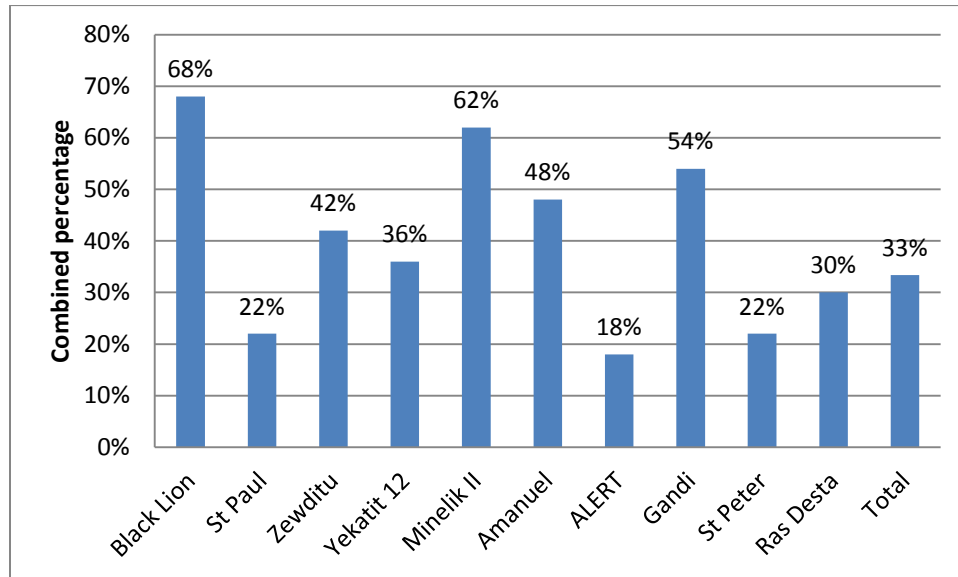


Figure 4: Management of medical equipment maintenance in the public hospitals of Addis Ababa

Most of the hospitals lack clear procedures on maintenance management. 60% of the respondents rated “very poor” for presence of clear procedures on the management of maintenance. 10% rated as poor, 20% as good and 10% as very good.

The management of preventive maintenance in the hospitals was rated from 0 to 4 out of 5 with an average rating of 2, fair management of preventive maintenance. 30% of the respondents rated the preventive maintenance of their hospital as very poor, 30% as good, 20% as very good and 10% as poor. In most of hospitals preventive maintenance is conducted by most of laboratory technologists and x-ray technicians and few nurses. Since laboratory technologists are provided with training on the operation of laboratory machines, they are in a better position to manage the preventive maintenance.

The hospitals are good in scheduled inspection and testing of medical equipment. The scheduled inspection and testing of medical equipment practice is rated from 0 to 5 with an average of 3. 30% of the respondents rated as excellent, 10% rated as very good and 20% as good. Only in the 20% of the facilities it is rated below fair.

The study also disclosed that there is insufficient recording of history of medical equipment in the hospitals. Only 20% of the hospitals believe that they have excellent history record. Equal amount of the hospitals have very poor recording. 30% considers the recording of history as good and 20% believe that it is very good.

The availability of all the necessary resources including finance to manage medical equipment maintenance is rated from 0 to 4. According to the respondents, 40% of the hospitals have poor in terms of availability of resources and 20% of the respondents rated as very poor and fair, 10% as good and very good.

The response from the primary users of medical equipment working in different four units of the hospitals indicates that 50% of the users of the medical equipment have taken training on how to use the equipment. In 78% of the units, there was at least one medical equipment which is not functional. 40 % of these units provide preventive maintenance for the medical equipment used by the units and only 38% of the units get curative maintenance services in a reasonable period of time. The study also indicated that 50% of the hospitals don't have maintenance record for medical equipment managed by the hospitals. In the 50% recording of maintenance was started recently and it has been observed that the recording system is not as per the standard practices.

Except Black Lion hospital, none of the hospitals have biomedical engineer to manage the maintenance of medical equipment. Most of the hospitals have one or two biomedical technicians, most of which are new graduates. In addition to the human resource, the availability of different resource required for the management of maintenance of medical equipment in the hospitals was assessed and the following table indicates the status of the

hospitals in terms of availability of workshop, reference materials, spare parts and finance for maintenance management.

Table 5: Availability of resources for the management of medical equipment in the public hospitals of Addis Ababa

Name of the Hospital	Workshop	Reference Materials	Spare parts	Finance
Black Lion	Yes	Yes	No	Yes, with other facility management budget
St Paul	Yes	No	No	No
Zewditu	No	No	No	Yes
Yekatit 12	Yes	No	No	No, not adequate
Minelik II	Yes	Yes, Catalogue	Yes	No, not adequate
Amanuel	No	No	Yes	Yes
ALERT	No	No	Yes	Yes
Gandi	Yes, the management is working on it to strengthen it	Yes, not adequate	No	Yes
St Peter	No	No	No	Yes
Ras Desta	Yes	No	No	Yes

4.1.1.5. Disposal of Medical Equipment

The following table depicts medical equipment disposal practice in the public hospitals. Half of the hospitals have fixed asset disposal committee which is responsible to manage the disposal of unusable medical equipment. All of the facilities have stock of unusable medical equipment which has to be disposed. Only 20% of the facilities keep value of medical equipment as per the fixed asset management procedure.

Table 6: Disposal of medical equipment in the public hospitals of Addis Ababa

Name of the Hospital	Presence of Fixed Asset committee	Frequency	Stock of unusable	Record of current value of ME	Last time disposal
Black Lion	Yes	It is conducted once	Yes	No	Before a year
St Paul	No	Not established	Yes	No	Once metals of ME were taken to Defense Engineering
Zewditu	No	Not established	Yes	No	No
Yekatit 12	Yes	No	Yes	No	Not conducted
Minelik II	Yes	Not disposed	Yes	No	Before a year
Amanuel	No	Not at all	Yes	Yes	Never conducted
ALERT	No	Not	Yes	Yes	Not conducted
Gandi	Yes, not functional	No	Yes	No	Before 10 years
St Peter	No	No	Yes	No	Not at all
Ras Desta	Yes	Yes	Yes	No	Before a year

The combined percentages mean ratings for public hospitals' medical equipment disposal management was 12 per cent, with a minimum of 0% in Minelik II and St Peter hospitals and a maximum of 42% in Zewditu hospital (Figure 5).

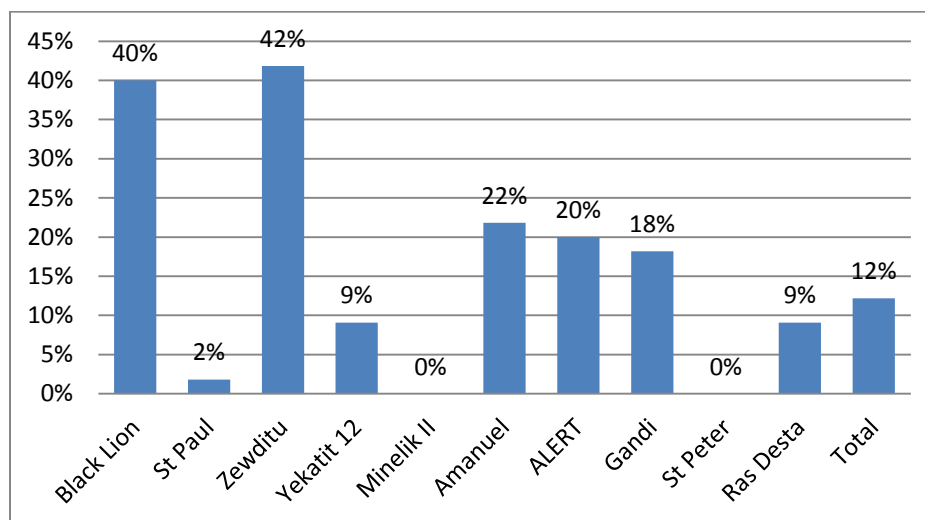


Figure 5: Management of medical equipment disposal in public hospitals of Addis Ababa

The following table indicates the descriptive statistics on the rating of technicians on each components of the medical equipment disposal combined measures. The maximum mean of the individual components is 2.8 with a standard deviation of 2.5 for the presence of fixed assets disposal committee in the hospitals. The smallest mean is the mean for regular disposal of unusable stock with a value of 0.3 (Table 7).

Only one of the hospitals claimed to conduct regular disposal of medical equipment for selected medical equipment, which is rated as good by the biomedical technician. In one of the hospitals it has been reported that the technicians recommend the hospital management to outsource the identification of nonfunctional equipment to science and technology engineers, however, due to lack of budget the hospital fail to proceed with it.

Table 7: Management of disposal of medical equipment in the public hospitals of Addis Ababa

S.No.	Parameters of disposal of medical equipment	Rating (0-5)				
		N	Minimum	Maximum	Mean	Std. Deviation
1	Hazardous parts of the medical equipment is disposed safely	10	0.00	5.00	.7000	1.63639
2	The hospital has clear direction on identification of medical equipment to be disposed	10	0.00	5.00	1.6000	1.95505
3	There are policies and procedures for medical equipment disposal	10	0.00	5.00	.8000	1.75119
4	The facility conducts regular disposal of outdated and unusable medical equipment	10	0.00	3.00	.3000	.94868
5	All obsolete and damaged medical equipment are disposed properly	10	0.00	4.00	.7000	1.49443
6	The procedures used for disposal of medical equipment is effective, efficient and simple	10	0.00	1.00	.1000	.31623
7	The hospital documents the detail information about the disposed medical equipment	10	0.00	3.00	.6000	1.07497
8	Information on disposal of medical equipment is used as an input for development plan	10	0.00	4.00	1.0000	1.63299

4.1.1.6. Management Support to Medical Equipment Management

The responses on degree of recognition of biomedical engineering units by hospital administration fell into three categories: Full recognition, partial recognition and no recognition. Out of the total of 10 hospital respondents, 10% indicated that their departments were sufficiently recognized, 20% achieved no recognition and 70% attained partial recognition (Table 8). According to the respondents, 70% of the hospitals provide training for end users on medical equipment operation. 60% of the hospitals provide adequate training for biomedical engineers or technicians. Only 2 of the 10 hospitals have human resource capacity building plan.

Table 8: Management support for medical equipment management in public hospitals of Addis Ababa

Name of the Hospital	Training to Biomedical Eng. / Tech.	Training to users	Recognition	HR capacity building plan
Black Lion	Yes, 4 post graduate	Yes, there is high staff turnover	Partial	No
St Paul	Yes, but not advanced	Yes	Partial	No
Zewditu	No	No	Partial	No
Yekatit 12	No	Yes	Partial	No
Minelik II	Yes	Yes	Partial	No
Amanuel	No	No, at the time of installation of the machine	No	Yes
ALERT	Yes	Yes	Partial	Yes
Gandi	Yes	Yes, but the number of professionals trained is not enough	Partial	No
St Peter	No	No	No	No
Ras Desta	Yes	Yes	Full	No

In spite of continuous inter-departmental transfer of nurses, there is no ongoing regular training of nurses in their "new" departments. 50% of the interviewed primary users of medical equipment including laboratory technologists, x-ray technicians and nurses during the field visits had not even been trained on new medical equipment before using it. According to the biomedical technicians, only 60% of the facilities have training for users of medical equipment.

60% of the hospitals provide training for biomedical engineering units ranging from local short term training to MSc program in Biomedical engineering. It is worth mentioning that Black Lion hospital sent its 4 biomedical engineers to attend Master's program in Addis Ababa University. In the rest of the hospitals the training of professionals is not governed by proper planning of human resource development. In most of the cases, the professionals get trained when the hospitals receive invitation of training from other institutions like the Science and Technology.

4.1.2. Medical Equipment Performance

The performance of medical equipment in the public hospitals of Addis Ababa, vary from 53 % to 82 % with an average of 66%. The following table indicates the performance of medical equipment in the nine public hospitals of Addis Ababa (Table 9). It was impossible to get the information from one of the hospitals.

Table 9: Performance of selected medical equipment in public hospitals of Addis Ababa

S. No	Name of hospitals	Total number of medical equipment included in the study (Sample equipment)	Number of operational medical equipment (Functional devices)	Performance of medical equipment (%)
1	Black Lion	294	185	63%
2	St Paul	31	21	68%
3	Zewditu	39	22	56.4%
4	Yekatit 12	77	60	78%
5	Minelik II	39	32	82%
6	Amanuel	24	17	71%
7	Alert Hospital*			
8	Gandi	16	10	63%
9	St Peter	14	9	64%
10	Ras Desta	34	18	53%
	Total	568	374	66%

*Data was not collected from the hospital because of absence of database and difficulty of conducting physical inventory.

4.1.3. Factors Affecting Performance of the Medical Equipment

4.1.3.1. Technological complexity of equipment

As it is indicated in the methodology, complexities of medical equipment involved in the study are measured as indicated in Appendix E.

The following graph shows the relationship between complexity and performance of medical equipment.

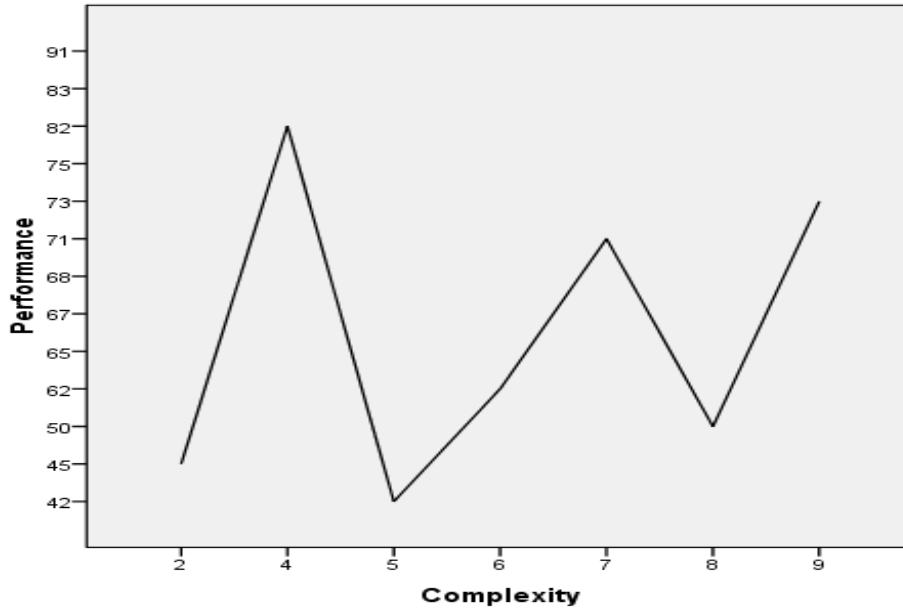


Figure 6: Relationship between performance (%) and complexity of machines (0-10)

The following table indicates the bivariate correlation between complexity of medical equipment and performance of the equipment.

Table 10: Bivariate correlation between complexity of medical equipment and performance

		Complexity	Performance
Complexity	Pearson Correlation	1	.026
	Sig. (2-tailed)		.924
	N	16	16
Performance	Pearson Correlation	.026	1
	Sig. (2-tailed)	.924	
	N	16	16

4.1.3.2. Degree of standardization and equipment performance

The following table shows the degree of standardization and equipment performance in Addis Ababa public hospitals. The degree of standardization varies from 0.09 of Amanuel hospital to the maximum of 0.50 of Black Lion hospital. Information on models and manufacturers of the medical equipment was not found for St Paul hospital and the inventory was not done in ALERT. Hence, degree of standardization was not calculated for the hospitals.

Table 11: Degree of standardization and performance of medical equipment

S. No	Name of hospitals	Degree of standardization (STD)	Performance of medical equipment (%)
1	Black Lion	0.4	63%
2	St Paul	NA	68%
3	Zewditu	0.14	56.4%
4	Yekatit 12	0.31	78%
5	Minelik II	0.50	82%
6	Amanuel	0.09	71%
7	ALERT	NA	NA
8	Gandi	0.2	63%
9	St Peter	0.04	64%
10	Ras Desta	0.14	53%

Table 12: Bivariate correlation between Degree of standardization and performance of medical equipment in the public hospitals of Addis Ababa

		Performance	STD
Performance	Pearson Correlation	1	.582
	Sig. (2-tailed)		.130
	N	8	8
STD	Pearson Correlation	.582	1
	Sig. (2-tailed)	.130	
	N	8	8

4.2. DISCUSSION

4.2.1. Medical Equipment Management System

4.2.1.1. Policies and procedures for the management of medical equipment

The EHRIG recommends establishment of a committee on medical equipment management in all hospitals of the country. Although all the public hospitals of Addis Ababa are implementing the hospital reform, as indicated in the result part, only 6 out of the 10 hospitals have the committee. Since the committee has the responsibility to oversee the management of equipment in the hospitals, the absence of the committee greatly hinder the improvement of medical equipment management in the hospitals. The study also indicated that the committee is not active in hospitals where it exists.

According to the EHRIG, to develop and monitor implementation of medical equipment strategy, to establish and monitor the implementation of policies on procurement, donation, installation, maintenance, and disposal are enumerated as a role of the committee (FMOH, 2010b).

Because of the absence or weak performance of the committee, most of the hospitals don't have the policies and procedures for the management of medical equipment. Amanuel hospital is the only hospital with the policies and procedures. The policies and the procedures of Amanuel hospital provide the framework for the management of medical equipment and it is a good start to have detailed policies.

The presence of list and specification of medical equipment to be used by the hospitals is the road map for the management of medical equipment in the hospitals. The hospitals are required to prepare their own list of medical equipment to address essential health service package of the hospitals. The absence of the list in six of the hospitals may cause procurement of medical equipment of poor quality. If the hospitals lack well thought specifications, they may be forced to urgent preparation of the specifications for procurement purpose.

Although the hospital reform guidelines prescribe development of different policies on medical equipment management including donation, servicing and disposal, nine of the

hospitals failed to prepare policies. Since the hospitals are getting most of their medical equipment through donation it is decisive to guide the management of medical equipment for better performance of medical equipment in the hospitals. Therefore, the lack of the policies and procedures on donation of medical equipment may contribute to poor performance of medical equipment.

4.2.1.2. Procurement of Medical Equipment

Fifty per cent of the hospitals lack medical equipment development plan. The remaining 50% do have some sort of plan which is not comprehensive. Hence, the procurement of medical equipment is not being led strategically. In the absence of the plan, it is not an easy task for hospitals to dedicate budget and other resources for the procurement of capital items including medical equipment. If the hospitals don't have clear plan on the development of medical equipment, the hospital's resource is in a higher risk of being spent on less important equipment.

One of the gaps identified in the management of procurement of medical equipment is absence of leasing as a means of procuring medical equipment. Leasing is a growing trend world-wide and an option worth considering, with advantages such as minimal initial capital outlay and quick availability. However, they should be based on analysis of comparable break-even costs between lease cost, ownership cost and the percentage of time the equipment will be productively employed over its useful economic life-span.

Another problem with the procurement of medical equipment is absence of plan for procurement of medical equipment. Since hospitals initiate procurement abruptly because of unplanned allocation of budget by the government or development partners, list and specification of medical equipment is prepared urgently. Because of this, it has been reported that hospitals face a problem of physical space to install the medical equipment procured by the hospitals. In one of the hospitals, ultrasound machine has been kept without being installed for 3 years, because of lack of standard room for the machine.

All of the hospitals don't have monitoring and evaluation for the management of the procurement on medical equipment. As monitoring and evaluation is a key for the regular and continuous improvement of performance, its absence in the facilities aggravates the situation.

4.2.1.3. Donation of Medical Equipment to the Hospitals

The combined percentage of the donation management of medical equipment indicates that the donation management of medical equipment in the public hospitals is poor. This means that the hospitals are not in a good position in terms of donation management as it is measured by the parameters that are crucial for the better management of donation.

Appropriate donations of medical equipment can be of benefit to hospitals in resource-poor settings, but recipients and donors need to actively manage donations to ensure that the donations are beneficial (Stephen RC, et al., 2008).

Hospitals should be able to consider donation of medical equipment as purchasing of medical equipment and hence the donation of medical equipment should follow all the necessary steps followed in the purchasing of the equipment. The procurement of medical equipment through donation starts from the request of the hospital after analyzing the medical equipment need of the hospital. In the study only one biomedical technician rated excellent for the "donation is based on request from the hospital". Others claim that some of the medical equipment are donated based on the request of the hospital and there are also equipment which are donated by the sole interest of the donor.

WHO guideline highly recommends the involvement of the hospital commencing from pre donation receipt preparation. Although the Ethiopian drug donation guideline is not prepared specifically to manage medical equipment donation, it indicates that the hospitals have the right to return drugs, medical supplies and medical equipment if they fail to satisfy the requirements (DACA, 1996). Except two of the hospitals, other hospitals never practiced to refuse receiving medical equipment which is not needed by the hospitals.

The low rating of donation of medical equipment management practice in the hospitals emanates from lack of clear direction and due to wrong perception of the hospital management i.e. “it is not fair to refuse to receive donation”.

Since most of the hospitals don't have the medical equipment development plan, the donation management is governed by sudden decisions and wishes of individuals who have access to request donations from the donors.

4.2.1.4. Maintenance of Medical Equipment

The 33 % composite rate on maintenance management indicates that the management of medical equipment in the hospitals is poor. This poor performance is mainly manifested by absence or weak preventive maintenance management, lack of policies and procedures on maintenance, testing and acceptance of medical equipment etc.

One major gap which is documented in this study is weak management support of the management for the management of medical equipment maintenance. In the contrary, 70% of the respondents mentioned that they have enough finance for medical equipment maintenance management. Hence, the facilities are mainly facing shortage of other resources than finance.

As indicated in the result, 70% of the hospitals don't hold reasonable amount of spare parts for maintenance of medical equipment. Since maintenance materials are needed for the lifetime of the equipment, the availability of equipment spare parts and maintenance materials will dictate how long maintenance staff can keep a piece of equipment functioning. Once spare parts and maintenance materials are no longer available, a piece of equipment cannot be repaired even if it is fixable. Therefore, unavailability of spare parts is exerting high burden on the maintenance management.

Since most of the hospitals don't have acceptable history file, the management of maintenance of medical equipment is at a higher risk. New technicians who are working on

maintenance of machines need to have the whole history of the machines, so that they can easily identify the problems.

Standardization of medical equipment is beneficial for the improvement of medical equipment maintenance management. In many countries, machine breakdown is a common challenge to delivering diagnostics results and providing monitoring service of patients. In some countries, having a larger number of one type of equipment has allowed ministries of health to negotiate maintenance contracts with the purchase of reagents. Given that nonfunctional equipment is a major bottleneck to medical equipment management, the negotiation of service as part of the commodity contract is critical to the success of management of medical equipment.

Standardization of medical equipment, which is identified as one of the major contributors for better management of maintenance, is rated from very poor to good with an average rating of poor. The degree of standardization of the medical equipment is very low with the maximum degree of standardization of 0.5 for Minelik II hospital, which is due to the specialization of the hospital in ophthalmic services.

Data supplied by the respondents indicated that all the hospitals were predominantly using a combination of internal and external maintenance services. For the maintenance of minor problems the internal biomedical technicians handle the management of maintenance. However, complicated problems which require costly spare parts are managed by the agents of the manufacturer or well trained technicians from Science and Technology Ministry.

During the interview, biomedical technicians mentioned that primary users of medical equipment don't operate medical equipment as per the requirements. One of the reasons for this is inadequate training provided to the users. Since the training on the equipment is provided during the installation of the equipment and there is no continuous training on the operation of the machine, medical professionals who are using the machines are obliged to run the machine without adequate knowledge and skill on the operation and safety of the equipment.

The maintenance of medical equipment requires a huge amount of money. During the interview, the respondents repeatedly mentioned that there is lack of adequate budget for maintenance management. In addition to finance, they also lack workshops and tools that are needed for maintenance of the equipment. In one of the hospitals, x-ray machine is not maintained for more than 10 years because of the high cost of maintenance.

The vital problem in the maintenance of medical equipment is lack of spare parts. In most of the hospitals there are equipment which are old and obsolete, for which getting spare parts is difficult. In some cases the problem extends to failure to get spare part for the new medical equipment. Since some of the vendors don't have agent in the country, getting spare parts becomes an issue. The PFSA is exerting efforts in selecting vendors which have agents in Ethiopia, so that the agent ensures provision of maintenance with spare parts imported from the manufacturer. In one of the hospitals, one x-ray machine is not functional for the last 3 years and in the same hospital a fluoroscopy machine is non-functional for three years because some spare of the machine were taken to maintain non-functional x-ray machine.

4.2.1.5. Disposal of Medical Equipment

Disposal of medical equipment is one of the major areas where there is an enormous problem in the management of medical equipment. As it has been observed in the hospitals, there is not any regular disposal of medical equipment in all of the hospitals. The low composite rate of disposal management is comprised of absence of policies and procedures, unable to conduct disposal regularly, absence of fixed asset committee and lack of clear direction on the identification of unusable medical equipment.

As per the recommendation of the EHRIG, the majority of the hospitals have fixed asset disposal committee to oversee the disposal of fixed assets including medical equipment. However, the absence of disposal in the hospitals indicates that the committee is not functioning as per the recommendation.

4.2.1.6. Management Support to Medical Equipment Management

Management support is crucial for the management of medical equipment. The support of the management in the hospitals included in the study was found to be insufficient. Only one of

the hospitals is fully recognized. In most of the hospitals the recognition of the unit is not satisfactory. The less attention given to the unit can be well explained by the absence or weak functioning of the medical equipment management committee.

The provision of modern medical equipment in the hospitals is as important as the availability of human resources which can operate appropriately and maintain properly. Without the availability of well- trained biomedical technicians it is not possible to improve the management of medical equipment in the hospitals. Also, there was total agreement amongst all respondents that training for primary users and operators reduce equipment downtime.

4.2.2. Medical Equipment Performance

The data on equipment performance confirms the finding that the 'medical equipment problem' indeed exists. The striking variation in performance between hospitals raises the question why one hospital, in this case, Amanuel performs so much better than the others. The presence of the policies on medical equipment management as well as better performance of the hospital with respect to management of procurement, maintenance and donation of medical equipment may have contributed to the better performance in Amanuel hospital.

The total equipment performance for the hospitals (66%) is in agreement with the low performance of medical equipment in most of the developing countries. The fact that 34% of the medical equipment don't provide the intended services has a great meaning for countries like Ethiopia. Given the huge investment of government and development partners in medical equipment, the low utilization of medical equipment causes inefficient use of the scarce resource.

The average performance in the hospitals is better than the average performance selected hospitals from Sri Lanka (58%) and Yemen (54.2%). The performance is comparable with Ghana's performance (66.8%) and it is lower than Costa Rica (86.4%) (Rommelzwaal, 1997a) (Dasanayaka, 2006).

4.2.3 Factors Affecting Performance of the Medical Equipment

4.2.3.1 Technological complexity of equipment

The finding indicates that there is no relationship between operational performance and inherent complexity of equipment. The relationship between the two variables is statistically insignificant at 95% confidence interval. Therefore, the hypothesis which states that there is negative relationship between degree of complexity and performance is rejected.

In a study it is noticed that for the hospitals in Yemen and Ghana the performance of the medical equipment is clearly related to the degree of complexity of the equipment. In those countries relatively more problems are encountered for equipment of medium and high complexity than for the more simple and robust equipment. By contrast, for Costa Rica it is reported that performance is rather constant over the entire range of complexity.

4.1.3.2 Degree of standardization and equipment performance

The overall result on performance and degree of standardization shows that the relationships between the degree of standardization and equipment performance is not significant at 95% confidence interval. Therefore, the hypothesis of positive correlation between the two variables is rejected.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1. Summary

Most of the hospitals established medical equipment management committee to oversee the management of medical equipment in the hospitals. However, all of them are not functional. As a result, except in one of the hospitals, medical equipment management policies and procedures prescribed by EHRIG are not developed by the hospitals.

Public hospital of Addis Ababa acquires medical equipment both by donation and purchase. None of the hospitals acquire equipment by leasing. The composite measure of the procurement system is rated as 52%, indicating fair management of medical equipment procurement. The hospitals procure medical equipment directly from the PFSA if the medical equipment is available in the agency. If the agency doesn't have stock of the medical equipment the hospitals transfer budget and the agency procures the equipment as per the procurement proclamation of the country.

Most of the medical equipment donated to the hospitals were not requested by the hospitals. The procurement of the medical equipment by donation follows different procedure from purchase of medical equipment. The composite measure of the donation system for medical equipment is rated as 33%. The hospitals lack clear direction not to receive medical equipment which doesn't satisfy the requirements of the hospital. In most of the cases, the medical equipment are directly delivered to the pharmacy store and the biomedical technicians get acquainted with the arrival of the equipment after it is received without technical approval from them.

Poor quality of medical equipment, lack of standardization of medical equipment, long lead time of procurement are among the major challenges of procurement of medical equipment. The PFSA incorporated installation of machine, presence of local reliable agent, provision of spare parts for five years in the tender document of the procurement of medical equipment.

The study reveals that none of the hospitals do have inventory management of medical equipment, spare parts, safety materials and workshop tools.

The combined percentages mean ratings for public hospitals medical equipment maintenance management was 33 per cent. This has contributed to the low performance of medical equipment in the hospitals. The low measure of maintenance management is demonstrated by lack or weak preventive maintenance, shortage of qualified professionals, lack of spare parts, shortage of budget for maintenance, inadequate training of biomedical technicians and users of the medical equipment, using obsolete medical equipment, lack of standardization of machines, lack of clear procedures.

The combined percentages mean ratings for public hospitals' medical equipment disposal management was 12 per cent. Although 60% of the hospitals do have the fixed asset committee responsible for disposal of medical equipment, none of the hospitals disposed medical equipment except that some of them have disposed metallic medical equipment. There is also lack of direction to identify medical equipment to be disposed.

Only 10% of the biomedical technicians believe that the biomedical unit is sufficiently recognized, 70% and 20% believe that the unit is partially and not recognized respectively. The medical equipment management of the hospitals suffers with inappropriate staffing of biomedical technicians. Except Black Lion Hospitals other don't have the required number of staff for the management of medical equipment.

In 70% of the hospitals, the budget allocated for the management of medical equipment is adequate. Paradoxically, most of the hospitals (70%) suffer from shortage of spare parts, which is mainly unavailability of the spare parts.

The performance of medical equipment in the public hospitals of Addis Ababa is 66 % with the minimum 53% in Ras Desta hospital and a maximum of 82% in Minelik II hospital with a standard deviation of 10%.

The study indicated that there is no correlation between complexity of medical equipment and performance of medical equipment. Also, performance of medical equipment is not correlated to degree of standardization.

5.2 Conclusions

The availability of medical equipment management committee in the hospitals is crucial. All the facilities are weak in ensuring well- functioning medical equipment management committee. Also most of the hospitals lack policies, procedures and guidelines to manage medical equipment in their organization.

There are significant problems on the management of procurement of medical equipment in all of the hospitals included in the study. Lack of standard list and specification of medical equipment, lack of clear direction on management of donation of medical equipment, less involvement of biomedical technicians in preparation of specifications and less standardization of medical equipment contributed to the poor quality of medical equipment acquisition.

The procurement of medical equipment which is handled by PFSA considers after sales services, installation of the equipment, and availability of spare parts. The practices followed by the agency have the potential to ensure getting the right quality of product at the right cost. However, the lack of flexibility on the procurement procedure to accommodate modern principles like standardization of medical equipment compromises the best return the country can get out of the procurement.

The hospitals don't have well established inventory control management for the management of medical equipment. Quantities of equipment to be procured, when to order new ones and how much to handle is determined by unprofessional guess and personal interest of professionals.

The attention given for biomedical engineering unit is not satisfactory. In most of the hospitals the unit is not well staffed, it doesn't have workshops, spare parts and other tools that are required for the better management of the unit.

The management of medical equipment in all of the hospitals is at its infancy stage and there are efforts to reform the management. With the assignment of new biomedical technicians in the hospitals, there is a potential to improve the management with minimal efforts. The low

performance of donation management and poor maintenance management of medical equipment may have caused the low performance of medical equipment.

In Addis Ababa public hospitals, the low performance of medical equipment is not explained by the complexity and lack of standardization of medical equipment.

5.3. Recommendations

The following recommendations were made for Federal Ministry of Health, PFSA, FMHACA, Addis Ababa City Administration Health Bureau and hospitals to take corrective action for the better management of medical equipment.

FMHACA

- The FMHACA has to accelerate approval of the national list and specifications of medical equipment prepared by the authority.
- FMHACA has to prepare national donation guideline on medical equipment or revise the drug donation guideline to address specific situations relevant to medical equipment.
- The country spends a huge amount of money for the procurement of medical equipment. The medical equipment procured by the hospitals are registered by FMHACA. Hence, in order to avoid poor quality of medical equipment FMHACA has to introduce stringent regulatory requirements for the registration of medical equipment.

Federal Ministry of Health

- The Ministry has to scrutinize the implementation status and be able to provide regular feedback for the improvement of the management of medical equipment.
- The ministry has to work on standardization of medical equipment starting from capital intensive medical equipment.
- Provide clear guidance on major gaps of medical equipment management specially donation and disposal of medical equipment.

- The Ministry has to create pool of technicians that are specialized in the maintenance management of high value medical equipment. This can be done through establishment of national workshop or rotation of hospital based technicians among the hospitals.
- The Ministry has to advocate the EHRIG to Addis Ababa Health Bureau and Federal hospitals, so that all the hospitals establish well- functioning medical equipment management committee.

PFSA

- PFSA has to create clear communication with the hospitals including signing of contract and evaluation of performance with the clients.
- PFSA should give attention to quality of medical equipment beyond the compliance to the proclamation of public procurement. One way of doing so is to advocate for standardization of medical equipment in the public hospitals.
- PFSA has to strengthen the consideration of installation of equipment, availability of spare parts and presence of local agents in its future procurements.
- PFSA has to involve the biomedical technicians of its clients on the evaluation of tender.

Addis Ababa City Administration Health Bureau

- The bureau has to enforce management of medical equipment through proclamations, regulation and directives that promote improved management of medical equipment.
- The bureau has to enforce the establishment of medical equipment management committee and implementation of the EHRIG in all hospitals managed by the bureau.
- The bureau has to work closely with the Addis Ababa Finance Bureau, to introduce appropriate accounting recording of medical equipment.
- The bureau has to work closely with PFSA to monitor the procurement of medical equipment so as to improve the procurement practice of the agency and hence to get better and quality medical equipment.
- The bureau has to provide training to the management of the hospitals to ensure implementation of the reform in the hospitals.

- Allocate adequate budget to the hospitals for the management of medical equipment.

Public hospitals of Addis Ababa

- Make sure that the structure of biomedical engineering unit commensurate with the vast roles and responsibilities of the unit.
- Hire biomedical engineers and technicians.
- Revitalize or establish the medical equipment management committee and develop terms of reference that addresses the major components of medical equipment management.
- Provide all the required support for the committee so as all the relevant policies and procedures will be in place and it is implemented accordingly.
- Prepare medical equipment development plan of the hospital and allocate resources including finance for the management of medical equipment.
- Identify all the non-functional medical equipment, analyze the clinical and financial implication of the non- functionality, advocate for allocation of budget for maintenance and disposal of medical equipment.
- Introduce clear monitoring and evaluation of medical equipment management.
- Introduce inventory control management system to manage medical equipment in the hospitals.

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APPENDIXES

APPENDIX A: Medical Equipment Management System Assessment Tool

This study is conducted for the partial fulfillment of MBA program at St. Mary's University College. The objective of the assessment is to identify major gaps on management of medical equipment and propose solutions for the improvement of the management in public hospitals of Addis Ababa. To this end, I kindly request you to complete the following questionnaire. It should take no longer than 20 minutes of your time. Your response is of the utmost importance to us.

Thank you for your cooperation!!!

Sincerely yours,

Tesfaye Seifu

Direction for completion of the questionnaire: This questionnaire asks to rate the current status of medical equipment management in your health facility. For each item, circle number 0 - Very poor, 1 - Poor, 2 - Fair, 3 - Good, 4 - Very good, and 5 - Excellent.

Name of the hospital

Name of the respondent: _____ : _____

Years of exp. Total _____ In the hospital _____

Position: _____

S.No.	Parameters	Rating					
I	Donation						
1	Most of the donated medical equipment are beneficial to the hospital	0	1	2	3	4	5
2	The hospital accepts donation after ensuring availability of accessories, SPs and consumables.	0	1	2	3	4	5
3	The hospital follows the normal process of acceptance of ME as in the case of purchases	0	1	2	3	4	5

S.No.	Parameters	Rating					
		0	1	2	3	4	5
4	The hospital refuses donation of medical equipment that doesn't satisfy the requirement of the hospital	0	1	2	3	4	5
5	Donations are made based on the request of the hospital	0	1	2	3	4	5
6	Donations conform with the medical equipment development plan of the hospital	0	1	2	3	4	5
7	The hospital involves in all stages of donation of ME	0	1	2	3	4	5
8	The donors provide/ arrange all relevant services to the hospital	0	1	2	3	4	5
9	The hospital gets spare parts and consumables for the sustainable operation of the machines	0	1	2	3	4	5
II	Procurement						
1	The tender committee gives attention to the decision of technical team/ the tender committee has the expertise on medical equipment management	0	1	2	3	4	5
2	The procurement of ME considers appropriateness to the setting of the hospital	0	1	2	3	4	5
3	The procurement of ME considers ease of utilization and maintenance	0	1	2	3	4	5
4	The procurement of ME considers cost and affordability	0	1	2	3	4	5
5	The hospital has medical equipment leasing procedure system	0	1	2	3	4	5
6	The hospital is good in negotiating with the vendors in setting warranties	0	1	2	3	4	5
7	The hospital has good medical equipment procurement service contract management	0	1	2	3	4	5
8	The hospital has medical equipment development plan	0	1	2	3	4	5
9	The hospital has clear direction as when to replace medical equipment	0	1	2	3	4	5
10	The hospital has monitoring and evaluation of ME procurement	0	1	2	3	4	5
III	Maintenance						
1	There are policies and procedures for medical equipment servicing	0	1	2	3	4	5
2	A maintenance notification and work order system has been established	0	1	2	3	4	5
3	The hospital has preventive maintenance (PM) management system	0	1	2	3	4	5
4	PM of medical equipment is scheduled	0	1	2	3	4	5

S.No.	Parameters	Rating					
		0	1	2	3	4	5
5	Inspection and testing of medical equipment (ME) is scheduled and conducted	0	1	2	3	4	5
6	All new equipment undergo acceptance testing	0	1	2	3	4	5
7	The hospital has acceptable maintenance record system	0	1	2	3	4	5
8	There is standardization of medical equipment in the hospital	0	1	2	3	4	5
9	The hospital has all the necessary resources including finance to manage ME maintenance	0	1	2	3	4	5
10	The hospital has enough human to resource to manage the maintenance of ME s	0	1	2	3	4	5
11	The hospital holds reasonable amount of spare parts for maintenance of medical equipment	0	1	2	3	4	5
IV	Disposal						
1	There are policies and procedures for medical equipment disposal	0	1	2	3	4	5
2	The facility conducts regular disposal of outdated and unusable medical equipment	0	1	2	3	4	5
3	There are policies and procedures for medical equipment decommissioning	0	1	2	3	4	5
4	The facility has fixed assets disposal committee	0	1	2	3	4	5
5	All obsolete and damaged medical equipment are disposed properly	0	1	2	3	4	5
6	The procedures used for disposal of medical equipment is effective, efficient and simple	0	1	2	3	4	5
7	The hospital documents the detail information about the disposed medical equipment	0	1	2	3	4	5
8	Information on disposal of medical equipment is used as an input for development plan	0	1	2	3	4	5
9	Hazardous parts of the medical equipment is disposed safely	0	1	2	3	4	5
10	The hospital has clear direction on identification of medical equipment to be disposed	0	1	2	3	4	5

APPENDIX B: Semi structured interview Questions

S.No	Questions	Yes	No
1	Does the hospital have the following for the management of medical equipment?		
	i. ME selection guideline		
	ii. ME procurement guideline		
	iii. Specification of ME		
	iv. List of ME		
	v. Policies and procedures for acquisition		
	v. Policies and procedures for donation		
	vi. Plan for replacement of obsolete		
	vi. Leasing procedures		
	vii. ME servicing policies and procedures		
	vii. ME disposal policies and procedures		
	<i>Note: If the hospital has one, collect them for possible review</i>		
2	Who is responsible for the procurement of medical equipment?		
	i. The procurement unit		
	ii. The biomedical engineering unit		
	iii. The tender committee		
	iv. Technical staff from relevant departments		
3	Who are involved in the preparation of medical equipment specification?		
	i. The procurement unit		
	ii. The biomedical engineering unit		
	iii. The tender committee		
	iv. Technical staff from relevant departments		
4	Who are involved in the evaluation of medical equipment tender		
	i. The procurement unit		
	ii. The biomedical engineering unit		
	iii. The tender committee		
	iv. Technical staff from relevant departments		
5	What are the major sources of medical equipment in the hospital?		
	i. Purchasing		
	ii. Donation		

S.No	Questions	Yes	No
	iii. Leasing		
	Other, specify _____		
5	Does the hospital include installation and commissioning in the procurement of ME		
6	What are the major challenges of the hospital with regard to procurement of medical equipment?		
	Maintenance		
1	Is there any standardization of medical equipment in the hospital?		
2	Does the facility has plan for preventive maintenance		
	<i>Note: Review the plan and take short note on which of the ME are included.</i>		
3	Does the hospital have maintenance record system?		
4	Does the facility has all appropriate resources to manage the maintenance?		
	i. Workshop		
	ii. Reference materials		
	iii. Spare parts		
	iv. transport		
	v. Information		
	vi. Finance		
5	How many Staff does the maintenance unit have?		
6	Rate the level of medical equipment management problems in your hospital		
	Major		
	Significant		
	Insignificant		
	No problem		
7	Which of the medical equipment take the highest maintenance budget?		
	i. Diagnostic		
	ii. Monitoring		
8	What are the major challenges of the hospital with respect to medical equipment maintenance?		

S.No	Questions	Yes	No
III	Disposal		
1	Does the hospital have medical equipment (fixed assets) disposal committee?		
2	How frequently the hospital disposes medical equipment? _____		
3	Does the facility have stock of obsolete and unusable medical equipment?		
4	If yes, why it is not yet disposed? _____		
5	Does the hospital properly record the current value of the ME? <i>Note: Refer fixed assets</i>		
7	Does the facility have inventory control system for the following? spare parts Workshop equipment Safety equipment Medical equipment		
IV	Management Support		
1	Where the medical equipment management unit does fits in the structure of the hospital? _____		
	Note: Sketch the organizational structure of the organization indicating the biomedical engineering unit		
2	The biomedical engineering team has: Full recognition No recognition partial recognition		
3	Does the facility have plan for HR capacity building for medical equipment management?		
4	Does the maintenance team get regular training on maintenance for biomedical engineers/technicians?		
5	Does the hospital provide training for primary users of the medical equipment?		

APPENDIX C: Questionnaire for primary users

S.No	Questions	Yes	No
1	Have you taken training on how to operate the medical equipment you are using in your unit?		
2	Do you provide preventive maintenance to the ME you are using?		
3	Is there scheduled PM for the ME you are using?		
4	Who is responsible to maintain the machine? A. Biomedical technician of the hospital B. Sole agent of the machine C. External technician		
5	Do you get the maintenance service in a reasonable period of time?		
6	Is there any machine in your unit which is not functional?		
7	For how long did the machine remained nonfunctional?_____		
8	Why it is not maintained till now?		
9	Are you confident that the machine you are working with provides the intended service with quality?		
10	If No, to No.9 why?_____ _____ _____		
11	What do you think are major problems with medical equipment in your unit?_____ _____ _____ _____ _____ _____ _____ _____ _____ _____		

APPENDIX D: Medical Equipment inventory form

Dept	Equipment Name	Model	Manufacturer	Country of Origin	Year of Manufacture	Oper Cond	When Down	Use	Oper	Eng	Stock Man	Oper Man	Serv Man	Prts Man

APPENDIX E: Evaluation of complexity of medical equipment

Who performs maintenance of this equipment? C= Mainly company (>75%) I=Mainly In-house (>75%) M=Mixed	Is the equipment easy or difficult to repair and calibrate										What type of components and technique are used in the equipment										Is the equipment user-friendly and easy to operate?										Are many connections and supplies required? (For example: Steam, water, electricity, gas and solar)										
Name and EQUIPMENT CATERGORY	MAINTENANCE AND CALIBRATION Weight 40%										INCORPORATED COMPONENTS Weight 30%										OPERATOR COMPLEXITY Weight 20%										AUX SUPPLIES AND CONNECTIONS Weight 10%										Score
	Simple					Complex					Simple					Complex					Simple					Complex															
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	
X-ray machine					X										X								X																		5
Ultrasound		X														X				X											X										4
Electrocardiograph				X															X												X										5
Operating Theatre Light	X										X												X								X										2
Operating Table	X										X												X								X										2
Anesthesia trolley (Anesthesia machine with ventilator and monitor)										X										X														X							7
Suction pump	X											X											X								X										2
Pulsoximeter				X															X				X								X										6
Patient monitor, ICU	X																		X				X								X										4
Oxygen concentrator				X											X					X			X												X						6
Analyzer Hematology									X											X				X				X													9
Chemistry Analyzer									X											X					X			X													9
Electrical Autoclave	X										X												X						X												2
Electroencephalograph - Analyzer									X											X					X						X										8
CT-Scanner									X											X					X						X										8
CD4 Machine									X											X					X						X										8

Note: Complexity score calculated as: 0.4(Score Column 1) + 0.3(Score Column 2)+0.2(Score Column 3)+0.1(Score Column 4)