

Maintenance Management of Medical Equipment in Hospitals

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Abstract

The research paper evaluated the existing facilities maintenance management practices and processes in major hospitals in Kenya. The facility managers from major hospitals were interviewed on medical equipment management. The data collected from the facility managers determined their effectiveness as they managed the life cycle of the medical equipment. The results offered management the opportunity to appraise the overall maintenance program and sought improvement for increased efficiency and more effective utilization of available resources. The challenges encountered in this research included hospital's policy and technological resources. The facility maintenance management in the public hospitals was not effective as they were ranked forty percent on their performance. The maintenance computer program was developed to improve the existing facilities maintenance management for hospitals in Kenya. The program guides the user on the causes of the fault, possible personnel to handle the fault and establishment of inventory system of medical equipment.

Keywords: Health facilities, Maintenance, Medical equipment management

1. Introduction

Facilities management is a strategic function and makes a positive contribution to business growth and organization success. This is a diverse profession whose main aim is to provide quality environments, which are fit for the purpose designed for. It also involves a constant balancing act between the competing pressures of time, cost and quality (Andrew and Michael, 2007). The process yields a better productivity which means a state of efficiency or the rate and quality of output based on the rate and quality of input (Kirkland, 1985). As it relates to hospital facilities management, higher productivity can mean safer and more reliable equipment, less service cost, less equipment downtime, more revenue and more effective use of man power (Hashem and Al-Fadel, 1986).

The medical equipment management professionals ensure that equipment used in the patients care are operational, safe, properly configured to meet the mission of the medical treatment facility and continue to function effectively in a good working condition. For example, proper maintenance can extend the life of equipment. This is essential for providing 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 and budgeted for, procured, and operated etc. Human factors engineering is used to influence medical device procurement decisions in hospitals. The process ensures that the safest, most efficient and effective devices are purchased. Human factors engineering is frequently being cited as an important method to reduce medical error and adverse events and to increase patient safety, when it is applied to the design and evaluation of medical devices (Gill Ginsburg, 2004).

The medical equipment life cycle includes the tendering and commissioning of new equipment in conjunction with the end users, the training and education of all devices for staff on their operation and application, performing the necessary preventive maintenance, conducting repairs and finally device

disposal, at which point the life cycle begins again (Andreas et al, 2000). Figure 1 shows a cycle of activities in the life of equipment under equipment management (Andreas et al, 2000).

2. Case Study on Medical Equipment Failure

Medical equipment should be maintained at a higher safety level than other types of equipment. Most of sophisticated and complicated machines found in the intensive care unit, have their electrical connection existing between the equipment and patient. The equipment may be used on the patients who are not able to respond to hazardous conditions or pain while other types of medical equipment function as life support and their failure may result in the patient's death when the machine is in use.

In an Iranian hospital, a 48 year old man with left hand paresthesia and weakness lasting five years had to be operated. During the surgery the injury site temperature raised progressively leading to a grade two burn in a five by five centimetre area. The burns emerged as an iatrogenic complication of the operation. The operation room lamps were inspected and the problem was a faulty bulb. When the light was dismantled, the 110 volt lamp had been changed to a 220 volt unit. After 50 years of life, the original unit became obsolete. Additionally, the glass covering the lamp was broken. The high voltage lamp produced a considerable amount of heat, which was transferred to the operation site owing to the broken glass, resulting in a significant rise in temperature at the total point of the mirror sited on patient's elbow (Hassan et al, 2007).

Iatrogenic burns in children are quite rare and are associated with accidents in the process of paediatric treatment and care. They are most frequent in operating theatres and consist of both electrical and chemical (alcohol disinfectant) burns. These misadventures are due to misused or faulty medical equipment. Also frequent are the thermal burns that form the biggest aetiological group in the neonatal period. These are usually the result of hot water scalds when a baby is bathed after birth or else they occur because of faulty hot-water bottles (Dyakov and Hadjiliski 2001).

Emergency Care Research Institute (ECRI) investigated different incident caused by equipment malfunctioning in either diagnosing or therapeutic process. For instance the institution investigated a case in which a five year old male patient was fatally crushed beneath the pedestal-style electric bed in which he was placed upon admission to the hospital. The accident occurred when the boy was playing with or accidentally operated the beds walk-away down control, which caused the bed to continue to descent even after the control switch was released (Emergency Care Research Institute, 1987). Another case included incorrect placement of a positive end-expiratory pressure (PEEP) valve in the inspiratory limb of an anaesthesia circle system.

Indeed, equipment may be used until repairs are no longer possible. It is important, therefore, that original parts are available so that the facilities maintenance organization can use the correct parts when repairing devices (Hassan et al, 2007). The minister for medical services had to explain why cervical cancer radiotherapy machine at Kenyatta National Hospital has been inoperative for the past four years (Hansard, 2008). The East Africa Standard media established that Kenyatta National Hospital had been burdened by obsolete equipment some of which never worked from the time they were purchased. For instance the embalming machines, three X-ray machines, Sterile processing unit (SPU), Laundry equipment and dental facilities are among a huge portfolio of non-functional equipment (East African Standard, 2003). The sorry state of cancer treatment was revealed by the Nation Media Group in Nyanza Provincial General Hospital where the brachytherapy equipment used to treat cancer, was revealed to be laying dormant. For the last six years, most Kenyan cancer patients had to seek treatment outside the country, enduring lengthy travel and incurring huge expenses in the process. But it is not that treatment is not available in the country; specialized brachytherapy equipment capable of destroying cancer cells in the early stages had been lying idle both at Nyanza Provincial General Hospital and Kenyatta National Hospital (Cosmas, 2009).

The equipment for the Nyanza General Hospital was acquired in 1998 by the Government at a cost of Sh30 million and was installed in 2002. The equipment at Kenyatta Hospital was installed in 2001; it was yet to be used on a single patient. As the machine from Kenyatta National Hospital gathers dust for unclear

reasons, Nyanza General Hospital had incurred huge costs through repairs and counter-repairs of the equipment. The hospital had flown in teams of engineers several times from the Netherlands, where the branchytherapy equipment had been sent for repair (Cosmas, 2009).

The article *'The eyesore that is Kenya's hospitals'* exposed the sorry state of government hospitals. It indicated the dilapidated facilities that can barely cope with emergencies and do not adhere to clinical guidelines. The audit conducted by Ministry of medical services established that scores of hospitals have failed to live up to their billing and thus raising questions about the safety of patients (KenTV, 2009).

3. Literature Review

In 1997, an audit assessment of the facilities maintenance management in a public hospital in Malaysia was carried out. The purpose of the research was to assess the existing facilities maintenance management practices and processes in public hospital, in accordance with the concession agreement, in order to identify the performance status. The government of Malaysia took the initiative to implement this major privatization project for the provision, maintenance and management of hospital support services (HSS) of public hospital throughout the country (Maisarah et al, 2009). Three concession companies were selected to initially take responsibility on a total of 123 hospitals and four health institutions throughout the entire country making a total of 127 hospitals, on a fixed price and period basis. The questionnaire constructed was based on the following:

- Standards and guidelines in managing the environment of care as stipulated in Juran Institute (1998) Management of environment of care standards;
- Concession Agreement, hospital support services (HSS) privatization project;
- Requisites, determined as necessary from the experience of the assessors, in order to provide effective management of facility engineering maintenance.

The data was collected through questionnaires, guided interviews, documentation review and archival records. Reviews were conducted to assess five key elements: Leadership policies, service performance, supervision, training and orientation. The findings of the research described the status of facilities maintenance management in the hospitals under study to be having a good planning and management with all essential requirements and compliance with regulation. However the audit assessment was not able to develop and implement comprehensive and systematic policies, plan and procedures of facilities management through a maintenance management program. This is because the main objective of the research was only to identify the maturity level of the maintenance organization in specific hospitals with regard to the effectiveness of their management of facility engineering maintenance services. The result from the research suggested that the maintenance organization in the case study hospitals had still not realized the importance and effective maintenance management. It was apparent from the research findings that the maintenance organization had not made much effort to accomplish their roles and responsibilities towards successful implementation of facility engineering maintenance services.

In contrast the research paper on maintenance management of medical equipment in hospitals increases awareness of the maintenance contribution and highlights the practices to be introduced or requiring changes in the maintenance management in hospitals. The commitment and synergy of the maintenance organization team will prove towards realising the successful implementation of this research objective. The research project creates a computer programme to assist in solving faults of medical equipment in the hospitals.

Research on strategic management of technology in public health sector was conducted in Kenya and South Africa. The main objective was to investigate factors contributing to health care equipment problems and associated technological investments in public hospitals (Kachieng'a and Ogara, 2004). The research reviewed the processes of equipment planning, procurement and management in ten public equipment maintenance institutions. Fifty six questionnaires were mailed to target technology managers, clinical/medical engineers and technicians in public hospitals in Kenya and South Africa. Thirty eight equipment maintenance experts participated in the survey where majority of them were drawn from

teaching hospitals. After the research it was evident that the way health technology is managed in health care institutions directly affects the quality of treatment patients receive (Kachieng'a, 2004). Despite the strategic importance of technology in health care being documented widely in scientific literature; equipment planning, procurement and management have not received the attention they deserve in the transformation of health care service in the two countries under the survey (Kachieng'a and Ogara, 2004).

On the basis of the results of the research, several recommendations were proposed:

- Hospitals need equipment assets management systems for monitoring equipment life-cycle costs, maintenance costs and management of equipment replacement.
- There is need to strengthen and streamline management of technical infrastructure for health care equipment selection, procurement and maintenance management.
- To achieve optimum utilization of expensive equipment, specialized departments in public hospitals, such as radiation therapy, radiology, nuclear medicine and Renal units, should be permitted to provide specialized services to private patients to generate funds for equipment maintenance.

The research concentrated on equipment maintenance experts from public hospitals in Kenya and South Africa. The questionnaires were emailed to the responders in their respective institutions (Kachieng'a and Ogara, 2004).

The research paper on maintenance management of medical equipment in hospitals ensured that the maintenance organizations from both public and private hospitals were interviewed. The main objective was to evaluate the existing hospitals facilities maintenance management practices and processes. A computer maintenance program was developed to assist the maintenance organization.

4. Methodology

The major public and private hospitals in Kenya have 300 and above bed capacity. They admit and serve a considerable large number of clients. Several biomedical technicians were interviewed to determine the effectiveness of the existing facilities maintenance management practices and processes. Thirty two questionnaires were distributed to the facility maintenance managers in the research institutes, hospitals and other health care companies that played the role of agents or suppliers. Eighteen out of thirty two questionnaires were completed. The distributions of the respondent were 8 in-house technicians from public hospital, 3 in-house technicians from private hospitals, 5 suppliers and 2 contractors.

The questionnaire comprised of seven parameters of equipment life cycle which was adequately answered by the technicians in their respective institutions. The questionnaire had two main parts; Section A and Section B. In section A, the questionnaire defines the goal of the research and outlines the seven main parameters to be interviewed on. In section B, each main parameter had several questions in which the facility maintenance managers were required to answer appropriately. The weighting of each question was answered based on the following tabulation;

0	-	Very poor:	0%
1	-	Poor:	20%
2	-	Fair:	40%
3	-	Good:	60%
4	-	Very good:	80%
5	-	Excellent:	100%

5. Results and Discussion

The results were introduced into the SPSS program which is a powerful statistical analysis and data management system. The histograms were developed for each of the seven parameters;

- Technological Assessment and Selection
- Procurement and Logistics
- Installation and Commissioning
- Training and Skill Development
- Operation and Safety
- Maintenance and Repair
- Decommissioning and Disposal

The histograms showed the weighting of each question in their respective parameters vs. facility managers in the particular institution. In the histogram the y-axis showed the weighting of the performance while the case number in x-axis showed the facility maintenance managers in their respective institution.

5.1. Technological Assessment and Selection

The combined percentages mean ratings for public, private, consultant and contracted maintenance organizations were 67, 89, 80 and 87 percent respectively. Public hospitals are not effective in terms of proper selection as this has contributed to the failure of the equipment management in their institutions. Despite having a good performance in selection of the equipment most of their practices lead to earlier failure rate of the equipment either through manufacturing faults, design faults and misuse of the equipment as they selected faulty equipment. The following factors are not wholly considered; safety, infection control and decontamination, effective performance of the equipment, full life cost, reliability of the equipment, availability of spare parts and installation requirements.

All organizations should consider medical equipment performance with reference to the change of environment before purchasing the equipment; they should advice the supplier to undertake environmental measures and ways to reduce the environmental impact on medical equipment. The equipment should be bought from reliable companies. Technical and user manuals should be provided and the equipment should have standard parts before the equipment are purchased. The availability of spare parts will reduce the down time of the medical equipment. Increasing numbers of medical devices and complexity with increased attention to field problems has led to an increase in the number of recalls. The absence of Unique Device Identification (UDI) means hospitals often must use manual and imprecise systems to find and properly identify recalled devices. Implementing UDI in combination with device tracking would potentially increase patient safety and decrease the work load and cost to address recalls. Finding patient care devices when and where clinicians and other personnel need them is crucial to patient care.

The maintenance managers from most of the hospitals fail to assess the new technology when selecting new equipment thus compromising the patient safety. The findings show that the maintenance managers from the public hospitals need to improve on technology assessment of the equipment and their selection before the institutions buys them.

5.2. Procurement and Logistics

The combined percentages mean ratings for public, private, consultant and contracted maintenance organizations were 62, 83, 76 and 74 per cent respectively. The maintenance organizations from public hospitals do not have excellent procedures to acquire the best equipment in their procurement processes. The institutions managements or hospital boards do not involve the facility maintenance managers in equipment selections or evaluations. This has contributed to acquisition of incorrect equipment by the

hospitals or equipment for which there is difficulty in acquiring spares parts for them. The warrants of the equipment do not cover most of the crucial needs which leads to earlier failure of the equipment. The equipment are compromised due to lack of co-operation between hospital management and facility maintenance managers. The facility maintenance manager from public hospital should develop an up to date computerized inventory system. This will aid the maintenance department on identification of the type and amount of the equipment in the system. It will also help in identifying the new technology in the market.

5.3. Installation and Commissioning

The combined percentages mean ratings for public, private, consultant and contracted maintenance organizations were 74, 93, 83 and 86 per cent respectively. The organizations from the private hospitals are categorized to be excellent on installation and commissioning of equipment in the hospitals. The public hospitals maintenance managers however had lower standards compared to the rest of the organizations. This is because most of public hospitals maintenance team do not implement basic requirements procedures of installation and commissioning of medical equipment properly. Nevertheless, there existed some areas of weakness revealed from the evaluation on all the organization; applicable standards and codes of the equipment does not appear on most of the equipments labels after an installation procedure has been performed. In-service training and technical manuals are not always provided for. Acquisition of the operator's manuals, technical and in-serving training by some of the consultants and contractors has proven difficult.

The facility maintenance managers should ensure that the equipment are safe to use and complies with all required standards. Equipment should meet the specified performance criteria and should not be damaged. They should also match with the order and arrive complete with specified accessories. Equipment should be placed on a routine maintenance programme and the maintenance personnel must be trained and conversant with its use and servicing arrangements.

The availability of the technical and operational manual in every equipment being installed guarantees proper equipment managements. Technical training to facility maintenance managers ensures that medical equipment are properly managed. The suppliers may not offer training to the public hospital maintenance team as result they become incompetent not conversant with the equipment model and also servicing arrangements.

5.4. Training and Skill Development

The combined percentages mean ratings for public, private, consultant and contracted maintenance organizations were 47, 63, 62 and 72 per cent respectively. The training of equipment users and maintenance managers reduces the equipment downtime. To reduce the possibility of equipment malfunction following service or repair, all personnel involved in maintaining and servicing equipment should be trained fully to appropriate standards. From the data collected it demonstrated several weaknesses and failures by the facility maintenance managers. Public hospital maintenance organizations have no computerized medical maintenance system which could either predict necessary preventive maintenance or analyze the data streams to predict calibration problems. The in-service training programs are not normally provided to the new employees, on all equipment involved in frequent operator errors and all new equipment after the purchase. The training may be conducted by supplier agents however the organization does not fully maintain equipment manuals and training guides. The facility maintenance managers do not document orientation and annual review of employee proficiency in use and safety of each type of device. The technicians are not well trained and most of them do not proceed for higher learning especially on medical equipment training.

Equipment training is necessary in managing risk and establishing expectations for safe, quality and effective use. All health care employees who use medical equipment should be oriented to each type of device and be able to demonstrate proficiency in its use. In a given piece of equipment there are

maintenance problems of different levels of complexity. The majorities of the problems are relatively simple and can be corrected by in-house maintenance manager trained in front-line maintenance. Training of public hospital maintenance team to a high level of skills has proven to be expensive although necessary. Furthermore, upon completion of their training staff are often lured away by companies paying higher salaries. However during the purchase of new equipment, suppliers can be requested to train in-house technicians in maintenance, often at no cost. Public hospitals maintenance organizations always take advantage of the opportunity during the purchase of new equipment by inclusion of this condition in the tender or purchase order. The concept does not work for their system as they lack credible training therefore unable to repair most of the equipment. Public hospitals maintenance organizations are ranked to be "fair" on their performance on training and skill development. The facility maintenance managers in public hospital should acquire proper training. This will enable the organization in public hospital repair the equipment effectively.

5.5. Operation and Safety

The combined percentages mean ratings for the respective maintenance organizations are 63, 85, 83 and 81 percent respectively. The results denote the organizations to be at the best position on the issue of operation and safety. With the exception of facility managers from public hospital, other organizations were almost performing at the same position. The finding revealed that public hospital facility managers are not well equipped for the maintenance purposes, although most of their institutions have state of art medical equipment. Testing procedures for the medical equipment are not properly documented. The organizations do not necessarily bring unsafe equipment operation to the attention of user and their supervisor by either placing the stickers on the medical equipments to indicate their conditions or through other means.

The inspection of the equipment by the facility maintenance managers is performed to establish medical equipment achieving all applicable safety standards. The equipment should perform in accordance with the manufacturer's specification. Equipment passing the safety inspection should be tagged with an inspection sticker and entered into the inventory maintenance program. Equipment not passing safety tests are not placed into the service and should be tagged as "defective". The facility maintenance managers do not have proper tools to determine the safety and functional test hence contributing to faulty medical equipment being used by the patients. To provide an electrically safe environment for all patients, visitors and staff is by ensuring compliance with applicable codes and standards by the maintenance managers.

Improvement on some of the failures by the public hospitals maintenance and contractors organizations could transform the respective organizations into better teams.

5.6. Maintenance and Repair

The combined percentage mean rating for the public, private, consultant and contracted maintenance organization are 58, 69, 75 and 81 per cent respectively. 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.

Healthcare equipment that is out of order quickly leads to a decline in demand, which will in turn reduce the income and quality of services of the health facilities. The hospital may lose clients if, for example, it becomes known that malfunctioning of medical equipment, for instance if sterilization equipment may endanger the health of the patients. Similarly, patients will avoid visiting health facilities which do not possess functioning diagnostic equipment. The maintenance managers are required to accomplish the maintenance for medical equipment in a timely, economical, and professional manner. Due to ever-changing operational requirements and conditions, effective maintenance management requires leadership, planning, organization, assignment of responsibilities, functions and resources, direction, and

flexibility. Management of resources (tools, test equipment, standby equipment, spare parts, time, and personnel) should be a daily concern. All resources must be present in sufficient quantity when needed to accomplish the maintenance objective.

The findings reveal that the public maintenance managers are ranked as 'fair' at 58 per cent. The other organizations had complied with the most of the standard as they were operating above 60 per cent of the combined mean. The facility maintenance management in the public hospitals do not adhere mostly to basic fundamentals when performing maintenance to the equipment; their inventory systems are not up to date. Improper documentation in the inventory system leads to poor selection and procurements of equipment and delay in the maintenance management. Inadequate spare parts lead to most of valuable equipment to lay dormant. This has been contributed by poor co-operation of suppliers to hospital management and lack of team work in facility maintenance managers. The planned preventive maintenance is not prioritized leading to failure of the equipment due to undetectable defects, low safety factors, abuse and natural failures. The public maintenance managers do not have adequate information of most of the products thus developing ineffective manuals. Adequate professional training to both operators or users and facility maintenance managers will reduce frequent failure and improve on maintenance management in the public hospital. The faults that occur suddenly and which are not detected or prevented by PPM measures should not take longer to be repaired. The computer program developed assists the facility maintenance manager to overcome this challenge. With help of the computer program adequate time is created for repairing the faulty equipment thus improving the efficiency of maintenance management in hospitals.

5.7. Decommissioning and Disposal

The combined percentage mean rating for the public, private, consultant and contracted maintenance organizations are 44, 60, 63, and 85 per cent respectively. The maintenance managers from the institution should be consulted before disposal process is completed. All safety requirements should be adhered to before equipment is released. There are few challenges which need some improvement in decommissioning and disposal of medical equipments.

Public hospital maintenance organizations should put in place appropriate program for liquidation of aged and unreliable facilities. Toxic equipment infection control companies are rarely consulted for the cleaning schedules or procedures before the equipment is disposed in public hospitals.

The finding revealed the public maintenance managers were operating in 'a fair standard' as per their combined mean of 44 per cent. The organizations dismantle old units to provide spare parts for similar units. They are not included in recommendation for and assistance in disposition of equipment by replacement, refurbishment, upgrading or declared obsolescence. Improper method of acquiring medical equipment contributes to obtaining faulty equipment in the inventory system with unclear warrant. Most of this equipment are disposed due to lack of spares as they lay dormant occupying space in the maintenance workshop. Decommissioning and disposal process provides an opportunity for cultivating technical innovation using local resources. The disposed equipment may be re-used or recycled by the facility maintenance managers. This will need the facility maintenance managers to be highly trained to manage the equipment effectively. Decommissioned equipment must be deleted to update the inventory system with fresh information.

6. Programme Development

During the interviews some of the equipment were identified to be repaired often. Eight of these equipment were picked randomly and divided into their respective categories;

- Laboratory equipment; Blood gas and Bacterial incubators.
- Diagnostic equipment; Diagnostic X-ray machine, Ultra-sound machine.
- Therapeutic equipment; Dialysis Machines, Short-wave machine.

- Hospital equipment; Oxygen plant, Autoclaves

The maintenance computer program was developed based on the results to improve on the existing facilities maintenance management's performance by the major public and private hospitals in Kenya. The maintenance program is written in a C++ program. It restricts the operator to enter only valid data by checking the validity of data code and data format. The program development begins from identification of the category in which the equipment is categorized. The equipment is identified in terms of its category and whether the equipment is in the inventory. This approach reduces accumulation of paper work in the office and proper monitoring of the equipment. The system diagnosis the possible causes with relation to their possible faults in the equipment. It further guides the user to identify the possible personnel to handle the fault in the equipment. The program makes decision on which fault in the diagnosed equipment to be repaired by the supplier, the contractor or the in-house technician.

Implementation of the computer program should improve the maintenance practices by detecting the faults in the shortest duration. This will reduce the time allocated for the repair of equipment because the information required will be accessed immediately. The facility maintenance management practices and process and the quality of patient care will be improved. Paper work and loss of data in the maintenance management will be reduced.

7. Conclusion

Proper management of medical equipment which includes selection, purchase, installation and maintenance are important for ensuring continued readiness of the service, positive impact on the safety and effectiveness of health services. It increases the lifetime of the equipment and provides information essential for equipment management. The findings from the data collected revealed that the public maintenance organization does not have proper management of the medical equipment. Private, consultant and contractor maintenance organization have excellent procedures to coordinate and oversee the safe, secure and environmentally sound operations. They also maintain the hospital assets in a cost effective manner which is aimed at long-term preservation of the asset value.

The public hospital maintenance managers are operating in 'a fair standard' as per their combined mean on seven parameters in the questionnaire. The organization fails to assess the new technology when selecting new equipment thus compromising the healthcare and patient safety. Lack of proper involvement of the organizations on procurement of the medical equipment has contributed to acquisition of incorrect equipment by the hospitals or equipment which have difficulties in acquiring their spares parts. The technicians are not well trained and most of them do not proceed for specialized training especially on medical equipment training. The institutions do not provide job training to their staff at national and international level. They lack proper training and are therefore unable to repair most of the modernized equipment.

The performance of scheduled preventive maintenance services on the medical equipment does not take priority over corrective repairs in most of the public hospitals compared to private hospitals. Public hospitals have no quality control system for the repair and preventive maintenance. Technical manuals are not fully utilized when repairs are made, maintenance on the medical equipment are not done on the stipulated time frame. Deferment of maintenance may be required due to non-availability of manpower or other extenuating circumstance for instance lack of spare parts.

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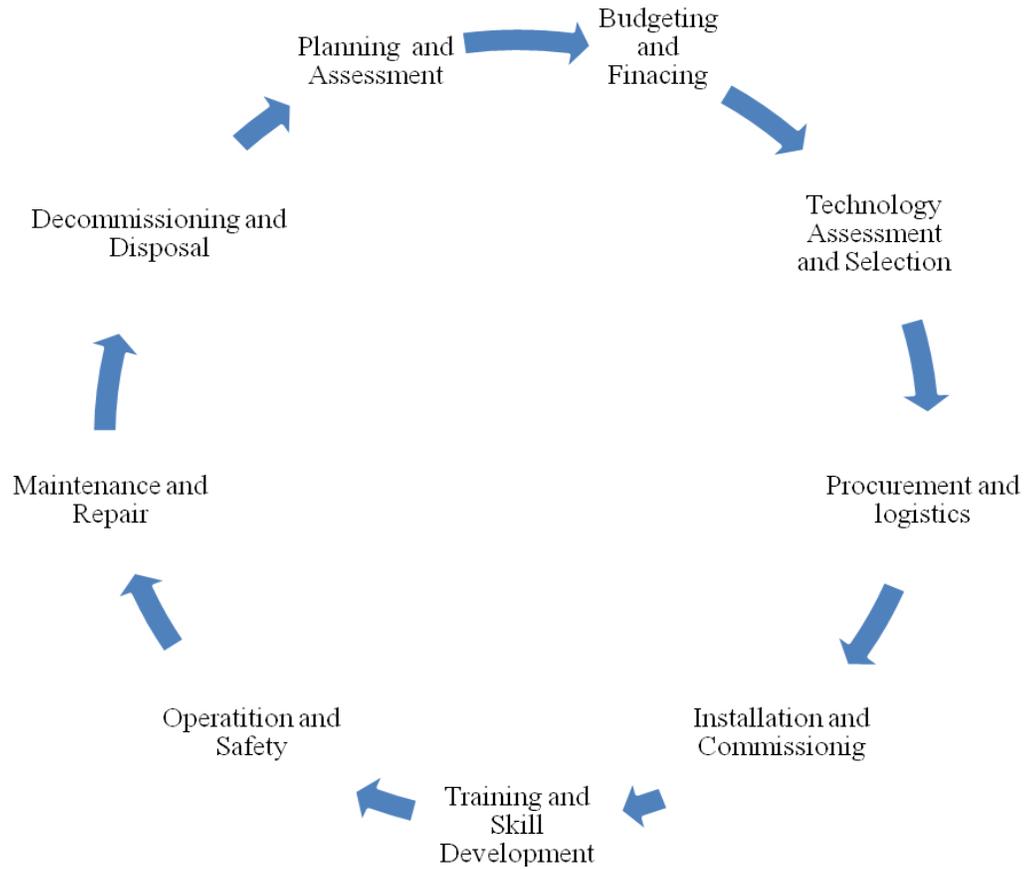


Figure 1. Medical equipment cycle

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