AN ANALYSIS OF THE FUNCTIONAL STATE AND COSTS OF MAINTENANCE AND REPAIR OF CAPITAL MEDICAL EQUIPMENT AT DR. YUSUF DADOO HOSPITAL

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Public Health in the field of Hospital Management

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DECLARATION

I, Patrick Mbeko Sofohlo, declare that the work contained in this research report is my own original work , that it has not been submitted before in its entirety or in part for any degree or examination in any other University, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

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Patrick Mbeko Sofohlo Date

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ABSTRACT

BACKGROUND: Medical equipment is used in the diagnosis, treatment and monitoring of patients and their maintenance is a fundamental part of managing these technologies in hospitals. Over the recent years equipment down-time has been an increasing concern within the delivery of health care services. This study focussed on the analysis of the functional state and costs of maintenance and repair of all capital medical equipment (CME) at a district hospital in the Gauteng Province.

AIM: To analyse the functional state and purchasing and service costs of CME at the DYD Hospital during ten year study period (April 2001 to March 2011)

METHODOLOGY: The setting of this study was Dr Yusuf Dadoo Hospital (DYD Hospital) a district hospital situated in the West Rand District in the Gauteng Province. A cross-sectional retrospective record review study of all CME was done in OPD, In-patient units, Radiology and Surgical Theatre. The data for this study was extracted from the records which were captured and kept by the asset management department, finance and maintenance divisions of the Hospital.

RESULTS: Most of the CME (196, 97%) procured during the study period was still functional and only seven (3%) was condemned. Nearly a quarter of them (24%) were in a good condition. However, a high proportion (73%) was in a fair condition requiring replacement within three to four years and only a small proportion (3%) was in a poor condition nearing the end of its life expectancy benchmark. There were significant differences in terms of condition of equipment among different departments of the Hospital (Chi-square test, $p<0.001$). The actual lifespan of CME was significantly lower than the expected useful lifespan (Mann Whitney's U test, $p<0.001$).

The total purchasing costs for all four departments were R 8,217,760.36 (median R 18,500, IQR R 9,690 – R 100,500). The individual purchasing cost of CME in the Radiology department was significantly higher than the other departments (ANOVA, $p<0.01$). The total service costs for all four

departments were R 1,454,566.85 (median R3,500, IQR R1,250 - R10,075). There was no significant differences in service costs among the four departments (ANOVA, p=0.10).

CONCLUSION: DYD Hospital had adequate numbers of CME and they were well maintained. However, significant replacement was likely to be required by the Hospital in the near future as the majority of CME was nearing the end of its life expectancy benchmark. These findings were reported as a research report which was submitted to the University of the Witwatersrand and the Gauteng Department of Health. The detailed findings were also presented and explained to all staff of DYD Hospital in a workshop that was held in the Hospital for implementation of the recommendations from this study.

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GLOSSARY OF TERMS

Achieved availability: The probability that the equipment will operate satisfactorily at a given point in time when used under stated conditions in an ideal support environment e.g. personnel, tools, spares etc. are instantaneously available (Gauteng Provincial Administration Manual, 1994).

Bar Coded Asset Audit System: An asset management system, to which the Combined System Group owns the IP (Gauteng Provincial Administration Manual, 1994).

Calibration: The units of measurement marked on other instrument so that it can be used for measuring something accurately (Gauteng Provincial Administration Manual, 1994).

Capital medical equipment: Equipment with an original purchase price of more than R5000 (Gauteng Provincial Administration Manual, 1994).

Condemn: Disposal of redundant, obsolete / unserviceable items (Gauteng Provincial Administration Manual, 1994).

Deferred maintenance: The practice of postponing maintenance activities such as repairs in order to save costs, meet budget funding levels or realign available budget monies as a result of underfunding of routine maintenance and failure to take care of major repair and / or restore equipment that have reached the end of their useful life that can result in equipment deterioration and ultimately impairment (University of Illinois, 2012).

Disposal: Disposal of medical equipment that is not suitable for reuse or trade in (Gauteng Provincial Administration Manual, 1994).

District hospital: A range of out and in-patient services are offered, mostly within the scope of general medical practitioner (Service Packages for PHC and DHS Services (Department of Health, 2007).

Functional: Making it possible for something (equipment) to do something or something to happen (Gauteng Provincial Administration Manual, 1994).

Functionality: The quality in something of being very suitable for the purpose it was designed for or expected to perform (Gauteng Provincial Administration Manual, 1994).

Maintenance: Maintenance refers to a routine and / or remedial intervention required, ensuring that the medical equipment is retained in a serviceable

condition and extends its planned economic life or improve its working performance (Gauteng Department of Health Asset Maintenance Management Framework, 2001).

Medical equipment: An instrument, apparatus or machine used to diagnose, treat, monitor or alleviate disease or injury and can also be used to prevent disease and compensate for injury (Gauteng Provincial Administration Manual, 1994)

Out-of-service days: When a CME is sent for service (such as routine maintenance, calibration and repair). During service, a CME is not available for use. Out-of-service days are counted as an efficiency indicator for clinical engineering department which is responsible for services of CME in a Hospital (University of Tasmania, 2000).

Repairs: It is anything that required to be done in order to achieve the same goals as that envisaged in the definition of “maintenance” above, but which requires more labour and more expenses than maintenance due to normal wear and tear (Gauteng Provincial Administration Manual, 1994).

Service: Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. During service, a CME is not available for use.

Step-down services: These provide in-patient care for patients who no longer require acute intervention and can be cared for mostly by professional nurses or allied professionals (Gauteng Provincial Administration Manual, 1994).

LIST OF ABBREVIATIONS

ANOVA	:	One way analysis of Variance
CME	:	Capital Medical Equipment.
DYD	:	Dr. Yusuf Dadoo.
GDHSD	:	Gauteng Department of Health and Social Development
MDG`s	:	Millennium Development Goals
OPD	:	Out Patients Department.
USA	:	United State of America
WHO	:	World Health Organization.

CHAPTER 1
INTRODUCTION

The purpose of this study was to analyse the functional state and costs of maintenance and repair of Capital Medical Equipment (CME) at a district hospital in the Gauteng Province. This introductory chapter will cover the background to the study, statement of the problem, its aims and objectives and an outline of subsequent chapters.

1.1 BACKGROUND

Medical equipment is the platform on which the delivery of health care services rests and the basis for the provision of quality health care to patients. The growing market for medical equipment is not only found in the united State of America (USA) and Japan, but also in less developed countries (Malkin, 2007).

District hospitals provide services at a primary health care level with the intention of getting the most out of their investment and delivering quality service to their communities (Department of Health, 2007). To enable district hospitals to do so, they need to adequately manage medical equipment and ensure that it is available and in good working condition. Medical equipment helps to save and to prolong patients` lives and is used in the diagnosis, treatment and monitoring of patients in the hospital. For example, surgical and anaesthetic equipment are used for surgical procedures, cancer is treated in radiotherapy units, and premature babies can be warmed with incubators.

At the Dr Yusuf Dadoo (DYD) Hospital, the hospital finance department usually presents detailed information on equipment to the equipment budget committee along with costs and data showing the effects of purchases on the operating budget. A certain percentage of the budget remains uncommitted to meet emergency needs that might arise throughout the financial year. Although a Provincial Policy on Asset Management was recently drafted and

circulated, there was no clear cut policy on acquisition, procurement, maintenance and repair of capital medical equipment.
With regard to the maintenance and repairs of capital medical equipment at DYD Hospital, this component was entirely outsourced because of inadequate in-house capacity.

1.2 PROBLEM STATEMENT

To maintain CME in a functional state was a challenge at DYD Hospital. There was a perception that CME at DYD Hospital did not operate optimally, adversely impacting on service delivery. The achieved availability of CME at DYD Hospital was perceived to be at 40% as compared to the standard norm of 100%. At times, the breakdown of the CME compromised delivery of services and led to escalation in health care service delivery costs. Inadequate budget planning of CME was also a problem at DYD Hospital with the cost of maintenance and repair viewed as unaffordable expenditure. For example, to repair one fluoroscopic machine in a given time at DYD Hospital cost more than R100 000 as compared to the allocated budget of R2 429 000.00 for all machinery and equipment for the financial year 2011/12 (Gauteng Department of Health and Social Development, 2011). It was therefore important to analyse the functional state and costs of maintenance and repair of the CME at DYD Hospital in order to support informed decision-making with regard to CME planning. This study was expected to review the functional state and costs of maintenance and repair of all capital medical equipment valued at more than R5000 at DYD Hospital to support current and future planning of medical equipment management at the DYD Hospital.

1.3 JUSTIFICATION OF THE STUDY

This study on the analysis of the functional state and costs of maintenance and repair of CME was conducted for the first time at DYD Hospital. The study was to analyse the CME at DYD Hospital and to identify deficiencies in the functioning and costs of maintenance and repair of these technologies. The

study would enable DYD Hospital to contain the burgeoning costs on maintenance and repair of CME. It was envisaged that this would ultimately help to improve the operation and performance of CME at this Hospital. In addition, this study would ultimately contribute towards improving the functioning of the CME in the service delivery platform and support similar processes in other institutions in the Gauteng Province. It was also envisaged that the methodology could be used by the Provincial and National departments of health to analyse the functional state and costs of maintenance and repair of CME at other district hospitals.

1.4 RESEARCH QUESTION

What is the functional state and purchasing and service costs of CME at DYD Hospital during ten year study period (April 2001 to March 2011)?

1.5 STUDY OBJECTIVES

1.5.1 BROAD OBJECTIVES

To analyse the functional state and purchasing and service costs of CME at the DYD Hospital during ten year study period (April 2001 to March 2011).

1.5.2 SPECIFIC OBJECTIVES

1 To describe the profile of CME on the Hospital asset register (a) Number of CME per department (b) Their functional state (good, fair, poor and condemned)
2 To describe the services of maintenance, calibration and repairs of CME per department (a) Number of out-of-service days (b) number of episodes
3 To determine the lifespan of CME during this study period (expected useful life span and actual life span) per department.
4 To determine the purchasing and service costs (maintenance, repair and calibration) of CME per department during the study period

1.6 CHAPTER LAYOUT

The research project was distributed over six chapters, namely:
Chapter 1: Introduction of the study. This chapter gave a brief background of the research and outlined the problem statement.

Chapter 2: Literature review. This chapter reviewed the relevant literature on medical equipment with regard to procurement, maintenance and repair.

Chapter 3: Methodology. This chapter focused on the methodology with regard to study setting, study period, study population, study instrument, data collection and data analysis.

Chapter 4: Results. This chapter dealt with the presentation of results.

Chapter 5: Discussion. This chapter dealt with the discussion of results as highlighted in chapter 4 with the purpose of answering the research question.

Chapter 6: Conclusions and recommendations. This chapter presented conclusions and recommendations by drawing results from the previous chapters. The chapter also dealt with the limitations and suggestions for future research.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses relevant literature on the functional state, cost of maintenance and repair of CME with particular reference to a public hospital.

2.1 MEDICAL EQUIPMENT

Medical equipment are essential for safe and effective prevention, diagnosis, treatment and rehabilitation of illness and disease. The achievement of health-related development goals, including the Millennium Development Goals (MDGs) depends upon proper manufacturing, regulation, planning, assessment, acquisition, management (such as maintenance, calibration and repair) and use of medical devices which are of good quality, safe and compatible with the settings in which they are used (WHO, 2011). The management process begins with understanding the needs of an organization and ends with decommissioning. In between, the process consists of good procurement practices, (donation if any), solicitation and provision, logistics of delivery and installation, inventory management, maintenance, safe use and training, and measurement of clinical effectiveness (WHO, 2013). The type and quantity of medical equipment vary according to level of health facilities. For example, district hospitals use low cost medical equipment in comparison to regional and national hospitals (Son, Thu, Tu, et al, 2007). Costs of medical equipment vary from few Rands to more than million Rands (capital medical equipment). In South Africa, capital medical equipment is defined as equipment with an original purchase price of more than R5000 (Provincial Administration Manual, 1994).

2.2 CAPITAL MEDICAL EQUIPMENT MANAGEMENT

Management of medical equipment is always a challenge particularly in institutions in developing countries. They always have shortage of equipment in terms of number and quality. Most of the equipment at hospitals in the

developing world countries were imported and of very poor quality (96% worked only 5 years after donation and 39% never worked due to lack of training, manuals or accessories (Malkin, 2007). In South Africa, services are also affected at public health institutions due to non-availability of proper medical equipment. For example, equipment at some hospitals at the Western Cape fell short of international standards due to inadequate maintenance and shortage of trained staff (Watermeyer, Van Wyk, Goldberg, 2008).

WHO (2010) reported in its preliminary results of the baseline countries` survey on medical devices that the availability of medical equipment in low-income and developing countries was still a problem (WHO, 2010). To guarantee the good physical condition of medical equipment, it is essential to recruit sufficient staff with the appropriate skills to maintain the equipment. Human factors such as misuse and overuse of medical equipment can have a negative impact to the institution and also on service delivery. Therefore, training of staff for proper use of CME is crucial to improve appropriate use of CME. In addition, having a team leader is important for mentoring inexperienced staff (Wang and Levenson, 2000).

Although medical equipment improves the quality of health care, it also adds complexity and cost. The functional state of capital medical equipment (CME) can be linked to issues of utilisation as well as cost of maintenance and repair. The poor functional state of CME is the result of inexperienced central tender boards, improper warranties and service contracts that are put in place, hospital health technology department not being consulted when CME purchased and inadequate budget for CME (Carter, 2004).

A clear cut policy on acquisition, maintenance and repair of medical equipment should be established to reduce future problems arising from the unavailability of medical equipment at institutions. A need analysis of the institution before purchase of equipment should be done (Vogt, Pinaar, de Wit, 2002). They suggested that when purchasing medical equipment, one of the conditions to the supplier in the purchase order must include the supply of

operating and service manuals as well as service training.

Medical equipment is an important asset and is included in the hospital`s budget cost estimates. Although it may account for less than 10% of the total hospital budget, it is an important contributor to the quality of health services (WHO, 2010). In India, only 2.5% of the district hospitals budget is set aside for machinery and equipment which shows that the budget allocated for CME was too low (Mavalankar, Raman, Dwivedi, et al, 2004). The cost of complex medical equipment management can shift important institution resources away from their core focus. For example, in the USA, the fast growing market and use of medical equipment in the healthcare system resulted in spending more than £130 billion in 2006 (Newton, Mytton, Aggarwal et al, 2010).

The establishment of the Asset Management Policy can improve equipment management, minimise costs, and alleviate equipment maintenance and management problems (Schiesl, 2006). In South Africa, the Gauteng Department of Health has introduced the Bar Coded Asset Audit System, to improve the asset management system for CME (Gauteng Department of Health, 2006).

2.3 PROCUREMENT OF CAPITAL MEDICAL EQUIPMENT

Sufficient medical equipment must be available in hospitals to support health care service delivery. There was an increasing demand for medical equipment with limited available financial resources (Kawohl, Temple–Bird, Lenel, et al, 2005). Value for money in the procurement of medical equipment requires that cost benefit analysis of the equipment should be done to identify options to minimise price. By defining the minimum requirements for an equipment purchase could help to keep costs down while still ensuring that clinicians get what they need (Angelo, 2009). One of the spectrums of purchasing options is establishing a central purchasing body where hospitals are mandated to utilise that body for the purchase of all medical equipment above a predetermined value.

A properly planned coordinated multidisciplinary approach towards the purchase of medical equipment is the key to the management of medical equipment. There should be a team effort for procurement of medical equipment based on the needs and mission of the institution (Angelo, 2009) as well as the size and type of the institution (Walters, 2003). In addition, challenges and constraints of the hospital should be considered when purchasing medical equipment (Sandham, 2008). In addition there should be a process of prioritisation to improve the purchasing process of medical equipment (Blazer, Jones, Faulkner, et al, 2006).

All medical equipment purchases should be processed through an institutional Medical Equipment Management Committee to ensure that input from clinicians is received. The development of a formal purchasing process managed by a trained specialist and involving a team of experts from various departments should be considered (Becker, 1989). For example, the Medical Equipment Management Plan of the Texas Tech University Health Sciences Centre (2010) stated that the decision to acquire new medical equipment in each department vested on the Departmental Chair.

2.4 MAINTENANCE AND REPAIR OF CAPITAL MEDICAL EQUIPMENT

The extent of equipment down time is a major factor in determining the availability state of medical equipment (Tarawneh and El-Sharo, 2009). Maintenance and repairs are used to support and to maintain the operations (Meredith and Shafer, 2011). Improved maintenance and repair technology of medical equipment ensure that medical equipment is always at its best. Planned maintenance is a statutory requirement to enhance the effectiveness and reliability of medical equipment and must be carried out at the appropriate frequency (Kainth, 2003). Only 30% of medical equipment in Nepal`s hospitals was in operation, 50% needed urgent maintenance, 10% needed repairs and 10% to be condemned (Kanel and Pokhrel, 2009).

A review of the purchase list should be done for all items considering various aspects of the maintainability of the medical equipment. Medical Equipment Management Services should provide equipment lists detailing equipment belonging to a specific department or areas (Grant, 2010). A gap analysis involving a comparison of the actual medical equipment in the departments and inventory list in the asset management system should be done to identify shortfalls or surpluses of medical equipment (Waters, 2003).

Maintenance is not a separate and isolated function that makes repairs and performs assorted activities as needed but, a full partnership that strives together with other functions to achieve the strategic goals of the organisation and involves specialists such as maintenance engineers and technicians (Fredendall, Patterson, Kennedy et al, 1997). On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994).

Replacement of medical equipment is planned taking into consideration the age, condition and critical nature of use. At the end of its life cycle it must be condemned, disposed and taken out of service (Temple – Bird, Kaur, Lenel, et al, 2005). Faulty or defective medical equipment must not be used regardless of how minor this is perceived. Inspection, testing and maintenance intervals should be based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). Owing to the life span of CME, it can take several years before it needs to be replaced and at the time of replacement, CME might prove to be technologically obsolete. Management of hospitals should consider the age, condition and critical nature of use of CME with care (Hugo, Badenhorst-Weiss, Van Bijoen, et al, 2006).

The use of complex electrical powered medical equipment in hospitals has brought about the need for a clearly defined policy on maintenance to avoid the occurrence of accidental injuries to both patients and staff. Staff involved

with medical equipment should be protected from these potential risks and hazards. Where there is a suspected hazard in the medical equipment, that equipment must be rendered harmful (Temple-Bird et al, 2005). Risk Managers should cover the financial risk of medical devices maintenance and repair (Anderson and Ruther, 2009). Before new medical equipment is put into service, the manager responsible for equipment should undertake a risk assessment to ensure that any possible hazards arising from the use of the equipment are identified and appropriate precautions undertaken. Risk protection could make a significant cost saving on medical equipment while receiving improved services (Tudor and Gremill, 1994).

2.5 SUMMARY

This chapter provided literature on the functional state, cost of maintenance and repair of CME. Literature on medical equipment, procurement of medical equipment, maintenance and repair of medical equipment indicated that CME cuts across all levels of management and personnel in an organisation. It can be seen that maintenance of medical equipment is not just a question of repairing broken things but an integral part of managing the whole lifecycle of equipment. To make the whole process of maintaining medical equipment work properly, inputs from different people are required.

CHAPTER 3
METHODOLOGY

This chapter documents the design and methodology followed during the research project. The methodology for this study was selected on the basis of its aims and objectives to answer the research question under investigation.

3.1 STUDY DESIGN

A cross-sectional retrospective record review was done. The study was based on descriptive analysis of the data obtained from the study.

3.2 STUDY SETTING AND SCOPE

The study setting was DYD Hospital, a district hospital in the West Rand District (Figure 3.1).

West Rand District

The Gauteng Province is about 16,548 square kilometres and is highly urbanized and industrialized. The total population is 11 100 000 of which 97% live in urban centres. The Province has three metropolitan municipalities (the City of Tshwane, Johannesburg and Ekurhuleni) and two District Municipalities (Sedibeng and West Rand). West Rand District has four local municipalities which include Mogale City, Merafong City, Randfontein and Westonaria. The catchments population for the West Rand District is 744 153 of which Mogale City is 295 497, Merafong City 210 484, Randfontein 128 848 and Westonaria 109 324 (Census, 2001). South Africa conducted three censuses (1996, 2001, and 2011). Census 2011 was the third Census to be conducted since the post democratic elections in 1994. The population of Mogale City is 362 422, an increase of 22.6%, Randfontein 149 286 which is 15.9%, Westonaria 111 767 which is 1.8% and Merafong City 197 520, a decrease of -6.2% (Census, 2011). The increase in Mogale City can be

attributed to strong flows between economic activity areas, leisure tourism (Cradle of Humankind World Heritage Site) and residential areas (West Rand Industrial Development Strategy, 2013).

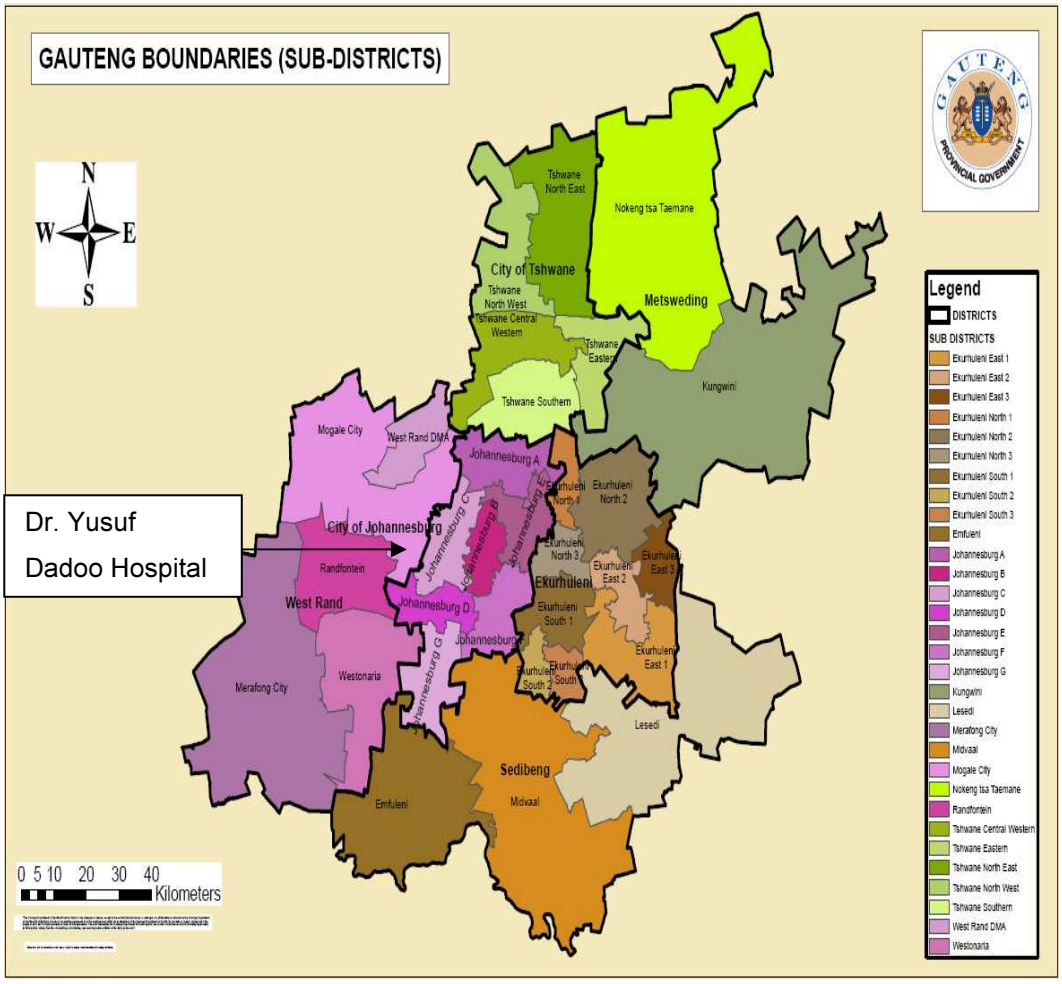

Figure 3.1: Map of the Gauteng Province depicting District boundaries

(Source: GDHSD Service Transformation Plan for 2010 - 2020)

Dr Yusuf Dadoo Hospital

The Hospital was built in 1910 and officially opened on the 22 November 1911 as a regional Hospital and was named Krugersdorp Hospital. In 1974, Krugersdorp Hospital was renamed Paardekraal Hospital. In 1997, the Hospital was again renamed Dr. Yusuf Dadoo Hospital and was then downgraded from a regional hospital to a district hospital due to the rationalisation of the Public Service. The Hospital is situated in Mogale City in

the West Rand. The Hospital has 255 approved beds of which 175 acute, 20 step-down and 60 tuberculosis beds. Its bed occupancy rate is between 68% and 75% per month. DYD Hospital is also a training facility for family medicine. There is no Community Health Centre in the area. Therefore, all 42 Primary health care clinics in the West Rand District refer their patients to this Hospital.

3.3 STUDY PERIOD

The study period was ten years (from April 2001 to March 2011).

3.4 STUDY POPULATION

The study population comprised of 203 capital medical equipment (CME) at the DYD Hospital that appeared in the asset Register of the Hospital. There was no sampling since the study included all CME of the DYD Hospital.

3.5 DATA COLLECTION

The researcher collected data from hospital records (Asset Management Register) after seeking approval from the Ethics Committee of the University of the Witwatersrand and the Research and Policy Department of the Gauteng Department of Health and Social Development (GDHSD). The data was also collected from records from the accounts and maintenance departments, using invoices and receipts. A full list of CME was retrieved, stating its profile such as full description, department, purchase cost, purchase date, supplier name, maintenance plan, initial training, asset state, expected life span and actual life span of CME. Data was also collected for the functional state of CME such as the condition and status of CME in the asset register. CME episodes for service maintenance, calibration and repair for the ten years period was collected as well as the total days CME was out of service for service maintenance, calibration and repairs. Data was also collected on the purchase cost of CME, purchase cost per activity and per department and

total cost of all activities. This information was captured in a data collection sheet designed for the study (Appendix B).

3.6 STUDY INSTRUMENT

Data relevant to this study was routinely collected electronically by the Hospital Asset Management System and maintenance Division. Information was captured from the asset management register using the data capture sheet designed for this study from the following Hospital`s units which are geographically clustered into one area which included Casualty/ OPD, Inpatient-wards, Radiology and Surgical Theatre. Data from the Hospital Asset Management System was exported to MS Excel based spread sheet designed for the study.

3.7 STUDY VARIABLES

The variables for this study are listed in Table 3.1.

Table 3.1 List of study variables

To describe the profile of CME on the Hospital asset register	Number of CME per department Functional state of CME (Good, Fair, poor and Condemned)
To describe the services of CME (maintenance, calibration and repairs)	Number of out-of-service days for In-patient wards, Casualty/ OPD, Surgical Theatres and Radiology departments. Number of episodes Casualty/ OPD, Surgical Theatres and Radiology departments.
To determine the lifespan of CME	Expected life span (in years) Actual life span (in years)
To determine the purchasing and service costs of CME	Total purchasing cost Total service cost (maintenance, repair and calibration)

- Functional state of a CME is classified as good, fair, poor and condemned in terms of the Gauteng Provincial Administration Manual (1994). CME was classified as being good if it had no defects and

required only general maintenance, minor repairs and little or no deferred maintenance existed. CME in fair condition showed signs of slight deterioration, required some corrective maintenance and deferred maintenance was intensive. Those in poor condition showed signs of severe deterioration and required corrective maintenance or emergency repair and deferred maintenance was extensive.

- Lifespan: Expected lifespan is determined according to the manufacturer whereas actual life span is determined based on the actual number of years a CME is in-use.
- Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. During service, a CME is not available for use.
- Out-of-service days: When a CME is sent for **s**ervice (such as routine maintenance, calibration and repair). During service, a CME is not available for use.
- Purchasing cost includes the cost paid by the Hospital at the time of purchase of a CME.
- Total service cost includes costs for maintenance, repair and calibration of a CME.

3.8 DATA ANALYSIS

Data exported to MS Excel based spread sheet was checked for error and missing values. The paper based register was used to verify discrepancies and to look for missing values. The data was then analysed with NCSS statistical software (NCSS, 2007).

Following descriptive statistics were reported upon.

- Continuous variables (such as cost): Continuous variables with normal distributions: mean and standard deviation. Other continuous variables: median and inter-quartile range.
- Categorical variables (such as functional state): proportion and range.

The following analytical statistics was used to compare among the four

departments (namely In-patient wards, Casualty/ OPD, Surgical theatre and Radiology).

- Continuous variables: Mann Whitney's U test (for comparing two variables) and One way Analysis of Variance (ANOVA) (for comparing more than two variables). Post-hoc test will be done, if statistical significance was found with ANOVA.
- Categorical variables: Chi-square test and Fisher's Exact test

The statistical significance will be calculated at the 95% confidence level.

The results were presented in absolute and percentile values, in tables and figures.

3.9 ETHICAL CONSIDERATION

Permission for conducting research and accessing documents was obtained from the Head of the department of the GDHSD. The study was also approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Appendix A). Confidentiality and anonymity was not an issue as the study related only to equipment records. A unique code was used on data extraction sheets. The researcher remained within the parameters of any applicable legislation, institutional guidelines and scientific standards relevant to the study.

CHAPTER 4
RESULTS

Chapter two provided a detailed literature review of CME. Chapter three focused on the methodology with regard to study setting, study period, study population, study instrument, data collection and data analysis. In this chapter results obtained from the analysis of data are presented. The study included all CME of the DYD Hospital and no sampling was done.

4.1 PROFILES OF CAPITAL MEDICAL EQUIPMENT

4.1.1 THE NUMBER OF CME

A detailed list of all CME used at DYD hospital is presented as Annexure C. A summary of the CME in the four departments is listed in Table 4.1.

Table 4.1 Distribution of CME

Condition	Number (%)
In-patient wards	80 (39.4%)
Casualty/ OPD	43 (21.2%)
Surgical theatre	62 (30.5%)
Radiology	18 (8.9%)
Total	**203 (100%)**

4.1.2 THE CONDITION OF CME

The majority of the CME (196, 97%) were in working-condition. Only seven (3%) had been removed from the asset register and condemned; six of them were from Radiology and one from the Casualty/OPD (Figure 4.1).

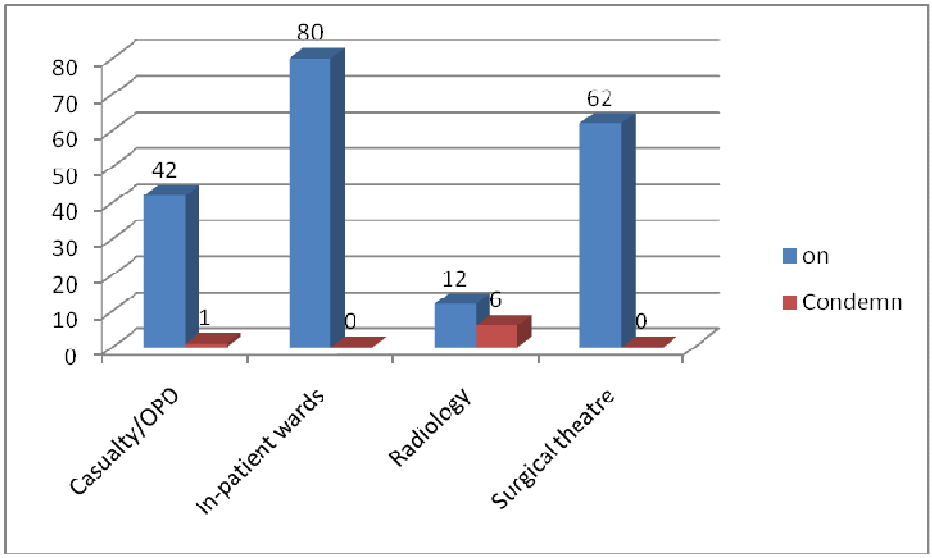

Figure 4.1 Frequency distribution of the asset state of CME per department

Among the 196 CME, 144 (73%) were in a fair condition, 47 (24%) were in good condition and few of them (5, 3%) were in poor condition (Figure 4.2). The last assessment of CME was done in February 2011 by the company *Bigen Africa*.

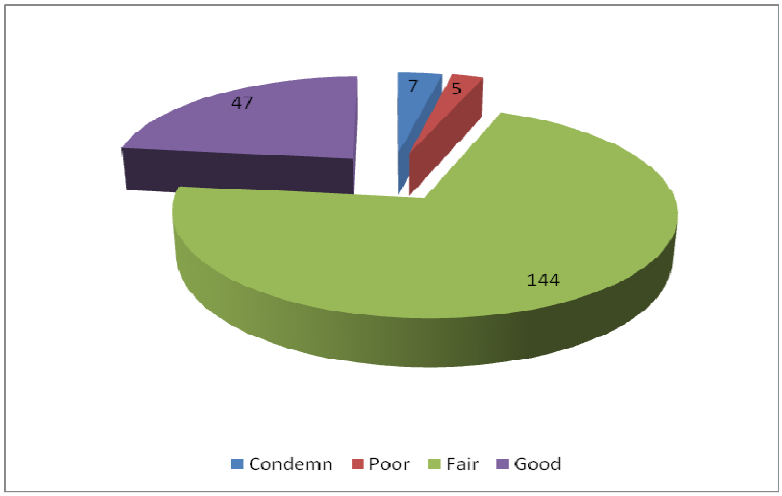

Figure 4.2 Frequency distribution of the condition of CME

The conditions of CMEs per department are listed in Table 4.2. In the In-patients wards, 66 (83%) out of 80 CME was in fair condition, 13 (16%) was good and one (1%) was poor. Radiology had 18 CME and six (33%) were condemned.

Table 4.2 Distribution of CME per department

Condition	Total	In-patient wards	Casualty/ OPD	Surgical theatre	Radiology
Good	47 (23%)	13 (16%)	10 (24%)	18 (29%)	6 (33.3%)
Fair	144 (71%)	66 (83%)	32 (74%)	41(66%)	6 (33.3%)
Poor	5 (2%)	1 (1%)	0	3 (5%)	0
Condemn	7 (4%)	0	1(2%)	0	6 (33.3%)
Total	**203 (100%)**	**80 (100%)**	**43 (100%)**	**62 (100%)**	**18 (100%)**

There were significant differences in terms of condition of equipment among different departments of the Hospital (Chi-square test, $p<0.001$). The majority of the CME in In-patient wards and Casualty/OPD were functional (good/ fair) in comparison to other two Departments (Surgical theatre and Radiology).

4.2 SERVICES OF CAPITAL MEDICAL EQUIPMENT

4.2.1 DURATION OF REPAIR AND SERVICES

Service of CME includes (a) routine maintenance and (b) calibration and (c) repair (During service, a CME is not available for use). Figure 4.3 described the total number of out-of-service days during the ten year study period. Since 2006/07, there were significant increases in number of out-of-service days, due to introduction of maintenance policy in the Hospital. This resulted in increase in *Out of service days* for calibration in comparison to *Out of service* days for repair.

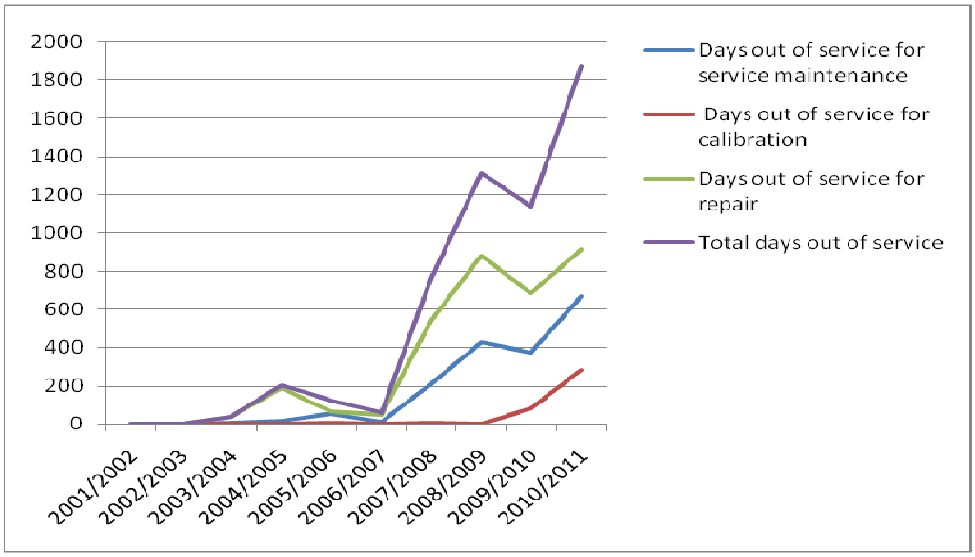

Figure 4.3 Number of out-of-service days

Figure 4.4 describes the number of out-of-service days for different services.

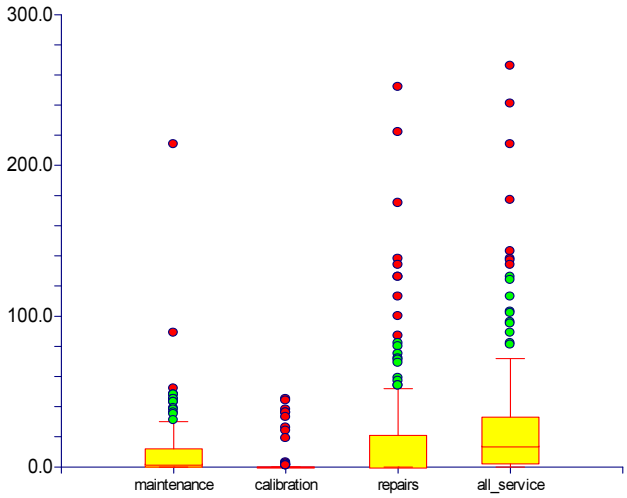

Figure 4.4 Box plot for number of out-of-service days

Table 4.3 and Figure 4.5 describe the number of out-of-service days for each of the four departments. During this period, there were significant differences among the four departments in terms of total number of out-of-service days (maintenance, calibration and repair) (One way ANOVA, $p<0.001$). The post-hoc test showed the total number of out-of-service days in the In-patient wards was significantly lower than the Casualty/ OPD and Radiology departments. The outliers (out of service days more than 6 months) were mainly in OPD due to type of equipment used in that Unit.

Table 4.3 Number of out-of-service days for four departments

Type of activity	**Department**	**Minimum** (days)	**Maximum** (days)	**Median** (days)	**IQR** (days)
Service maintenance	In-patients wards	1	52	1	1-10.5
	Casualty/OPD	1	214	2	1-8
	Surgical theatre	1	45	5.5	1-15
	Radiology	1	89	1	1-12
Service for calibration	In-patients wards	-	-	-	-
	Casualty/ OPD	1	33	1	1-1
	Surgical theatre	1	1	1	1-1
	Radiology	1	45	1	1-36
Service for repair	In-patients wards	1	126	1	1-21
	Casualty/ OPD	1	252	5	1-28
	Surgical theatre	1	59	1	1-12
	Radiology	1	222	13.5	1-73
Total for maintenance, calibration and repair	In-patients wards	1	126	1	1-21
	Casualty/OPD	1	252	5	1-28
	Surgical theatre	1	59	1	1-1
	Radiology	1	222	13.5	1-73

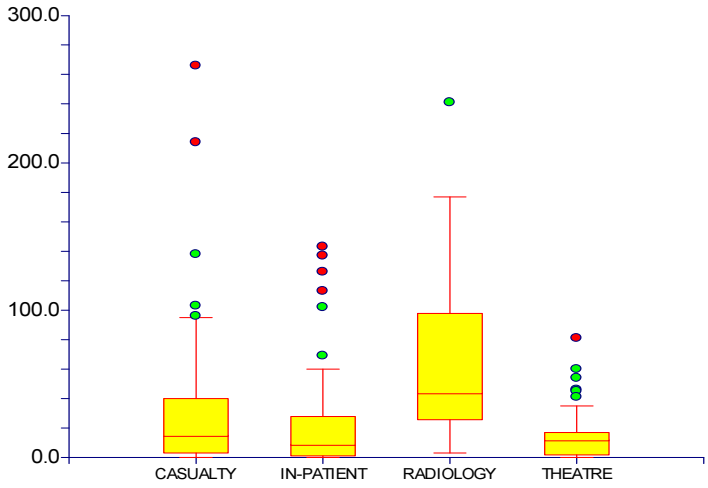

Figure 4.5 Box plot for total number of out-of-service days for four departments

MAINTENANCE SERVICES

There were no significant differences among the four departments in terms of number of out-of-service days required for maintenance (One way ANOVA, p = 0.82) (Table 4.3, Figure 4.6).

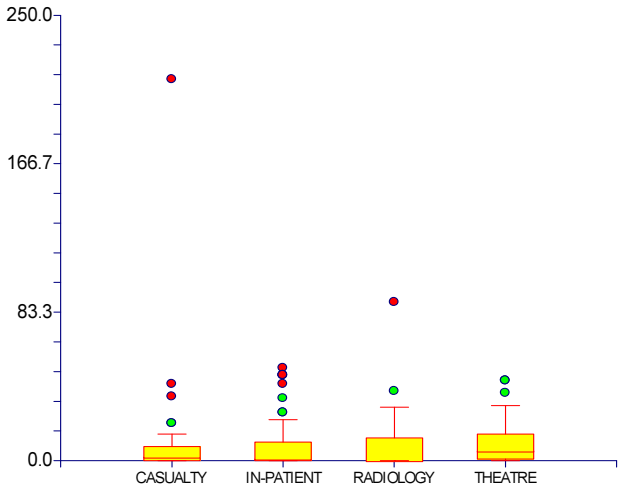

Figure 4.6 Box plot for number of out-of-service days for maintenance

CALIBRATION SERVICES

There were significant differences among the four departments in terms of number of out-of-service days for calibration (One way Analysis of Variance, $p<0.001$) (Table 4.3, Figure 4.7). The post-hoc test showed that the number of out-of-service days for calibration of CME in the Radiology department were significantly higher than the other three departments.

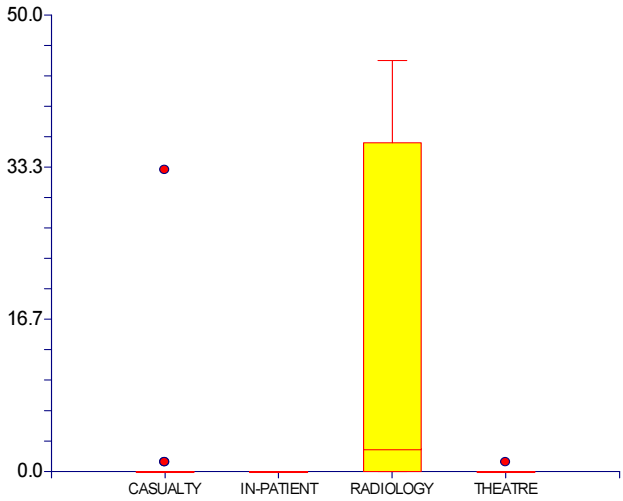

Figure 4.7 Box plot for number of out-of-service days for calibration

REPAIR SERVICES

There were significant differences among the four departments in terms of number of out-of-service days for repair (One way ANOVA, $p<0.001$) (Figure 4.8). The post-hoc test showed the number of out-of-service days for repair of CME in the Radiology department was significantly higher than the Surgical Theatre and In-patient departments. In addition, the number of out-of-service days for repair in Casualty/ OPD department was also significantly higher than in the Surgical Theatre.

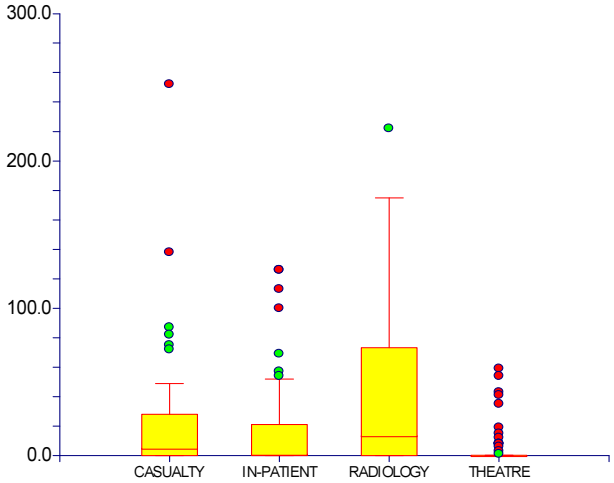

Figure 4.8 Box plot for number of out-of-service days for repair

4.2.2 EPISODES OF MAINTENANCE, CALIBRATION AND REPAIR SERVICES

Total episodes (number of times a CME sent for maintenance, calibration and repair) are described in Table 4.4 and Figure 4.9. There were no significant differences among different departments in terms of total episodes (One Way Analysis of Variance, p = 0.10)

Table 4.4 Number of episodes for all services

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	12	2	1-4
In-patient units	80	1	5	2	1-3
Radiology	18	1	11	3	2-5
Surgical Theatre	62	1	9	1	1-5
Total	**203**	**1**	**12**	**2**	**1-3**

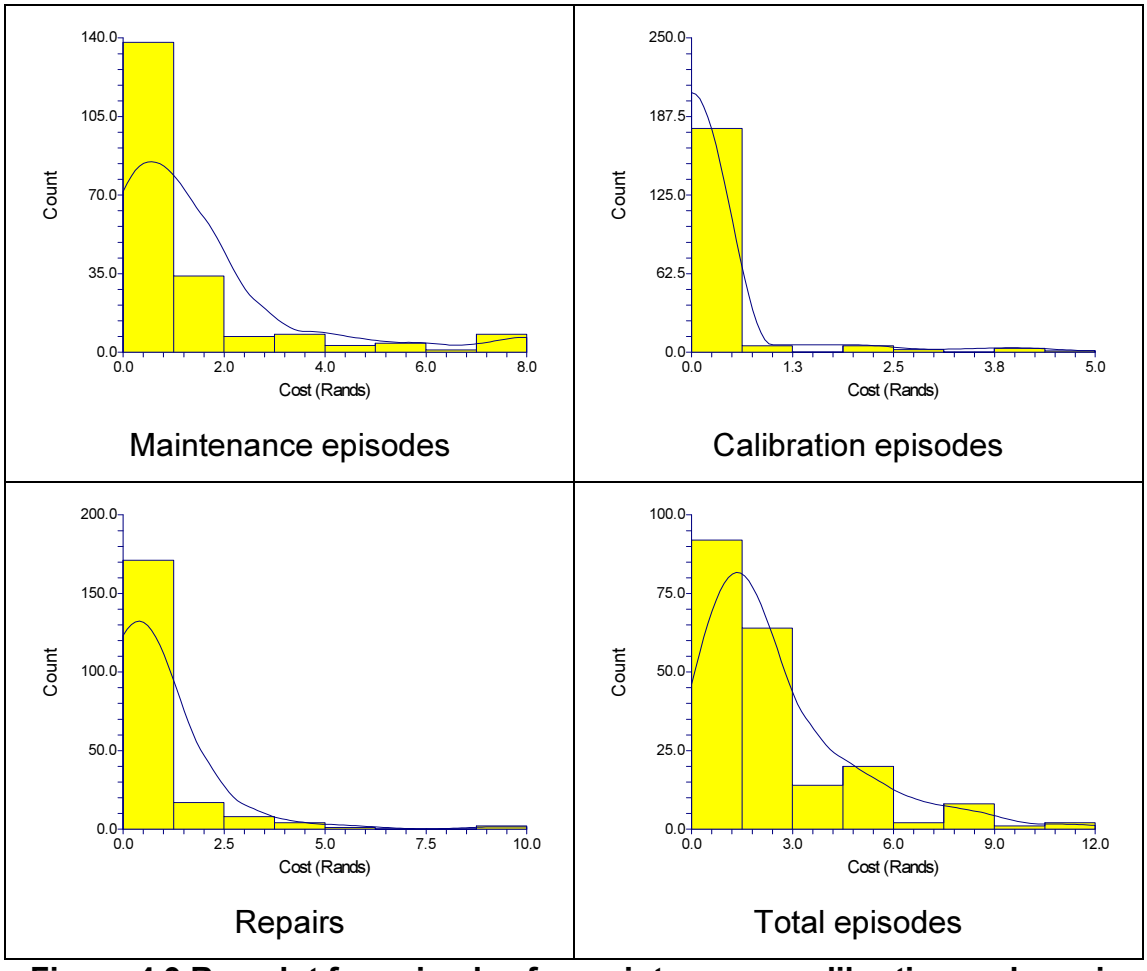

Figure 4.9 Box plot for episodes for maintenance, calibration and repair services

MAINTENANCE SERVICES

In Table 4.5, the number of episodes for maintenance was described. There were no significant differences in terms of number of episodes among different departments for maintenance of CME (One Way ANOVA, p = 0.20).

Table 4.5 Number of episodes for maintenance

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	4	1	1-2
In-patient units	80	1	4	1	1-2
Radiology	18	1	6	1	1-6
Surgical Theatre	62	1	8	1	1-4
Total	**203**	**0**	**8**	**1**	**1-2**

CALIBRATION SERVICES

The number of episodes for calibration was described in Table 4.6.

Table 4.6 Number of episodes for calibration

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	40	1	4	-	-
In-patient wards	77	-	-	-	-
Radiology	18	1	5	2	1-3
Surgical Theatre	59	1	1	-	-
Total	**194**	**1**	**5**	**1**	**1-1**

REPAIR SERVICES

The number of episodes for repair was described in Table 4.7. There were no significant differences in terms of number of episodes among different departments for repair of CME (One Way Analysis of Variance, p = 0.21).

Table 4.7 Number of episodes for repair

Departments	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	10	1	1-2
In-patient units	80	1	5	1	1-1
Radiology	18	1	9	1	1-2
Surgical Theatre	62	1	3	1	1-1
Total	**203**	**1**	**10**	**1**	**1-1**

4.2.3 MAINTENANCE PLAN OF CAPITAL MEDICAL EQUIPMENT

176 (87%) out of 203 CME had a maintenance plan and only 27 (13%) were without maintenance plan (Figure 4.10).

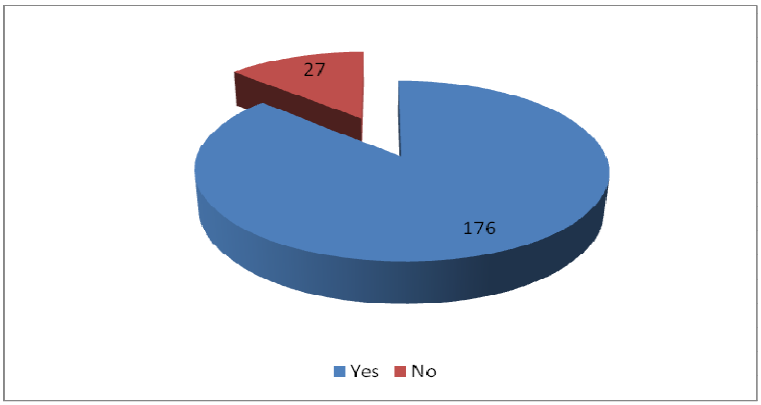

Figure 4.10 Frequency distribution of CME existence of maintenance plan

Figure 4.11 shows that out of 176 CME with maintenance plan, 71 (40%) was in the In–patient wards followed by 50 (28%) in the Surgical theatre. All CME in Radiology had maintenance plan. There was no significant differences among these four units in terms of the maintenance plan (Fisher's Exact test, p =0.16).

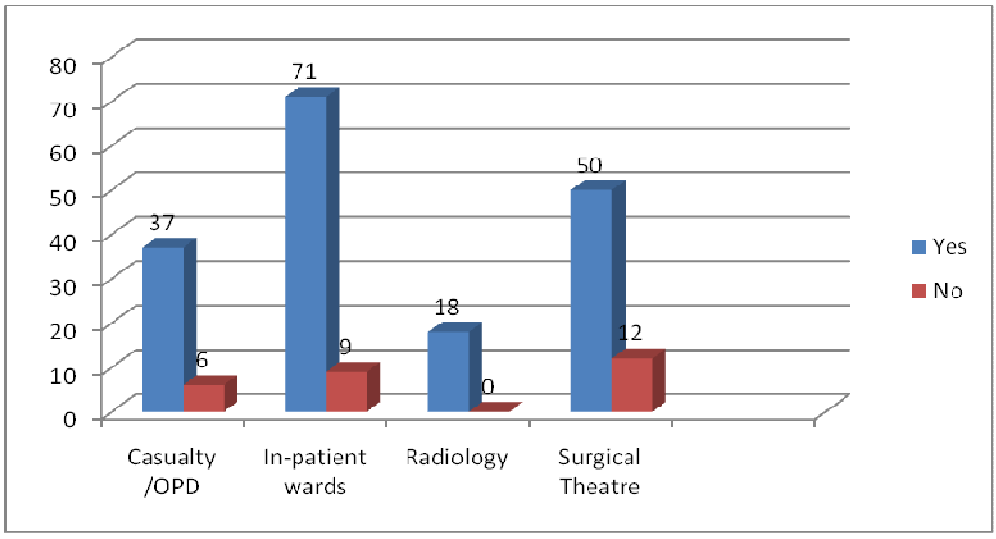

Figure 4.11 Frequency distribution of CME maintenance plan in four departments

4.2.4 TRAINING ON USE OF CAPITAL MEDICAL EQUIPMENT

Most of the initial training in the Hospital was given by the suppliers, 176 (87%) out of 203 CME and only 27 (13%) of initial training was given by other entities (such as manufacturer, in-house or multiple provider) (Figure 4.12).

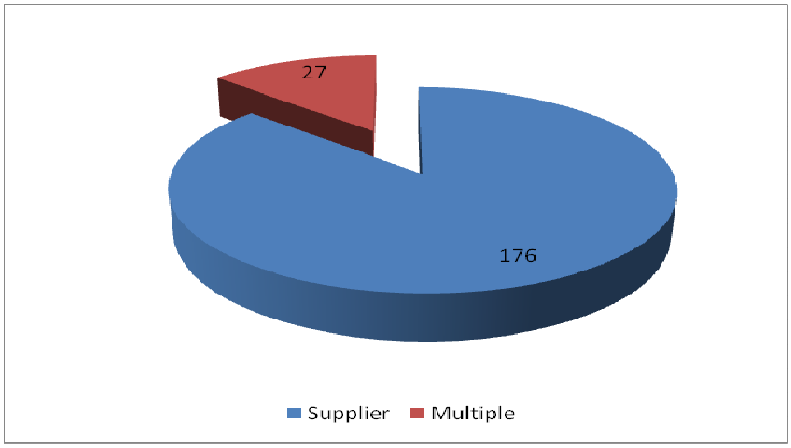

Figure 4.12 Frequency distribution of initial training on CME

Initial training per department was described in Figure 4.13. Suppliers gave most of the initial training to the In-patients wards (71, 41%) and Surgical theatre (50, 28%). These two departments had more CME than other departments.

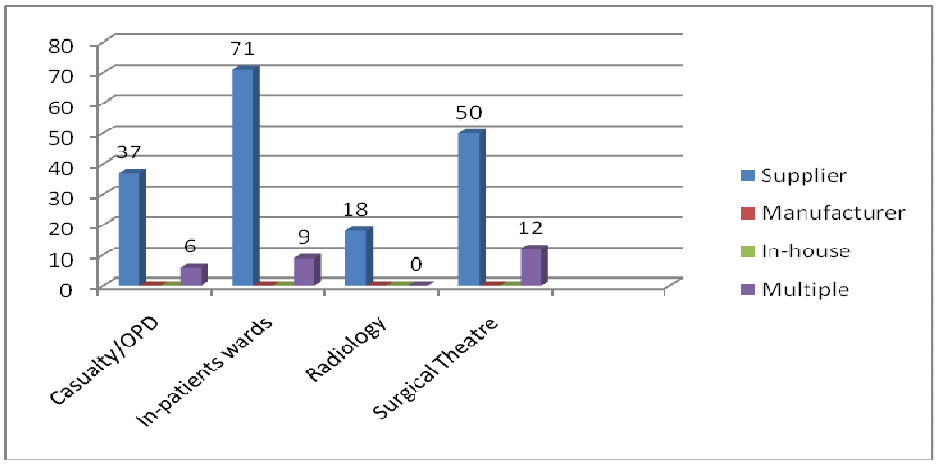

Figure 4.13 Frequency distribution of initial training on CME for four departments

4.3 THE LIFESPAN OF CAPITAL MEDICAL EQUIPMENT

The medians for the expected life span and actual life span were 10 years (IQR 8-10) and 7 years (IQR 5-10) respectively (Table 4.8 and Figure 4.14). The actual lifespan of the CME was significantly lower than the expected life span (Mann Whitney's U test, $p<0.001$). This implies that a significant number of CME did not reach their actual lifespan and could function without being replaced.

Table 4.8 Lifespan of CME (in years)

Life-span	Number of CME	Minimum	Maximum	Median	IQR
Expected life span	203	5	15	10	8-10
Actual life span	203	1	10	7	5-10

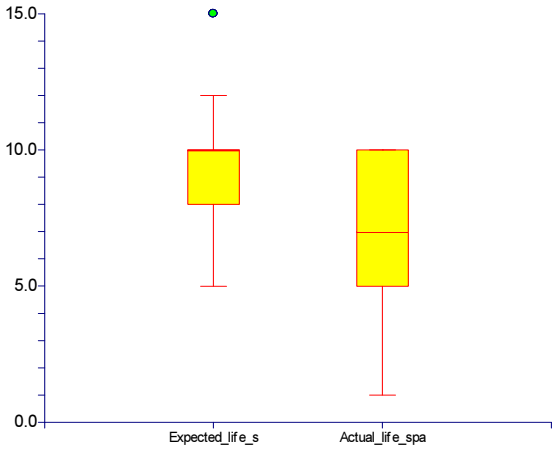

Figure 4.14 Box plot for expected and actual lifespans of CME

If the actual lifespan is less than the expected lifespan, it implies the equipment can be used safely without being replaced.

In Table 4.9, the expected and actual lifespans of the CME for the four departments are described. There were significant differences in expected and actual life span (in years) in Casualty/OPD (Mann Whitney's U test, $p < 0.001$), In-patient wards (Mann Whitney's U test, $p < 0.001$) (Figure 4.15).

The result shows that a significant number of CME in these two departments

did not reach their actual lifespan and could function without being replaced. On the other hand the CME in the Radiology and Surgical theatre departments would require replacement.

Table 4.9 Life span of CME per Department (in years)

	Department	Minimum	Maximum	Median	IQR
Expected life span	Casualty/ OPD	5	15	10	7-10
	In-patients wards	5	15	10	8.5-10
	Radiology	7	12	12	8-12
	Surgical theatre	5	15	10	10-12
Actual life span	Casualty/OPD	1	10	6	4-10
	In-patients wards	1	10	5	4-7
	Radiology	3	10	9	4.5- 10
	Surgical theatre	1	10	10	7-10

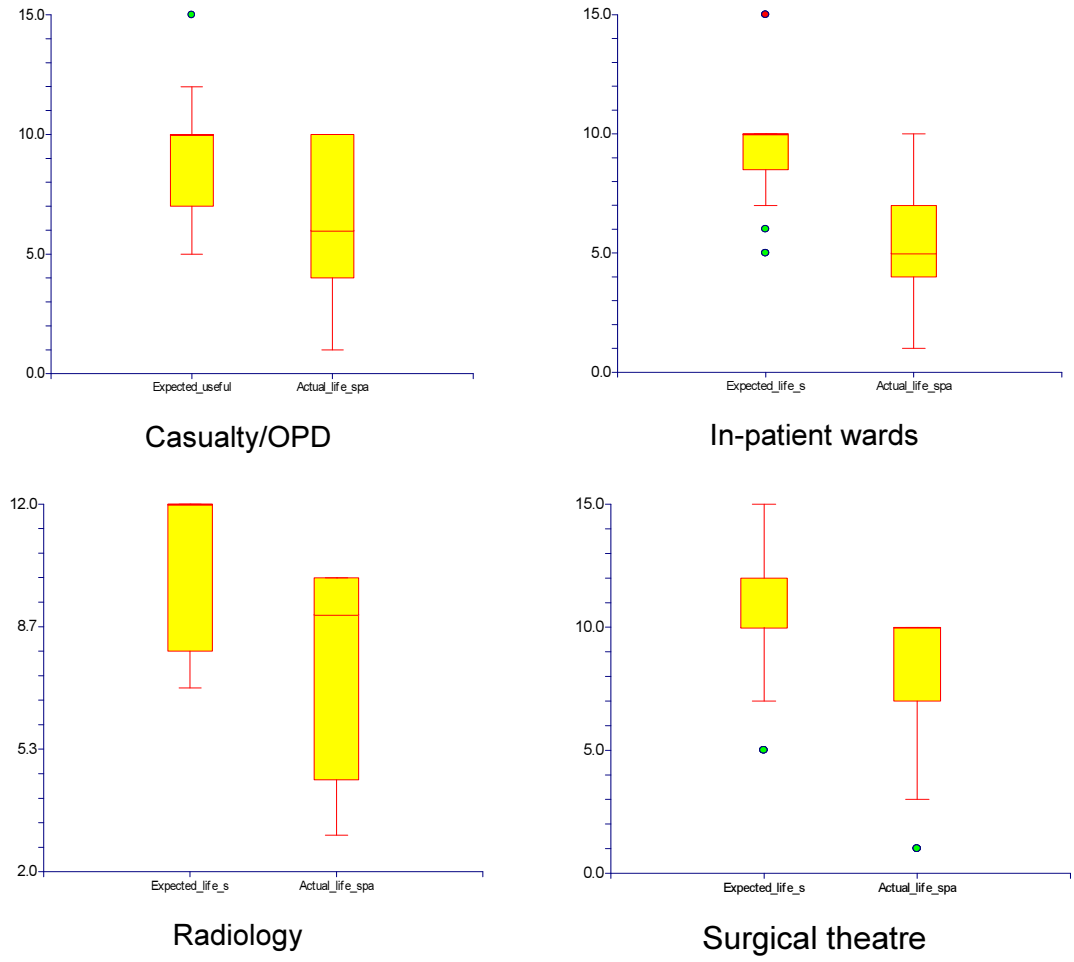

Figure 4.15 Box plot for expected and actual lifespans (in years) in four departments

4.4 COSTING OF CAPITAL MEDICAL EQUIPMENT

4.4.1 PURCHASING COST

The total purchasing costs for all four departments were R 8,217,760.36. The median for the purchasing cost for all four departments was R 18,500 (IQR R 9,690 – R 100,500) (Table 4.10, Figure 4.16). There were significant differences in the itemised purchasing cost (cost of each CME) among the four departments (One way ANOVA, $p<0.01$). The post-hoc test showed the itemised purchasing cost of CME in the Radiology department was significantly higher than the other departments.

Table 4.10 Purchasing costs of CME for four departments

	N	Minimum	Maximum	Median	IQR
Casualty/ OPD	43	R 5292	R138,681	R 15,527	R 10,277 - R 27,712
In-patients wards	80	R5,358	R 412,793	R 19,956	R 13,050 - R 27,561
Radiology	18	R6,500	R432,602	R90,310	R 17,000 - R168,720
Surgical theatre	62	R 5160	R 450,000	R 12,353	R 7,294- R 37,985
All departments	203	R 5,160	R450,000	R18,500	R9,690-R100,500

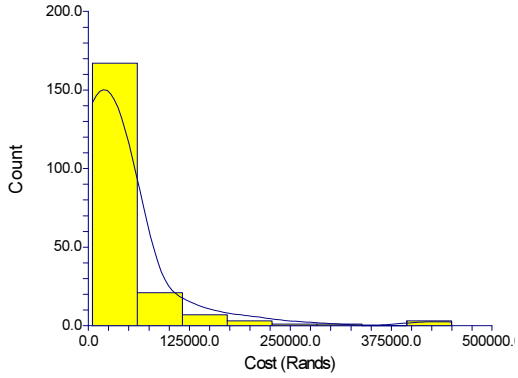

Figure 4.16 Box Plot of total purchasing costs (in Rands)

Total purchasing costs were highest in the In-patients department followed by Surgical Theatre, Radiology and Casualty/ OPD departments. (Figure 4.17).

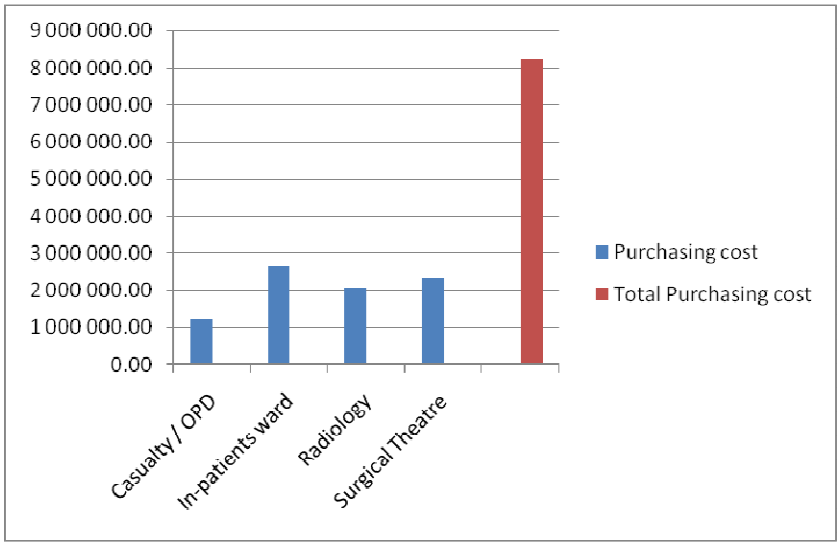

Figure 4.17 Total Purchasing costs for four departments

4.4.2 SERVICE COSTS

The service costs are described in Table 4.11. The total service costs for all four departments were R1, 454,566.85.

Table 4.11 Total service costs for CME during ten year period

Services	N	Minimum	Maximum	Median	IQR
Maintenance	130	R111	R 45,712	R 2,189	R 8,780 – R 59,830
Calibration	19	R 275	R 29,616	R 9,138	R 5,814 - R15,477
Repair	95	R 170	R 113,402	R 3,312	R1,482 - R7,792
All services	**187**	**R 111**	**R 126,497**	**R3,500**	**R1,250 - R10,075**

The median cost of calibration is quite high due to change in hospital policy about instituting regular calibration of all CME. The costs of different services (Maintenance, Calibration and Repair) for four departments are described in Table 4.12 (Figure 4.18). There were no significant differences in the cost of services among the four departments (One Way ANOVA, p =0.10).

Table 4.12 Cost of services for four departments

Services	Department	N	Minimum	Maximum	Median	IQR
Maintenance	Casualty/ OPD	26	R124	R24,274	R1,544	R996 – R3,770
	In – patients	48	R124	R 22,386	R1,800	R750 –R3,534
	Radiology	6	R3,055	R32,108	R5,510	R3,512-R26,655
	Surgical theatre	50	R111	R 45,712	R2,500	R537 – R9,219
Calibration	Casualty/ OPD	5	R700	R15,477	R8,190	R1,376-R12,838
	In-patients	43	R350	R13,134	R3,147	R1,350–R6,430
	Radiology	13	R3,665	R29,616	R9, 538	R8,638-R18,457
	Surgical theatre	1	R275	R275	-	-
Repair	Casualty/ OPD	27	R 70	R33,145	R3,954	R1,605 -R6, 796
	In-patients	43	R350	R13,134	R3,147	R1,350 -R6, 430
	Radiology	10	R 205	R113,403	R10,069	R1,278-R23,993
	Surgical theatre	15	R835	R10,557	R2,910	R1,760 - R4,884
Total costs	Casualty/ OPD	40	R124	R51,164	R 3,805	R1,299 - R9,149
	In-patients	71	R124	R29,617	R 3,079	R1,350– R6,569
	Radiology	18	R205	R126,496	R 18,457	R7,770-R34,199
	Surgical theatre	58	R111	R50,596	R2,500	R1,150-R10,086

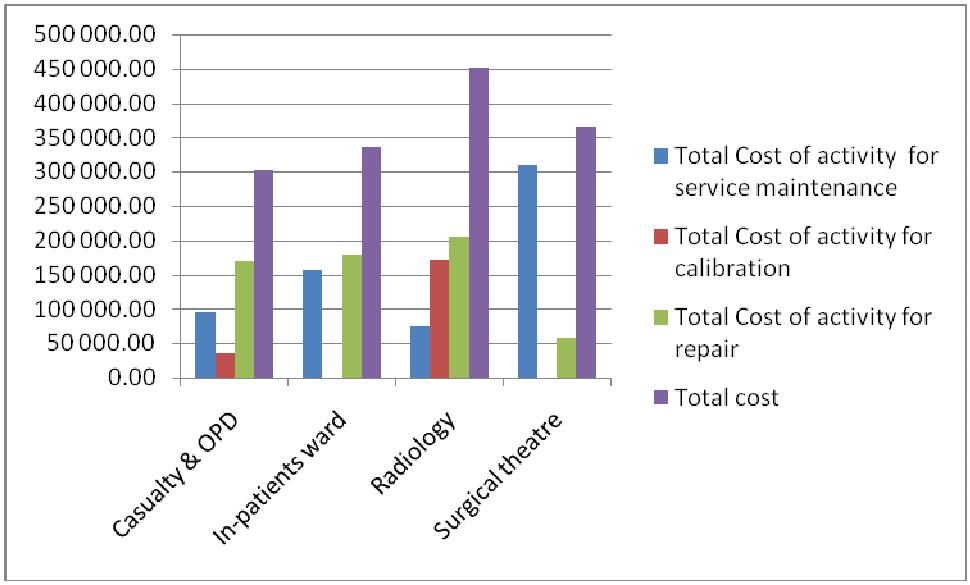

Figure 4.18 Costs of services for four departments

CHAPTER 5
DISCUSSION

This chapter focuses on discussing the results of the findings from the analysis of the functional state and costs of maintenance and repair of the CME at the DYD Hospital during the ten year study period.

5.1 THE PROFILE OF CAPITAL MEDICAL EQUIPMENT

Management of medical equipment includes assessment of the needs of an organization, followed by procurement, logistics of delivery and installation, inventory management, maintenance, safe use and training, and measurement of clinical effectiveness and ends with decommissioning (WHO, 2011; WHO, 2013). Although a district hospital uses low cost medical equipment in comparison to regional and national hospitals (Son, Thu, Tu, et al, 2007), the process still remains the same. It was not known how the current CME used in the DYD hospital was procured and any need assessment was done in the past as proposed by Vogt, et al (2002).

This was the first systematic study on medical equipment at this Hospital. The Hospital during the study period had 203 CME (defined as equipment with an original purchase price of more than R5000 (Gauteng Department of Health, 1994). The majority of them were in working condition (196, 97%), which was proportionately much higher than other studies done in developing countries (Malkin, 2007; Kanel and Pokhrel, 2009). However, based on the criteria stipulated in the Gauteng Provincial Administration Manual (1994), only a quarter of them (47, 23%) were in good working condition. One hundred and forty-four (71%) of them were in a fair condition requiring replacement within three to four years and only five (3%) was in poor condition. The Hospital condemned seven (3%) out of 203 CME (six from the Radiology department and one from the Casualty/OPD). The decision to condemn CME was taken into account not only the condition but also the costs of maintenance, calibration and repair. The Radiology Unit had a serious problem as a third of

its CME were condemned resulting in poor service delivery in this Unit. Notwithstanding the fact that there were policies and procedures with regard to the management of CME in Radiology, these policies and procedures were not always being followed. For example, the four CME in Radiology were condemned in April 2010 by the supplier (Tec Med Africa), but in March 2011 due to pressing service delivery needs these CME were still in use not condemned instead another company kept on maintaining them. Continued use of obsolete CME may result in higher costs, asset failure, and in some cases, health and safety implications.

It was incumbent for DYD Hospital that CME needed by staff to deliver services to patients was available as and when required. Therefore, the Hospital management should make a plan to replace these 11 CME (1 each from In-patient and Casualty/ OPD and three from Surgical theatre and six from Radiology), taking into consideration the age, condition and critical nature of use of these CME and their impact on service delivery (Temple–Bird, et al, 2005).

5.2 SERVICES OF CAPITAL MEDICAL EQUIPMENT

A hospital needs a policy on acquisition, maintenance and repair of medical equipment which should be implemented to reduce future problems arising from the unavailability of medical equipment at institutions (Vogt, et al, 2002). The availability of medical equipment depends on the out-of-service time (Tarawneh and El-Sharo, 2009) which in turn is influenced by regular and planned maintenance and repairs (Kainth, 2003; Meredith and Shafer, 2011). Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. The DYD Hospital introduced a planned maintenance policy for CME in 2006/07 resulting in a significant increase in number of out-of-service days.

The number of out-of-service days varied significantly among the four departments (In-patient, Casualty/ OPD, Surgical theatre and Radiology) and types of services (Maintenance, repair and calibration). Out-of service days

were significantly higher in Surgical theatre and Radiology Units (ANOVA, $p<0.001$), as these two units have complex equipment. Ideally, the out-of service days for maintenance should be significantly lower than those of repair. Out-of-service days for repair of CME in all four units were higher than that of maintenance, although not statistically significant. The number of episodes (number of times a CME sent for maintenance, repair or calibration) was not significantly different among the four departments. Even after introduction of a planned maintenance policy in 2006/2007, it was not changed. This was of concern and should be addressed by the hospital management. Hospital management should incorporate maintenance of CME as a part of routine instead of making it a separate and isolated function (Fredendall, et al, 1997). This would require development of maintenance policy and involvement of multi-disciplinary team comprised of end-users (health professionals) as well as maintenance engineers and technicians. The DYD Hospital recently introduced a policy to have maintenance plans for all CME and managed to cover 176 (87%) of them in line with the provincial policy (Gauteng Department of Health and Social Development, 2011).

On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994). This would ensure regular inspection, testing and maintenance intervals based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). In the DYD Hospital, most of the initial training was provided by the suppliers (176, 87%). It was not clear who were trained and whether follow-up training sessions were conducted to train newly appointed staff members. The hospital should organise regular training programme for all stakeholders as a part of continuous professional development activities.

5.3 THE LIFESPAN OF CAPITAL MEDICAL EQUIPMENT

The life-span of a CME depends on multiple factors such as planned maintenance at appropriate frequency, frequency of use, users; skills and

knowledge, surrounding environment (Kainth, 2003; Tarawneh and El-Sharo, 2009; Meredith and Shafer, 2011). As CME had to be replaced or upgraded at some point in time, it was important to identify the life expectancy of each CME and monitor its physical condition. This study found that the actual life-span of CME was significantly lower than the expected lifespan (Mann Whitney's U test, $p<0.001$). This implies a significant number of CMEs did not reach their life-span and a large proportion of them were in good (47, 23%) and fair (144, 71%) conditions. The Hospital CME acquisition policy should focus on those CME who are fair conditions as they require replacement in next 3-4 years. In addition a review of the purchase list should be done regularly for all items considering various aspects of the maintainability of the medical equipment as well as to identify shortfalls or surpluses of medical equipment in the various units in the Hospital (Waters, 2003; Grant, 2010).

Maintenance is not a separate and isolated function that makes repairs and performs assorted activities as needed but, a full partnership that strives together with other functions to achieve the strategic goals of the organisation and involves specialists such as maintenance engineers and technicians (Fredendall, Patterson, Kennedy et al, 1997). On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994).

Replacement of medical equipment is planned taking into consideration the age, condition and critical nature of use. At the end of its life cycle it must be condemned, disposed and taken out of service (Temple–Bird, et al, 2005). Faulty or defective medical equipment must not be used regardless of how minor this is perceived. Inspection, testing and maintenance intervals should be based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). Owing to the life span of CME, it can take several years before it needs to be replaced and at the time of replacement, CME might prove to be technologically obsolete. Management of hospitals should consider the acquisition of CME with care (Hugo, et al, 2006).

5.4 COSTING OF CAPITAL MEDICAL EQUIPMENT

Medical equipment is an important asset and is included in hospitals' budget cost estimates not only for procurement but also servicing these equipment. Although WHO suggested that it should account for 10% of the total hospital operational budget (WHO, 2010), in many developing countries such as India, only 2.5% of the district hospitals budget is set aside for machinery and equipment (Mavalankar, et al, 2004). The CME procurement and service costs incurred by the Hospital were primarily funded from the equipment budget allocated by the Department of Heath from the Province.

The total purchase cost of CME in the DYD Hospital during the study period was R 8,217,760.36 (approximately R 821,776 per year). The total purchasing costs for different units are as follows (a) In-patient unit: (Total R 2,632,551.03; Median R 19,956); (b) Casualty/ OPD (Total R 1,206,536.40; Median 15,527); (c) Surgical theatre (Total R 2,330,810.55; Median: R 12,353); and (d) Radiology (Total R 2,047,862.38; Median: R 90,310). Although the total purchasing cost in the In-patient unit was the highest, the median cost was the highest in Radiology unit due to the nature of equipment used in that unit.

The total service cost of CME in the DYD Hospital during the study period was R 1,454,566.85 (approximately R 145,456.68 per year), almost same amount for maintenance (R 635,476.86) and repair (R 611,206.15) and less for calibration (R 207,886.84). The service costs for different units are as follows: (a) Casualty/ OPD (Total R 196,024.20; Median R 3,805); (b) In-patient unit: (Total R 335,749.60; Median R 3,079); (c) Surgical theatre (Total R 366,415.40; Median: R 2,500); and (d) Radiology (Total R 451,047.10; Median: R 18,457). The total and median service cost in the Radiology Unit was highest among the four units.

Among the four units the total cost (purchasing and service) was the highest in

In-patient unit (R2,968,300.63) followed by Surgical theatre (R2,697,225.95), Radiology (R2,498,909.48), and Casualty/ OPD (R1,402,560.60).

The study showed that the Hospital spent a significant amount of resources on CME. A large portion of this resource was spent on repair. Therefore the Hospital management should perform a review of the purchase list for all items considering various aspects of the maintainability of the medical equipment. This should be followed by a comprehensive asset maintenance plan that showed the current condition and utilisation of CME, expected future demand and the cost of sustaining CME availability in the long run.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

In this chapter, conclusions and appropriate recommendations are made based on the findings of the study. Limitations and suggestions for future research are also included.

6.1 CONCLUSION

This was a cross-sectional study based retrospective record review that focused on the analysis of the functional state and costs of purchase and service of CME at DYD Hospital during a ten year period (1st April 2001 to 31st March 2011). In this chapter, conclusions and appropriate recommendations are made based on the findings of the study. Limitations and suggestions for future research are also included.

6.1.1 DESCRIPTION OF THE PROFILE OF CME ON THE HOSPITAL ASSET REGISTER

The Hospital during the study period had 203 CME (defined as equipment with an original purchase price of more than R5000). The majority of them were in working condition (196, 97%), which was much higher than other studies done in developing countries. Based on the criteria stipulated in the Gauteng Provincial Administration Manual (1994), only a quarter of them (47, 23%) were in good working condition and 144 (71%) of them were in a fair condition requiring replacement within three to four years and only four (3%) was in poor condition. In addition, the Hospital condemned seven (3%) of them during this period and six of them are from the Radiology Unit. This was a third of the total CME in that Unit resulting in poor radiology service delivery in this Hospital.

6.1.2 DESCRIPTION OF THE SERVICES OF CME

Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. The DYD Hospital introduced a planned maintenance policy for CME in 2006/07 resulting in a significant increase in number of out-of-service days. Out-of service days were significantly higher in Surgical theatre and Radiology Units, as these two units have complex equipment. Out-of-service days for repair of CME in all four units were higher than that of maintenance, which is of concern and should be addressed by the hospital management. The DYD Hospital had recently introduced a policy to have maintenance plans for all CME and managed to cover 176 (87%) of them and hopefully it would assist in better maintenance and reduced repair time and cost. In addition, the hospital should organise regular training programme for all stakeholders as a part of continuous professional development activities.

6.1.3 DETERMINATION OF THE LIFESPAN OF CME

This study found that the actual life-span of CME (203) was significantly lower than the expected lifespan implying that a significant number of CMEs did not reach their life-span and a large proportion of them were in good (47, 23%) and fair (144, 71%) conditions. The Hospital CME acquisition policy should focus on those CME who are in fair conditions as they require replacement in the next 3-4 years. In addition a gap-analysis should be conducted to determine the state of CME and to identify shortfalls or surpluses of these medical equipment in various units in the Hospital.

6.1.4 DETERMINATION OF THE PURCHASING AND SERVICE COSTS

The total purchase cost of CME in the DYD Hospital during the study period was R 8,217,760.36 (approximately R 821,776 per year). The total purchasing costs varied among different units. During the same period, the total service cost was R 1,454,566.85 (approximately R 145,456 per year), almost same

amount for maintenance (R 635,476.86) and repair (R 611,206.15) and less for calibration (R 207,886.84).

6.2 LIMITATION OF THE STUDY

Firstly, the subject is hardly researched in South Africa and elsewhere. Therefore, the literature related to the subject is scanty.

Secondly, this study focussed on retrospective record review of records from a district hospital. However, the hospital had a good asset management system resulting in the generation of good quality of data.

Thirdly, the study focussed on a specific district hospital, therefore, its finding cannot not be generalised to other health facilities.

Fourthly, the researcher did not do the assessment. The assessment of CME requires specific skills of a clinical engineer, which the researcher do not have.

Lastly, the study only documented the information from the asset register; no physical verification was done to validate the findings of the study. In addition, no interviews were conducted to understand the impact of out-of-service CME, as it was beyond the scope of the study.

6.3 RECOMMENDATIONS

6.3.1 RECOMMENDATIONS TO THE HOSPITAL MANAGEMENT

There is a need for DYD Hospital to embrace CME maintenance as a high priority rather than Adhoc maintenance to avoid high costs of repairs and to reduce out-of-service days. The Hospital should establish a comprehensive asset maintenance plan that shows the current condition and utilisation of CME, expected future demand and the cost of sustaining CME availability in

the long run. The Hospital should also ensure that its medical equipment management unit is adequately staffed with the requisite manpower and a qualified Health Technology Officer is appointed.

All 203 CME should have maintenance plans in place and it should be made mandatory for different suppliers and manufacturers to provide training to technicians and staff followed by continuous professional development.

The DYD Hospital should develop an evidence based CME procurement system to ensure that a high quality and durable CME are purchased to prolong their life span.

The Hospital should compare the actual costs of CME (calibration, maintenance and repairs) against the budget allocation and any difference between actual and budget data should trigger a review of the reasons for the variance. Unexpected and expensive repair required for a critical CME can cause a substantial budget variance, as such, expenses of this type should be anticipated as much as possible so that, over time, the average level of expenses remains within the allocated budget.

A Provincial CME policy should be formulated as part of the Departmental Policy to compel institutions to periodically report on the functional state, maintenance and repair of CME. In addition, the Department of Health should allocate specific CME budget at hospitals and ring-fence it from other capital equipment budget.

6.3.2 SUGGESTION FOR FUTURE RESEARCH

Based on the findings of this study, the researcher would suggest that a following research should be conducted as a follow-up to this study:

- The study should be extended to other hospitals in South Africa.
- A comparative study should be done to verify information from the asset register and the actual state of the CME.

- A prospective study should be done to interview end-users to develop an understanding of the effect of CME on service delivery.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE CERTIFICATE AND LETTERS OF APPROVAL

Postgraduate Office, Faculty of Health Sciences

Wits Medical School, 7 York Road, PARKTOWN, 2193, Johannesburg • Tel: (011) 717 2108 • Fax: 086 622 9569 • e-mail: mathikhui.moshabesha@wits.ac.za

Dear Postgraduate Student

I take pleasure in informing you that your application for change of title has been approved by the Chair of the Faculty Graduate Studies Committee.

Kind regards

Mathikhui Moshabesha (Mrs)

Senior Faculty Officer Postgraduate Studies: Allied Disciplines

Faculty of Health Sciences

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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Patrick Mbeko Sofohlo

CLEARANCE CERTIFICATE	M110810
PROJECT	An Analysis of the Functional State and Cost of Maintenance and Repair of Capital Medical Equipment at Dr Yusuf Dadoo Hospital
INVESTIGATORS	Patrick Mbeko Sofohlo.
DEPARTMENT	School of Public Health
DATE CONSIDERED	26/08/2011
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Dr Moreshnie Govender

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementi research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

Umyango Wezwmpilo no Kuthuthukiswa Komphakathi
Lefapha La Maphelo le Tshebeletso le Ntshetsopele ya
Department of Health & Social Development
Departmente van Gesondheid en Maatsplike
Ontwikkelia

health and
social development
Department: Health and Social Development
GAUTENG PROVINCE

To: Mr. P Sofohlo

From: Dr B Ikalafeng, Research Coordinator: Research and Epidemiology

Date: 21 September 2011

RE: Approval by GDH&SD on change in title

This serves as an acknowledgment to the change in title of Mr Sofohlo's research study which was previously titled: "Assessment of capital medical equipment management in a district hospital" and now is changed to: "an analysis of the functional state and costs of maintenance and repair of capital medical equipment at Dr. Yusuf Dadoo hospital"

The content of the research study is still the same and therefore approval is granted on the change in title.

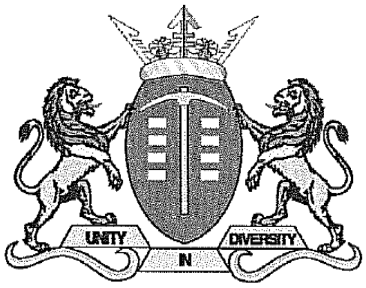
Kind Regards,

2011/09/21

Dr Ikalafeng

Research Coordinator: Research and Epidemiology

CONDITIONS OF APPROVAL OF A RESEARCH STUDY PROPOSAL



health and social development
Department: Health and Social Development
GAUTENG PROVINCE

Vision of the Department

"To be the best provider of quality health and social services to the people in Gauteng"

POLICY, PLANNING AND RESEARCH (PPR)
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Date	04 April 2011
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Email	SofohloP@gpg.gov.za
Researcher /Principal Investigator (PI)	P.M. Sofohlo
Supervisor	Dr. M. Govender
Institution	University of Witwatersrand
Research title	**Assessment of capital medical equipment management in a district hospital**

This approval is granted only for a research study entitled **"Assessment of capital medical equipment management in a district hospital"** which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

Approval is hereby granted by the Gauteng Department of Health and Social Development for the above mentioned research study proposal for a study to be conducted within GDHSD domain. Approval is limited to compliance with the following terms and conditions:

1. All principles and South African regulations pertaining to ethics of research are observed and adhered to by all involved in the research project. Ethics approval is only acceptable if it has been provided by a South African research ethics committee which is accredited by the National Health Research Ethics Council (NHREC) of South Africa; this is regardless of whether ethics approval has been granted elsewhere.

   Of key importance for all researchers is that they abide by of all research ethics principles and practice relating to human subjects as contained in the Declaration of Helsinki (1964, amended in 1983) and the constitution of the Republic of South Africa in its entirety. Declaration of Helsinki upholds the following principles when conducting research, respect for:
   - Human dignity;
   - Autonomy;
   - Informed consent;
   - Vulnerable persons;
   - Confidentiality;
   - Lack of harm;
   - Maximum benefit;
   - and justice

2. The GDHSD is indemnified from any form of liability arising from or as a consequence of the process or outcomes of any research approved by HOD and conducted within the GDHSD domain;
3. Researchers commit to providing the GDHSD with periodic progress and a final report; short term projects are expected to submit progress reports on a more frequent basis and all reports must be submitted to the Director: Policy, Planning and Research of the GDHSD;
4. The Principal Investigator shall promptly inform the above mentioned office of changes of contact details or physical address of the researching individual, organisation or team;
5. The Principal Investigator shall inform the above office and make arrangements to discuss their findings with GDHSD prior to dissemination;
6. The Principal Investigator shall promptly inform the above mentioned office of any adverse situation which may be a health hazard to any of the participants;
7. The Principal Investigator shall request in writing authorization by the HOD via PPR for any intended changes of any form to the original and approved research proposal;
8. If for any reason the research is discontinued, the Principal Investigator must inform the above mentioned office of the reasons for such discontinuation;
9. A formal research report upon completion should be submitted to the Director: Policy, Planning and Research of the GDHSD with recommendations and implications for GDHSD, the Directorate will make this report available for the HOD.

This approval is granted only for a research study entitled **"Assessment of capital medical equipment management in a district hospital"** which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

AGREEMENT BETWEEN THE GAUTENG DEPARTMENT OF HEALTH AND SOCIAL DEVELOPMENT (GDHSD) AND THE RESEARCHER

Ms Sue le Roux

Director: Policy, Planning and Research, Department of Health and Social Development

Date:

Signature:

2/04/2011

Name and surname of Principal Researcher

Research/Academic Institution

Date: 2011/04/06

Signature:

3

This approval is granted only for a research study entitled "**Assessment of capital medical equipment management in a district hospital**" which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

APPENDIX B: DATA COLLECTION INSTRUMENTS

Tool 1: Profile of CME

Unique number	CME name	CME type	CME location	Purchase date	Purchase Price	Supplier name	Maintenance Plan	Initial training	Asset state	Date condemned	Life span

Tool 2: CME functionality (service maintenance, calibration and repairs)

Unique number	CME name	Department	Activity (Episodes of service maintenance)	Activity (Episodes of calibration)	Activity (Episodes of repairs)	Number of days CME out for service maintenance, calibration & repairs.	Cost of activity (service maintenance, calibration & repairs)	Name of the supplier

ANNEXURE C: LIST OF CAPITAL MEDICAL EQUIPMENT

Casualty and OPD (43 CME)

No	S/n	Full description	Classification	Department
1.	715PB	Bird Respiratory Ventilator	Respiratory Ventilator	Casualty
2.	716PB	Bird Respiratory Ventilator	Respiratory Ventilator	Casualty
3.	496EA	Medicare 4380 Baby Scale	Baby Scale	Casualty
4.	656KV	Weyer Infant Warmer Medical Trolley	Medical Trolley	Casualty
5.	657KV	Metal 1 Door & 1 Drawer Equipment Trolley	Equipment Trolley	Casualty
6.	FW619	Dkk Surgical Light	Surgical Light	Casualty
7.	099LX	Siemens E347E SV 900C Ventilator	Ventilator	OPD
8.	917KM	Welch Allyn Examination Light	Examination Light	Casualty
9.	KH757	Code master M1723A Defibrillator	Defibrillator	Casualty
10.	LC878	Nihon Kohden Tec7521K Defibrillator	Defibrillator	Casualty
11.	661MX	Metal 1 Door & 1 Drawer Equipment Trolley	Equipment Trolley	Casualty
12.	566DY	Fanem C186 Ts Infant Incubator	Infant Incubator	Casualty
13.	566DY	Cardio fax Gem 9022K ECG Machine	ECG Machine	Casualty
14.	565DY	Nihon Kohden 9022K ECG Machine	ECG Machine	Casualty
15..	738DY	Procare Auscultatory 100 Dinamap	Dinamap	Casualty
16.	UO201	Sony Lmd-1410 Patient Monitor	Patient Monitor	Casualty
17.	UO375	Engstrom Pro Ventilator	Ventilator	Casualty
18.	UO280	Tranpac 200D Ventilator	Ventilator	Casualty
19.	UO266	Mindray Vs-800 BP Monitor	Bp Monitor	Casualty
20.	448KV	Corometrics 170 Series Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
21.	258DM	Toshiba Capasee 11 Sonar Machine	Sonar Machine	Antenatal Clinic
22.	517EA	Tanita Baby Scale	Baby Scale	Antenatal Clinic
23.	KH579	TUV Mkco170-1530A Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
24.	LC842	Orchestra Mvp+Ms Infusion Pump	Infusion Pump	TB Focal Point
25.	VB612	Colin Bp8800 Blood Pressure Set	Blood Pressure Set	Termination of Pregnancy
26.	663MX	Procare Auscultatory 100 Dinamap Bp Monitor	Bp Monitor	TB Focal Point
27.	659MX	Dinamap Dpc121Xen Bp Monitor	Bp Monitor	Termination of Pregnancy
28.	293MZ	Procare Auscultatory Dpc321N-En Dinamap	Dinamap	Poly Clinic
29.	253MZ	Chison 8500 Sonar Machine	Sonar Machine	Termination of Pregnancy
30.	295MZ	Procare Auscultatory Dpc321N-En Dinamap	Dinamap	Poly Clinic
31.	KW995	Colin Next Bp-88S Patient Monitor	Patient Monitor	ARV Clinic
32.	789PA	Goldway Ut4000A Patient Monitor	Patient Monitor	TB Focal Point
33.	790PA	Goldway Ut4000A Patient Monitor	Patient Monitor	TB Focal Point
34.	771PA	Hospivac 350 Suction Unit	Suction Unit	Poly Clinic

35.	LC838	Orchestra Mvp+Ms Infusion Pump	Infusion Pump	TB Focal Point
36.	UO261	Philips Avalon Fm20 Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
37.	004KV	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Rehabilitation
38.	031KV	Enraf Nonius Delft 419 Curapuls Shortwave Diathermy Esu	Diathermy ESU	Rehabilitation
39.	163KV	Madsen Orbiter 922 Audiometer	Audiometer	Rehabilitation
40.	257DM	Physio Control Lifepak 6 Defibrillator	Defibrillator	Rehabilitation
41.	145PC	Enraf Nonius 462 Curapuls Diathermy ESU	Diathermy ESU	Rehabilitation
42.	146PC	Enraf Nonius 462 Curapuls Diathermy ESU	Diathermy ESU	Rehabilitation
43.	KW552	Gsi 38 Auto Tymp	Auto Tymp	Rehabilitation

In-patients wards (80 CME)

No	S/n	Full description	Classification	Department
44.	024ZW	Metal 1 Level Phototherapy Unit	Phototherapy Unit	Maternity Ward
45.	122DM	Imed 916 Infusion Pump	Infusion Pump	Paediatrics Ward
46.	273DM	Med shield System 900 Boils Machine	Boils Machine	Maternity Ward
47.	282DM	Salter Baby Scale	Baby Scale	Maternity Ward
48.	279DM	Salter Baby Scale	Baby Scale	Post Natal Ward
49.	265KV	Sms B-Vac Suction Machine	Suction Pump	Female Medical Ward
50.	256DM	Isolette C86H Infant Incubator	Infant Incubator	Paediatrics Ward
51.	339LW	Seca 727 Baby Scale	Baby Scale	Paediatrics Ward
52.	401EA	Metal Examination Light	Examination Light	Paediatrics Ward
53.	405EA	Metal Examination Light	Examination Light	Paediatrics Ward
54.	408EA	Metal Examination Light	Examination Light	Paediatrics Ward
55.	648EA	Isolette C86H Infant Incubator	Infant Incubator	Maternity Ward
56.	872PB	Critikon 8100 Vital Sign Monitor	Vital Sign Monitor	Male Medical Ward
57.	659EA	Isolette C86 Infant Incubator	Infant Incubator	Maternity Ward
58.	662EA	Meco Pti Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
59.	HR096	Sms Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
60.	KH761	Hospilite Dkk De53090 Surgical Light	Surgical Light	Maternity Ward
61.	9553B	Module Mvp +Ms Is Syringe Pump	Syringe Pump	Paediatrics Ward
62.	910DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
63.	500DM	Metal 4 Glass Doors & 1 Drawer Medicine Trolley	Medicine Trolley	Male Medical Ward
64.	530DM	Metal 1 Door & 1 Drawer Medicine Trolley	Medicine Trolley	Male Medical Ward
65.	579DM	Metal Cardiac Trolley	Cardiac Trolley	Female Medical Ward
66.	909DO	Isolette Yp-90 Infant Incubator	Infant Incubator	Maternity Ward
67.	911DO	David Yp-90 Infant Incubator	Infant Incubator	Maternity Ward
68.	903DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
69.	908DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
70.	749DO	Fresenius Vial Mvp + Msuk Infusion Pump	Infusion Pump	Post Natal Ward
71.	358MZ	Criticare 506Dxn Bp Monitor	Bp Monitor	Male Medical Ward
72.	083ZW	Metal Examination Light	Examination Light	Paediatrics Ward
73.	092MZ	Wall-mounted Suction Valve	Suction Valve	Paediatrics Ward
74.	386MZ	Orthovac Suction Machine	Suction Machine	Paediatrics Ward
75.	397MZ	Hanau Med Examination Light	Examination Light	Paediatrics Ward
76.	664MX	Isolette C450 Infant Incubator	Infant Incubator	Maternity Ward
77.	660MX	Procare Dinamap 100 Bp Monitor	Bp Monitor	Post Natal Ward

78.	KW531	Colin Next Bp-88S Patient Monitor	Patient Monitor	Female Medical Ward
79.	000DY	Dinamap Dpc321En Bp Monitor	Bp Monitor	Post Natal Ward
80.	9870B	Isumed Infant Warmer	Infant Warmers	Post Natal Ward
81.	010DY	Oximax Pro 400V2 Dinamap	Dinamap	Maternity Ward
82.	259DM	Metal 1 Door Vacoliter Warmer	Vacoliter Warmer	Maternity Ward
83.	452DY	Sonicaid Team Care 12345678910 CTG Machine	CTG Machine	Maternity Ward
84.	819DY	Sonicaid Team Care 12345678910 CTG Machine	CTG Machine	Maternity Ward
85.	KW991	Aloka Ip-1233Dv Sonar Machine	Sonar Machine	Maternity Ward
86.	LC835	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
87.	LC840	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
88.	LC841	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
89.	647MX	Optima Mis Infusion Pump	Infusion Pump	Paediatrics Ward
90.	9863B	Air Shields Infant Incubator	Infant Incubator	Paediatrics Ward
91.	9864B	Air Shields Infant Incubator	Infant Incubator	Paediatrics Ward
92.	557PA	Nt2A Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
93.	558PA	Nt2A Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
94.	843DO	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
95.	844DO	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
96.	9891B	Zoll M Series Defibrillator	Defibrillator	Paediatrics Ward
97.	LC903	Isolette C86 Infant Incubator	Infant Incubator	Paediatrics Ward
98.	879PB	Criticare 504 Plus Bp Monitor	Bp Monitor	Male Medical Ward
99.	LC925	Fresenius Uvp 5000 Volumetric Infusion Pump	Infusion Pump	Paediatrics Ward
100.	737DY	Procare Auscultator Dpc321N-En Dinamap	Dinamap	Paediatrics Ward
101.	958DY	Photizo 643 Phototherapy Light	Phototherapy Light	Maternity Ward
102.	757PA	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
103.	758PA	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
104.	560PA	Bionics Bpm-200 Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
105.	595PA	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
106.	783PA	Pc-900 Vital Sign Monitor	Vital Sign Monitor	Paediatrics Ward
107.	784PA	Aloka Ssd-3500 Sonar Machine	Sonar Machine	Maternity Ward
108.	787PA	Fanem C186 Ts Infant Incubator	Infant Incubator	Maternity Ward
109.	417LW	Lifepak 6 Defibrillator AED	Defibrillator AED	Female Medical Ward
110.	793PA	Volumat Agilia Infusion Pump	Infusion Pump	Paediatrics Ward
111.	794PA	Volumat Agilia Int Syringe Pump	Syringe Pump	Paediatrics Ward
112.	812PA	Auscultator Procare Dpc321N Dinamap	Dinamap	Maternity Ward
113.	615WL	Blt M900 Blood Pressure Set	Blood Pressure Set	Maternity Ward
114.	9889B	Sms Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
115.	194PC	David Yp90A Infant Incubator	Infant Incubator	Maternity Ward
116.	195PC	David Yp-90A Infant Incubator	Infant Incubator	Maternity Ward
117.	UO265	Mindray Vs-800 Vital Sign Monitor	Vital Sign Monitor	Maternity Ward
118.	192PC	David Yp90A Incubator	Incubator	Post Natal Ward
119.	193PC	David Yp90A Incubator	Incubator	Post Natal Ward
120.	191PC	David Yp-90A Infant Incubator	Infant Incubator	Paediatrics Ward
121.	UO365	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward
122.	UO392	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward
123.	UO399	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward

Radiology (X-Ray) - (18 CME)

No	S/n	Full description	Classification	Department
124.	506KV	Shimadzu Bf-11 Erect Bucky	X Ray Bucky	X-Ray Department
125.	517KV	Delayed Film Id Marker X Ray Identification Camera	X Ray Camera	x- Ray department
126.	621EA	Toshiba Kcd-10M-7At X Ray Machine	X Ray Machine	x- Ray department
127.	628EA	Toshiba Kcd-10M-6A1T X Ray Machine	X Ray Machine	x- Ray department
128.	721DR	Toshiba Kcd-10M-6A7S X Ray Machine	X Ray Machine	x- Ray department
129.	970EA	Target D850 Plus Dynatron Ultrasound Machine	Ultrasound Machine	x- Ray department
130.	550KV	Siemens Elema 6898589G025E X Ray Machine	X Ray Machine	x- Ray department
131.	553KV	Aloka Ssd-620 Sonar Machine	Sonar Machine	x- Ray department
132.	FY552	Conventional Pl-CW type X-Ray Cassette	X Ray Cassette	x- Ray department
133.	644MX	Classic Agfa X Ray Film Processor	X Ray Film Processor	x- Ray department
134.	9706B	Toshiba Kcd-10M-6A1T X Ray Machine	X Ray Machine	x- Ray department
135.	048SB	Toshiba Kcd-10M-6At X Ray Machine	X Ray Machine	x- Ray department
136.	UO203	Curix Film Id Marker X Ray Identification Camera	X Ray Camera	x- Ray department
137.	9901B	Shimadzu Collimator R-200 Portable X Ray Machine	X Ray Machine	x- Ray department
138.	005ZX	Shimadzu R-20J X Ray Machine	X Ray Machine	x- Ray department
139.	006ZX	Shimadzu Ch-200 Telescopic X Ray Machine	X Ray Machine	x- Ray department
140.	007ZX	Shimadzu QJC Erect Bucky	X Ray Bucky	x- Ray department
141.	010ZX	Fujifilm FCR IR 359 Digital X Ray Reader	X Ray Reader	x- Ray department

Surgical Theatre (62 CME)

No	S/n	Full description	Classification	Department
142.	121DM	Generic R-2.500 Suction Pump	Suction Pump	Surgical Theatre
143.	123DM	Hellige Servomed Anaesthetic Machine	Anaesthesia Machine	Surgical Theatre
144.	125DM	Servo 900C Ventilator	Ventilator	Surgical Theatre
145.	126DM	Sirecust 402 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
146.	127DM	Hellige Servomed Anaesthetic Machine	Anaesthesia Machine	Surgical Theatre
147.	128DM	M Stabler Suction Unit	Suction Unit	Surgical Theatre
148.	139DM	Scd5328 Sequential Compression Device	Compression Device	Surgical Theatre
149.	140DM	Hellige Smk230 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
150.	141DM	Hellige Smk230 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
151.	145DM	Eschmann R-2.2500 Suction Unit	Suction Unit	Surgical Theatre
152.	161DM	Critikon Dinamap Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre
153.	163DM	Ohmeda 700 Ventilator	Ventilator	Surgical Theatre
154.	199DM	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Surgical Theatre

155.	306DM	Anzy Jsd400 Autoclave	Autoclave	Surgical Theatre
156.	306DM	M Stabler Sterilizer Machine	Sterilizer Machine	Surgical Theatre
157.	307DM	Mainline Steam Autoclave	Autoclave	Surgical Theatre
158.	360DM	Siemens Radio tom 804E Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
159.	361DM	Mf450 Aspen Diathermy Esu	Diathermy ESU	Surgical Theatre
160.	369DM	Storz Cold Light Fountain	Cold Light Fountain	Surgical Theatre
161.	383DM	Storz Cold Light Fountain	Cold Light Fountain	Surgical Theatre
162.	393DM	Atom Trans capsule V-80Tr Infant Incubator	Infant Incubator	Surgical Theatre
163.	398DM	Mf450 Aspen Diathermy Esu	Diathermy ESU	Surgical Theatre
164.	661LW	Steri-Vac 3M Gas Sterilizer	Gas Sterilizer	CSSD
165.	662LW	Steri-Vac 400G Gas Sterilizer	Gas Sterilizer	CSSD
166.	995DR	Neomed 3000A Ventilator	Ventilator	Surgical Theatre
167.	998DR	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Surgical Theatre
168.	FW621	Generic Surgical Light	Surgical Light	Surgical Theatre
169.	KH855	Meco 100/1 Infant Warmer	Infant Warmers	Surgical Theatre
170.	KH861	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
171.	KH862	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
172.	KH863	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
173.	KH865	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
174.	KH866	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
175.	KH874	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
176.	KH875	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
177.	HP793	Bear1 Ventilator	Ventilator	Surgical Theatre
178.	LC847	Metal Frame Adjustable Bed	Stretcher Bed	Surgical Theatre
179.	LC846	Metal Frame Adjustable Bed	Adjustable Bed	Surgical Theatre
180.	LC848	Metal Frame Adjustable Bed	Adjustable Bed	Surgical Theatre
181.	927DO	Steri-Vac 3M Gas Sterilizer	Gas Sterilizer	CSSD
182.	795DO	Warm touch 501-5800 Patient Warmer	Patient Warmer	Surgical Theatre
183.	KH867	Simed S100E Pulse Oximeter	Pulse Oximeter	Surgical Theatre
184.	399MZ	Metal Examination Light	Examination Light	Surgical Theatre
185.	372MZ	Nihon Kohden 9010K ECG Machine	ECG Machine	Surgical Theatre
186.	064MZ	Sms B-Vac Suction Machine	Suction Pump	Surgical Theatre
187.	453MZ	Contoura 267Kg Stretcher Bed	Stretcher Bed	Surgical Theatre
188.	665MX	Olympus Bf 20D Gastroscope	Gastroscope	Surgical Theatre
189.	697MX	Olympus CF 20Hl Colonoscope	Colonoscope	Surgical Theatre
190.	702DO	Blease 560 Boyles Anaesthetic Machine	Boyles Machine	Surgical Theatre
191.	654DY	Dinamap Pro 1000 Patient Monitor	Patient Monitor	Surgical Theatre
192.	141DY	Dinamap Dpc121X Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre
193.	196DM	AME Diascope2 Defibrillator AED	Defibrillator AED	Surgical Theatre
194.	9353B	Nihon Kohden Tec7521K Defibrillator	Defibrillator	Surgical Theatre
195.	9374B	Carl Equipment Trolley	Equipment Trolley	Surgical Theatre
196.	9357B	Meco MIW Infant Warmer	Infant Warmers	Surgical Theatre
197.	9357B	Medi Tool Mobile Suction Unit	Suction Unit	Surgical Theatre
198.	9772B	Colin Next Bp-88S Patient Monitor	Patient Monitor	Surgical Theatre
199.	410PC	Lateral Tilt Surgical Table	Surgical Table	Surgical Theatre
200.	9375B	Stryker Stretcher Bed	Stretcher Bed	Surgical Theatre
201.	UO367	Stryker Stretcher Bed	Stretcher Bed	Surgical Theatre
202.	UO368	Datex-Ohmeda Aespine 7900 Anaesthesia Machine	Anaesthesia Machine	Surgical Theatre
203.	UO264	Mindray Vs-800 Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre

AN ANALYSIS OF THE FUNCTIONAL STATE AND COSTS OF MAINTENANCE AND REPAIR OF CAPITAL MEDICAL EQUIPMENT AT DR. YUSUF DADOO HOSPITAL

PATRICK MBEKO SOFOHLO

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Public Health in the field of Hospital Management

JUNE 2014

DECLARATION

I, Patrick Mbeko Sofohlo, declare that the work contained in this research report is my own original work , that it has not been submitted before in its entirety or in part for any degree or examination in any other University, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

_____ _____

Patrick Mbeko Sofohlo Date

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I thank them for their encouragement, tolerance and understanding.

ABSTRACT

BACKGROUND: Medical equipment is used in the diagnosis, treatment and monitoring of patients and their maintenance is a fundamental part of managing these technologies in hospitals. Over the recent years equipment down-time has been an increasing concern within the delivery of health care services. This study focussed on the analysis of the functional state and costs of maintenance and repair of all capital medical equipment (CME) at a district hospital in the Gauteng Province.

AIM: To analyse the functional state and purchasing and service costs of CME at the DYD Hospital during ten year study period (April 2001 to March 2011)

METHODOLOGY: The setting of this study was Dr Yusuf Dadoo Hospital (DYD Hospital) a district hospital situated in the West Rand District in the Gauteng Province. A cross-sectional retrospective record review study of all CME was done in OPD, In-patient units, Radiology and Surgical Theatre. The data for this study was extracted from the records which were captured and kept by the asset management department, finance and maintenance divisions of the Hospital.

RESULTS: Most of the CME (196, 97%) procured during the study period was still functional and only seven (3%) was condemned. Nearly a quarter of them (24%) were in a good condition. However, a high proportion (73%) was in a fair condition requiring replacement within three to four years and only a small proportion (3%) was in a poor condition nearing the end of its life expectancy benchmark. There were significant differences in terms of condition of equipment among different departments of the Hospital (Chi-square test, $p<0.001$). The actual lifespan of CME was significantly lower than the expected useful lifespan (Mann Whitney's U test, $p<0.001$).

The total purchasing costs for all four departments were R 8,217,760.36 (median R 18,500, IQR R 9,690 – R 100,500). The individual purchasing cost of CME in the Radiology department was significantly higher than the other departments (ANOVA, $p<0.01$). The total service costs for all four

departments were R 1,454,566.85 (median R3,500, IQR R1,250 - R10,075). There was no significant differences in service costs among the four departments (ANOVA, p=0.10).

CONCLUSION: DYD Hospital had adequate numbers of CME and they were well maintained. However, significant replacement was likely to be required by the Hospital in the near future as the majority of CME was nearing the end of its life expectancy benchmark. These findings were reported as a research report which was submitted to the University of the Witwatersrand and the Gauteng Department of Health. The detailed findings were also presented and explained to all staff of DYD Hospital in a workshop that was held in the Hospital for implementation of the recommendations from this study.

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GLOSSARY OF TERMS

Achieved availability: The probability that the equipment will operate satisfactorily at a given point in time when used under stated conditions in an ideal support environment e.g. personnel, tools, spares etc. are instantaneously available (Gauteng Provincial Administration Manual, 1994).

Bar Coded Asset Audit System: An asset management system, to which the Combined System Group owns the IP (Gauteng Provincial Administration Manual, 1994).

Calibration: The units of measurement marked on other instrument so that it can be used for measuring something accurately (Gauteng Provincial Administration Manual, 1994).

Capital medical equipment: Equipment with an original purchase price of more than R5000 (Gauteng Provincial Administration Manual, 1994).

Condemn: Disposal of redundant, obsolete / unserviceable items (Gauteng Provincial Administration Manual, 1994).

Deferred maintenance: The practice of postponing maintenance activities such as repairs in order to save costs, meet budget funding levels or realign available budget monies as a result of underfunding of routine maintenance and failure to take care of major repair and / or restore equipment that have reached the end of their useful life that can result in equipment deterioration and ultimately impairment (University of Illinois, 2012).

Disposal: Disposal of medical equipment that is not suitable for reuse or trade in (Gauteng Provincial Administration Manual, 1994).

District hospital: A range of out and in-patient services are offered, mostly within the scope of general medical practitioner (Service Packages for PHC and DHS Services (Department of Health, 2007).

Functional: Making it possible for something (equipment) to do something or something to happen (Gauteng Provincial Administration Manual, 1994).

Functionality: The quality in something of being very suitable for the purpose it was designed for or expected to perform (Gauteng Provincial Administration Manual, 1994).

Maintenance: Maintenance refers to a routine and / or remedial intervention required, ensuring that the medical equipment is retained in a serviceable

condition and extends its planned economic life or improve its working performance (Gauteng Department of Health Asset Maintenance Management Framework, 2001).

Medical equipment: An instrument, apparatus or machine used to diagnose, treat, monitor or alleviate disease or injury and can also be used to prevent disease and compensate for injury (Gauteng Provincial Administration Manual, 1994)

Out-of-service days: When a CME is sent for service (such as routine maintenance, calibration and repair). During service, a CME is not available for use. Out-of-service days are counted as an efficiency indicator for clinical engineering department which is responsible for services of CME in a Hospital (University of Tasmania, 2000).

Repairs: It is anything that required to be done in order to achieve the same goals as that envisaged in the definition of “maintenance” above, but which requires more labour and more expenses than maintenance due to normal wear and tear (Gauteng Provincial Administration Manual, 1994).

Service: Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. During service, a CME is not available for use.

Step-down services: These provide in-patient care for patients who no longer require acute intervention and can be cared for mostly by professional nurses or allied professionals (Gauteng Provincial Administration Manual, 1994).

LIST OF ABBREVIATIONS

ANOVA	:	One way analysis of Variance
CME	:	Capital Medical Equipment.
DYD	:	Dr. Yusuf Dadoo.
GDHSD	:	Gauteng Department of Health and Social Development
MDG`s	:	Millennium Development Goals
OPD	:	Out Patients Department.
USA	:	United State of America
WHO	:	World Health Organization.

CHAPTER 1
INTRODUCTION

The purpose of this study was to analyse the functional state and costs of maintenance and repair of Capital Medical Equipment (CME) at a district hospital in the Gauteng Province. This introductory chapter will cover the background to the study, statement of the problem, its aims and objectives and an outline of subsequent chapters.

1.1 BACKGROUND

Medical equipment is the platform on which the delivery of health care services rests and the basis for the provision of quality health care to patients. The growing market for medical equipment is not only found in the united State of America (USA) and Japan, but also in less developed countries (Malkin, 2007).

District hospitals provide services at a primary health care level with the intention of getting the most out of their investment and delivering quality service to their communities (Department of Health, 2007). To enable district hospitals to do so, they need to adequately manage medical equipment and ensure that it is available and in good working condition. Medical equipment helps to save and to prolong patients` lives and is used in the diagnosis, treatment and monitoring of patients in the hospital. For example, surgical and anaesthetic equipment are used for surgical procedures, cancer is treated in radiotherapy units, and premature babies can be warmed with incubators.

At the Dr Yusuf Dadoo (DYD) Hospital, the hospital finance department usually presents detailed information on equipment to the equipment budget committee along with costs and data showing the effects of purchases on the operating budget. A certain percentage of the budget remains uncommitted to meet emergency needs that might arise throughout the financial year. Although a Provincial Policy on Asset Management was recently drafted and

circulated, there was no clear cut policy on acquisition, procurement, maintenance and repair of capital medical equipment.
With regard to the maintenance and repairs of capital medical equipment at DYD Hospital, this component was entirely outsourced because of inadequate in-house capacity.

1.2 PROBLEM STATEMENT

To maintain CME in a functional state was a challenge at DYD Hospital. There was a perception that CME at DYD Hospital did not operate optimally, adversely impacting on service delivery. The achieved availability of CME at DYD Hospital was perceived to be at 40% as compared to the standard norm of 100%. At times, the breakdown of the CME compromised delivery of services and led to escalation in health care service delivery costs. Inadequate budget planning of CME was also a problem at DYD Hospital with the cost of maintenance and repair viewed as unaffordable expenditure. For example, to repair one fluoroscopic machine in a given time at DYD Hospital cost more than R100 000 as compared to the allocated budget of R2 429 000.00 for all machinery and equipment for the financial year 2011/12 (Gauteng Department of Health and Social Development, 2011). It was therefore important to analyse the functional state and costs of maintenance and repair of the CME at DYD Hospital in order to support informed decision-making with regard to CME planning. This study was expected to review the functional state and costs of maintenance and repair of all capital medical equipment valued at more than R5000 at DYD Hospital to support current and future planning of medical equipment management at the DYD Hospital.

1.3 JUSTIFICATION OF THE STUDY

This study on the analysis of the functional state and costs of maintenance and repair of CME was conducted for the first time at DYD Hospital. The study was to analyse the CME at DYD Hospital and to identify deficiencies in the functioning and costs of maintenance and repair of these technologies. The

study would enable DYD Hospital to contain the burgeoning costs on maintenance and repair of CME. It was envisaged that this would ultimately help to improve the operation and performance of CME at this Hospital. In addition, this study would ultimately contribute towards improving the functioning of the CME in the service delivery platform and support similar processes in other institutions in the Gauteng Province. It was also envisaged that the methodology could be used by the Provincial and National departments of health to analyse the functional state and costs of maintenance and repair of CME at other district hospitals.

1.4 RESEARCH QUESTION

What is the functional state and purchasing and service costs of CME at DYD Hospital during ten year study period (April 2001 to March 2011)?

1.5 STUDY OBJECTIVES

1.5.1 BROAD OBJECTIVES

To analyse the functional state and purchasing and service costs of CME at the DYD Hospital during ten year study period (April 2001 to March 2011).

1.5.2 SPECIFIC OBJECTIVES

1 To describe the profile of CME on the Hospital asset register (a) Number of CME per department (b) Their functional state (good, fair, poor and condemned)
2 To describe the services of maintenance, calibration and repairs of CME per department (a) Number of out-of-service days (b) number of episodes
3 To determine the lifespan of CME during this study period (expected useful life span and actual life span) per department.
4 To determine the purchasing and service costs (maintenance, repair and calibration) of CME per department during the study period

1.6 CHAPTER LAYOUT

The research project was distributed over six chapters, namely:
Chapter 1: Introduction of the study. This chapter gave a brief background of the research and outlined the problem statement.

Chapter 2: Literature review. This chapter reviewed the relevant literature on medical equipment with regard to procurement, maintenance and repair.

Chapter 3: Methodology. This chapter focused on the methodology with regard to study setting, study period, study population, study instrument, data collection and data analysis.

Chapter 4: Results. This chapter dealt with the presentation of results.

Chapter 5: Discussion. This chapter dealt with the discussion of results as highlighted in chapter 4 with the purpose of answering the research question.

Chapter 6: Conclusions and recommendations. This chapter presented conclusions and recommendations by drawing results from the previous chapters. The chapter also dealt with the limitations and suggestions for future research.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses relevant literature on the functional state, cost of maintenance and repair of CME with particular reference to a public hospital.

2.1 MEDICAL EQUIPMENT

Medical equipment are essential for safe and effective prevention, diagnosis, treatment and rehabilitation of illness and disease. The achievement of health-related development goals, including the Millennium Development Goals (MDGs) depends upon proper manufacturing, regulation, planning, assessment, acquisition, management (such as maintenance, calibration and repair) and use of medical devices which are of good quality, safe and compatible with the settings in which they are used (WHO, 2011). The management process begins with understanding the needs of an organization and ends with decommissioning. In between, the process consists of good procurement practices, (donation if any), solicitation and provision, logistics of delivery and installation, inventory management, maintenance, safe use and training, and measurement of clinical effectiveness (WHO, 2013). The type and quantity of medical equipment vary according to level of health facilities. For example, district hospitals use low cost medical equipment in comparison to regional and national hospitals (Son, Thu, Tu, et al, 2007). Costs of medical equipment vary from few Rands to more than million Rands (capital medical equipment). In South Africa, capital medical equipment is defined as equipment with an original purchase price of more than R5000 (Provincial Administration Manual, 1994).

2.2 CAPITAL MEDICAL EQUIPMENT MANAGEMENT

Management of medical equipment is always a challenge particularly in institutions in developing countries. They always have shortage of equipment in terms of number and quality. Most of the equipment at hospitals in the

developing world countries were imported and of very poor quality (96% worked only 5 years after donation and 39% never worked due to lack of training, manuals or accessories (Malkin, 2007). In South Africa, services are also affected at public health institutions due to non-availability of proper medical equipment. For example, equipment at some hospitals at the Western Cape fell short of international standards due to inadequate maintenance and shortage of trained staff (Watermeyer, Van Wyk, Goldberg, 2008).

WHO (2010) reported in its preliminary results of the baseline countries` survey on medical devices that the availability of medical equipment in low-income and developing countries was still a problem (WHO, 2010). To guarantee the good physical condition of medical equipment, it is essential to recruit sufficient staff with the appropriate skills to maintain the equipment. Human factors such as misuse and overuse of medical equipment can have a negative impact to the institution and also on service delivery. Therefore, training of staff for proper use of CME is crucial to improve appropriate use of CME. In addition, having a team leader is important for mentoring inexperienced staff (Wang and Levenson, 2000).

Although medical equipment improves the quality of health care, it also adds complexity and cost. The functional state of capital medical equipment (CME) can be linked to issues of utilisation as well as cost of maintenance and repair. The poor functional state of CME is the result of inexperienced central tender boards, improper warranties and service contracts that are put in place, hospital health technology department not being consulted when CME purchased and inadequate budget for CME (Carter, 2004).

A clear cut policy on acquisition, maintenance and repair of medical equipment should be established to reduce future problems arising from the unavailability of medical equipment at institutions. A need analysis of the institution before purchase of equipment should be done (Vogt, Pinaar, de Wit, 2002). They suggested that when purchasing medical equipment, one of the conditions to the supplier in the purchase order must include the supply of

operating and service manuals as well as service training.

Medical equipment is an important asset and is included in the hospital`s budget cost estimates. Although it may account for less than 10% of the total hospital budget, it is an important contributor to the quality of health services (WHO, 2010). In India, only 2.5% of the district hospitals budget is set aside for machinery and equipment which shows that the budget allocated for CME was too low (Mavalankar, Raman, Dwivedi, et al, 2004). The cost of complex medical equipment management can shift important institution resources away from their core focus. For example, in the USA, the fast growing market and use of medical equipment in the healthcare system resulted in spending more than £130 billion in 2006 (Newton, Mytton, Aggarwal et al, 2010).

The establishment of the Asset Management Policy can improve equipment management, minimise costs, and alleviate equipment maintenance and management problems (Schiesl, 2006). In South Africa, the Gauteng Department of Health has introduced the Bar Coded Asset Audit System, to improve the asset management system for CME (Gauteng Department of Health, 2006).

2.3 PROCUREMENT OF CAPITAL MEDICAL EQUIPMENT

Sufficient medical equipment must be available in hospitals to support health care service delivery. There was an increasing demand for medical equipment with limited available financial resources (Kawohl, Temple–Bird, Lenel, et al, 2005). Value for money in the procurement of medical equipment requires that cost benefit analysis of the equipment should be done to identify options to minimise price. By defining the minimum requirements for an equipment purchase could help to keep costs down while still ensuring that clinicians get what they need (Angelo, 2009). One of the spectrums of purchasing options is establishing a central purchasing body where hospitals are mandated to utilise that body for the purchase of all medical equipment above a predetermined value.

A properly planned coordinated multidisciplinary approach towards the purchase of medical equipment is the key to the management of medical equipment. There should be a team effort for procurement of medical equipment based on the needs and mission of the institution (Angelo, 2009) as well as the size and type of the institution (Walters, 2003). In addition, challenges and constraints of the hospital should be considered when purchasing medical equipment (Sandham, 2008). In addition there should be a process of prioritisation to improve the purchasing process of medical equipment (Blazer, Jones, Faulkner, et al, 2006).

All medical equipment purchases should be processed through an institutional Medical Equipment Management Committee to ensure that input from clinicians is received. The development of a formal purchasing process managed by a trained specialist and involving a team of experts from various departments should be considered (Becker, 1989). For example, the Medical Equipment Management Plan of the Texas Tech University Health Sciences Centre (2010) stated that the decision to acquire new medical equipment in each department vested on the Departmental Chair.

2.4 MAINTENANCE AND REPAIR OF CAPITAL MEDICAL EQUIPMENT

The extent of equipment down time is a major factor in determining the availability state of medical equipment (Tarawneh and El-Sharo, 2009). Maintenance and repairs are used to support and to maintain the operations (Meredith and Shafer, 2011). Improved maintenance and repair technology of medical equipment ensure that medical equipment is always at its best. Planned maintenance is a statutory requirement to enhance the effectiveness and reliability of medical equipment and must be carried out at the appropriate frequency (Kainth, 2003). Only 30% of medical equipment in Nepal`s hospitals was in operation, 50% needed urgent maintenance, 10% needed repairs and 10% to be condemned (Kanel and Pokhrel, 2009).

A review of the purchase list should be done for all items considering various aspects of the maintainability of the medical equipment. Medical Equipment Management Services should provide equipment lists detailing equipment belonging to a specific department or areas (Grant, 2010). A gap analysis involving a comparison of the actual medical equipment in the departments and inventory list in the asset management system should be done to identify shortfalls or surpluses of medical equipment (Waters, 2003).

Maintenance is not a separate and isolated function that makes repairs and performs assorted activities as needed but, a full partnership that strives together with other functions to achieve the strategic goals of the organisation and involves specialists such as maintenance engineers and technicians (Fredendall, Patterson, Kennedy et al, 1997). On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994).

Replacement of medical equipment is planned taking into consideration the age, condition and critical nature of use. At the end of its life cycle it must be condemned, disposed and taken out of service (Temple – Bird, Kaur, Lenel, et al, 2005). Faulty or defective medical equipment must not be used regardless of how minor this is perceived. Inspection, testing and maintenance intervals should be based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). Owing to the life span of CME, it can take several years before it needs to be replaced and at the time of replacement, CME might prove to be technologically obsolete. Management of hospitals should consider the age, condition and critical nature of use of CME with care (Hugo, Badenhorst-Weiss, Van Bijoen, et al, 2006).

The use of complex electrical powered medical equipment in hospitals has brought about the need for a clearly defined policy on maintenance to avoid the occurrence of accidental injuries to both patients and staff. Staff involved

with medical equipment should be protected from these potential risks and hazards. Where there is a suspected hazard in the medical equipment, that equipment must be rendered harmful (Temple-Bird et al, 2005). Risk Managers should cover the financial risk of medical devices maintenance and repair (Anderson and Ruther, 2009). Before new medical equipment is put into service, the manager responsible for equipment should undertake a risk assessment to ensure that any possible hazards arising from the use of the equipment are identified and appropriate precautions undertaken. Risk protection could make a significant cost saving on medical equipment while receiving improved services (Tudor and Gremill, 1994).

2.5 SUMMARY

This chapter provided literature on the functional state, cost of maintenance and repair of CME. Literature on medical equipment, procurement of medical equipment, maintenance and repair of medical equipment indicated that CME cuts across all levels of management and personnel in an organisation. It can be seen that maintenance of medical equipment is not just a question of repairing broken things but an integral part of managing the whole lifecycle of equipment. To make the whole process of maintaining medical equipment work properly, inputs from different people are required.

CHAPTER 3
METHODOLOGY

This chapter documents the design and methodology followed during the research project. The methodology for this study was selected on the basis of its aims and objectives to answer the research question under investigation.

3.1 STUDY DESIGN

A cross-sectional retrospective record review was done. The study was based on descriptive analysis of the data obtained from the study.

3.2 STUDY SETTING AND SCOPE

The study setting was DYD Hospital, a district hospital in the West Rand District (Figure 3.1).

West Rand District

The Gauteng Province is about 16,548 square kilometres and is highly urbanized and industrialized. The total population is 11 100 000 of which 97% live in urban centres. The Province has three metropolitan municipalities (the City of Tshwane, Johannesburg and Ekurhuleni) and two District Municipalities (Sedibeng and West Rand). West Rand District has four local municipalities which include Mogale City, Merafong City, Randfontein and Westonaria. The catchments population for the West Rand District is 744 153 of which Mogale City is 295 497, Merafong City 210 484, Randfontein 128 848 and Westonaria 109 324 (Census, 2001). South Africa conducted three censuses (1996, 2001, and 2011). Census 2011 was the third Census to be conducted since the post democratic elections in 1994. The population of Mogale City is 362 422, an increase of 22.6%, Randfontein 149 286 which is 15.9%, Westonaria 111 767 which is 1.8% and Merafong City 197 520, a decrease of -6.2% (Census, 2011). The increase in Mogale City can be

attributed to strong flows between economic activity areas, leisure tourism (Cradle of Humankind World Heritage Site) and residential areas (West Rand Industrial Development Strategy, 2013).

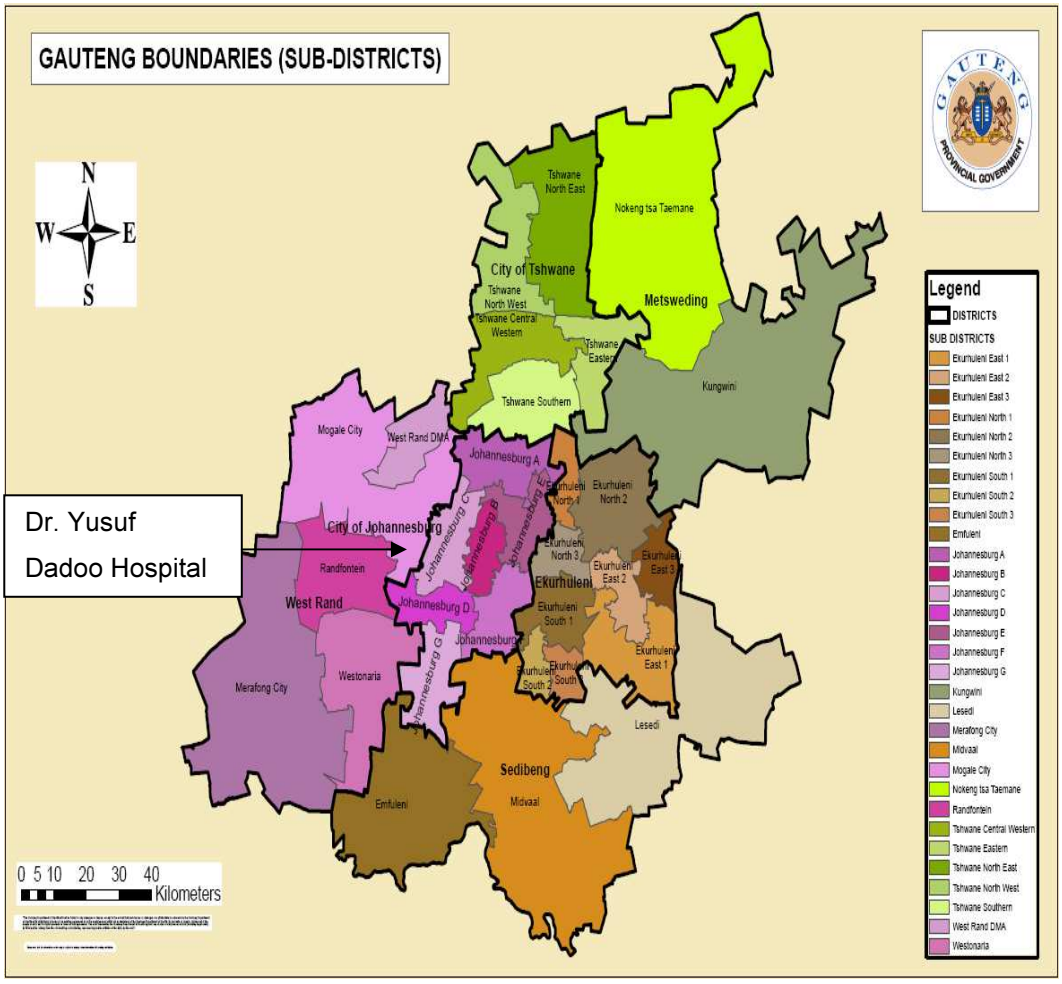

Figure 3.1: Map of the Gauteng Province depicting District boundaries

(Source: GDHSD Service Transformation Plan for 2010 - 2020)

Dr Yusuf Dadoo Hospital

The Hospital was built in 1910 and officially opened on the 22 November 1911 as a regional Hospital and was named Krugersdorp Hospital. In 1974, Krugersdorp Hospital was renamed Paardekraal Hospital. In 1997, the Hospital was again renamed Dr. Yusuf Dadoo Hospital and was then downgraded from a regional hospital to a district hospital due to the rationalisation of the Public Service. The Hospital is situated in Mogale City in

the West Rand. The Hospital has 255 approved beds of which 175 acute, 20 step-down and 60 tuberculosis beds. Its bed occupancy rate is between 68% and 75% per month. DYD Hospital is also a training facility for family medicine. There is no Community Health Centre in the area. Therefore, all 42 Primary health care clinics in the West Rand District refer their patients to this Hospital.

3.3 STUDY PERIOD

The study period was ten years (from April 2001 to March 2011).

3.4 STUDY POPULATION

The study population comprised of 203 capital medical equipment (CME) at the DYD Hospital that appeared in the asset Register of the Hospital. There was no sampling since the study included all CME of the DYD Hospital.

3.5 DATA COLLECTION

The researcher collected data from hospital records (Asset Management Register) after seeking approval from the Ethics Committee of the University of the Witwatersrand and the Research and Policy Department of the Gauteng Department of Health and Social Development (GDHSD). The data was also collected from records from the accounts and maintenance departments, using invoices and receipts. A full list of CME was retrieved, stating its profile such as full description, department, purchase cost, purchase date, supplier name, maintenance plan, initial training, asset state, expected life span and actual life span of CME. Data was also collected for the functional state of CME such as the condition and status of CME in the asset register. CME episodes for service maintenance, calibration and repair for the ten years period was collected as well as the total days CME was out of service for service maintenance, calibration and repairs. Data was also collected on the purchase cost of CME, purchase cost per activity and per department and

total cost of all activities. This information was captured in a data collection sheet designed for the study (Appendix B).

3.6 STUDY INSTRUMENT

Data relevant to this study was routinely collected electronically by the Hospital Asset Management System and maintenance Division. Information was captured from the asset management register using the data capture sheet designed for this study from the following Hospital`s units which are geographically clustered into one area which included Casualty/ OPD, Inpatient-wards, Radiology and Surgical Theatre. Data from the Hospital Asset Management System was exported to MS Excel based spread sheet designed for the study.

3.7 STUDY VARIABLES

The variables for this study are listed in Table 3.1.

Table 3.1 List of study variables

To describe the profile of CME on the Hospital asset register	Number of CME per department Functional state of CME (Good, Fair, poor and Condemned)
To describe the services of CME (maintenance, calibration and repairs)	Number of out-of-service days for In-patient wards, Casualty/ OPD, Surgical Theatres and Radiology departments. Number of episodes Casualty/ OPD, Surgical Theatres and Radiology departments.
To determine the lifespan of CME	Expected life span (in years) Actual life span (in years)
To determine the purchasing and service costs of CME	Total purchasing cost Total service cost (maintenance, repair and calibration)

- Functional state of a CME is classified as good, fair, poor and condemned in terms of the Gauteng Provincial Administration Manual (1994). CME was classified as being good if it had no defects and

required only general maintenance, minor repairs and little or no deferred maintenance existed. CME in fair condition showed signs of slight deterioration, required some corrective maintenance and deferred maintenance was intensive. Those in poor condition showed signs of severe deterioration and required corrective maintenance or emergency repair and deferred maintenance was extensive.

- Lifespan: Expected lifespan is determined according to the manufacturer whereas actual life span is determined based on the actual number of years a CME is in-use.
- Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. During service, a CME is not available for use.
- Out-of-service days: When a CME is sent for **s**ervice (such as routine maintenance, calibration and repair). During service, a CME is not available for use.
- Purchasing cost includes the cost paid by the Hospital at the time of purchase of a CME.
- Total service cost includes costs for maintenance, repair and calibration of a CME.

3.8 DATA ANALYSIS

Data exported to MS Excel based spread sheet was checked for error and missing values. The paper based register was used to verify discrepancies and to look for missing values. The data was then analysed with NCSS statistical software (NCSS, 2007).

Following descriptive statistics were reported upon.

- Continuous variables (such as cost): Continuous variables with normal distributions: mean and standard deviation. Other continuous variables: median and inter-quartile range.
- Categorical variables (such as functional state): proportion and range.

The following analytical statistics was used to compare among the four

departments (namely In-patient wards, Casualty/ OPD, Surgical theatre and Radiology).

- Continuous variables: Mann Whitney's U test (for comparing two variables) and One way Analysis of Variance (ANOVA) (for comparing more than two variables). Post-hoc test will be done, if statistical significance was found with ANOVA.
- Categorical variables: Chi-square test and Fisher's Exact test

The statistical significance will be calculated at the 95% confidence level.

The results were presented in absolute and percentile values, in tables and figures.

3.9 ETHICAL CONSIDERATION

Permission for conducting research and accessing documents was obtained from the Head of the department of the GDHSD. The study was also approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Appendix A). Confidentiality and anonymity was not an issue as the study related only to equipment records. A unique code was used on data extraction sheets. The researcher remained within the parameters of any applicable legislation, institutional guidelines and scientific standards relevant to the study.

CHAPTER 4
RESULTS

Chapter two provided a detailed literature review of CME. Chapter three focused on the methodology with regard to study setting, study period, study population, study instrument, data collection and data analysis. In this chapter results obtained from the analysis of data are presented. The study included all CME of the DYD Hospital and no sampling was done.

4.1 PROFILES OF CAPITAL MEDICAL EQUIPMENT

4.1.1 THE NUMBER OF CME

A detailed list of all CME used at DYD hospital is presented as Annexure C. A summary of the CME in the four departments is listed in Table 4.1.

Table 4.1 Distribution of CME

Condition	Number (%)
In-patient wards	80 (39.4%)
Casualty/ OPD	43 (21.2%)
Surgical theatre	62 (30.5%)
Radiology	18 (8.9%)
Total	**203 (100%)**

4.1.2 THE CONDITION OF CME

The majority of the CME (196, 97%) were in working-condition. Only seven (3%) had been removed from the asset register and condemned; six of them were from Radiology and one from the Casualty/OPD (Figure 4.1).

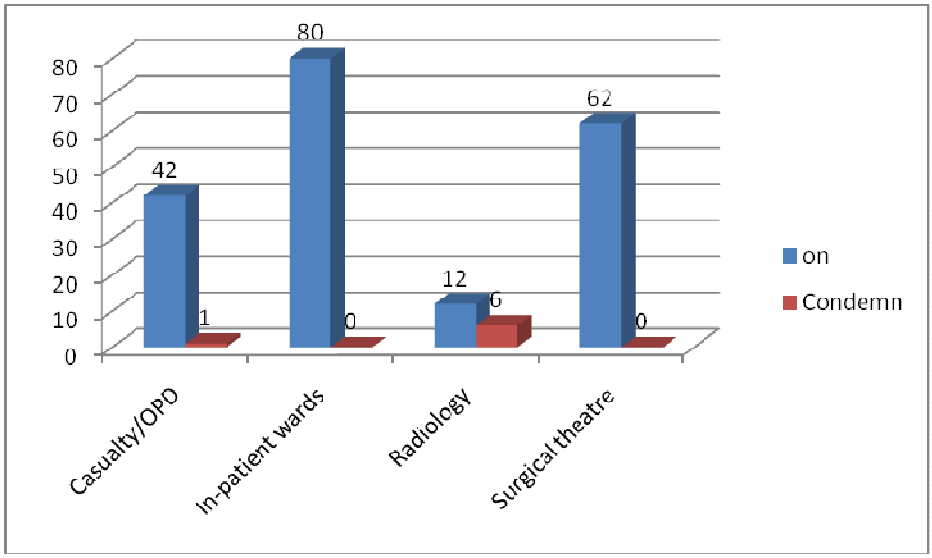

Figure 4.1 Frequency distribution of the asset state of CME per department

Among the 196 CME, 144 (73%) were in a fair condition, 47 (24%) were in good condition and few of them (5, 3%) were in poor condition (Figure 4.2). The last assessment of CME was done in February 2011 by the company *Bigen Africa*.

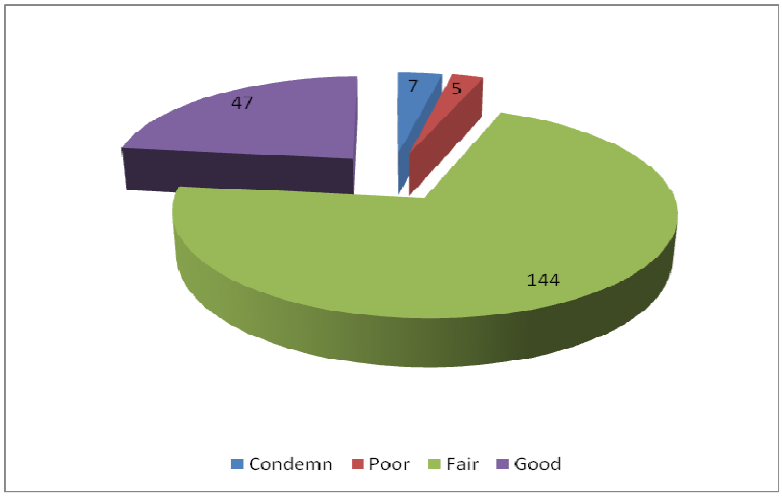

Figure 4.2 Frequency distribution of the condition of CME

The conditions of CMEs per department are listed in Table 4.2. In the In-patients wards, 66 (83%) out of 80 CME was in fair condition, 13 (16%) was good and one (1%) was poor. Radiology had 18 CME and six (33%) were condemned.

Table 4.2 Distribution of CME per department

Condition	Total	In-patient wards	Casualty/ OPD	Surgical theatre	Radiology
Good	47 (23%)	13 (16%)	10 (24%)	18 (29%)	6 (33.3%)
Fair	144 (71%)	66 (83%)	32 (74%)	41(66%)	6 (33.3%)
Poor	5 (2%)	1 (1%)	0	3 (5%)	0
Condemn	7 (4%)	0	1(2%)	0	6 (33.3%)
Total	**203 (100%)**	**80 (100%)**	**43 (100%)**	**62 (100%)**	**18 (100%)**

There were significant differences in terms of condition of equipment among different departments of the Hospital (Chi-square test, $p<0.001$). The majority of the CME in In-patient wards and Casualty/OPD were functional (good/ fair) in comparison to other two Departments (Surgical theatre and Radiology).

4.2 SERVICES OF CAPITAL MEDICAL EQUIPMENT

4.2.1 DURATION OF REPAIR AND SERVICES

Service of CME includes (a) routine maintenance and (b) calibration and (c) repair (During service, a CME is not available for use). Figure 4.3 described the total number of out-of-service days during the ten year study period. Since 2006/07, there were significant increases in number of out-of-service days, due to introduction of maintenance policy in the Hospital. This resulted in increase in *Out of service days* for calibration in comparison to *Out of service* days for repair.

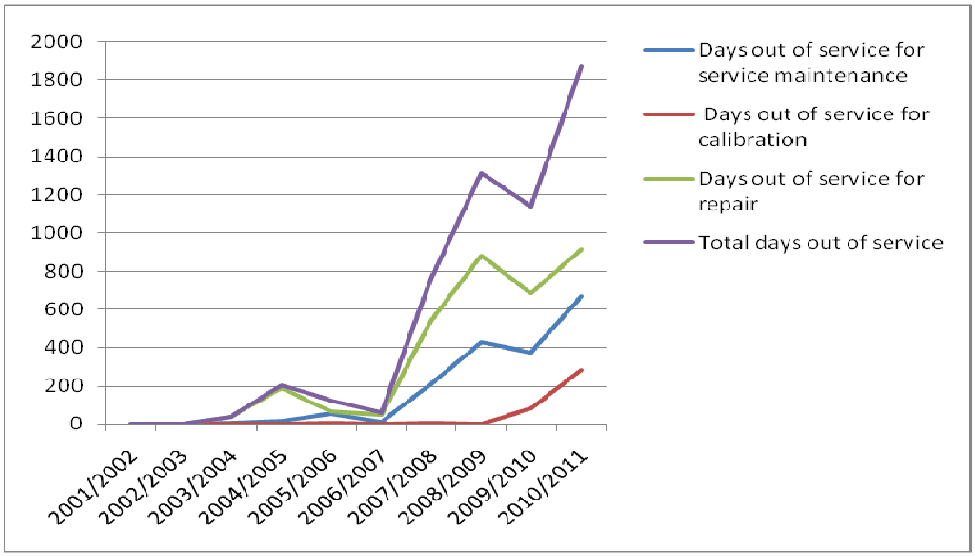

Figure 4.3 Number of out-of-service days

Figure 4.4 describes the number of out-of-service days for different services.

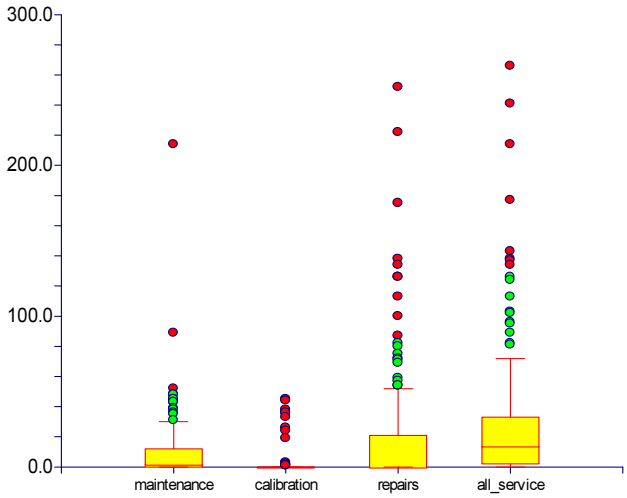

Figure 4.4 Box plot for number of out-of-service days

Table 4.3 and Figure 4.5 describe the number of out-of-service days for each of the four departments. During this period, there were significant differences among the four departments in terms of total number of out-of-service days (maintenance, calibration and repair) (One way ANOVA, $p<0.001$). The post-hoc test showed the total number of out-of-service days in the In-patient wards was significantly lower than the Casualty/ OPD and Radiology departments. The outliers (out of service days more than 6 months) were mainly in OPD due to type of equipment used in that Unit.

Table 4.3 Number of out-of-service days for four departments

Type of activity	**Department**	**Minimum** (days)	**Maximum** (days)	**Median** (days)	**IQR** (days)
Service maintenance	In-patients wards	1	52	1	1-10.5
	Casualty/OPD	1	214	2	1-8
	Surgical theatre	1	45	5.5	1-15
	Radiology	1	89	1	1-12
Service for calibration	In-patients wards	-	-	-	-
	Casualty/ OPD	1	33	1	1-1
	Surgical theatre	1	1	1	1-1
	Radiology	1	45	1	1-36
Service for repair	In-patients wards	1	126	1	1-21
	Casualty/ OPD	1	252	5	1-28
	Surgical theatre	1	59	1	1-12
	Radiology	1	222	13.5	1-73
Total for maintenance, calibration and repair	In-patients wards	1	126	1	1-21
	Casualty/OPD	1	252	5	1-28
	Surgical theatre	1	59	1	1-1
	Radiology	1	222	13.5	1-73

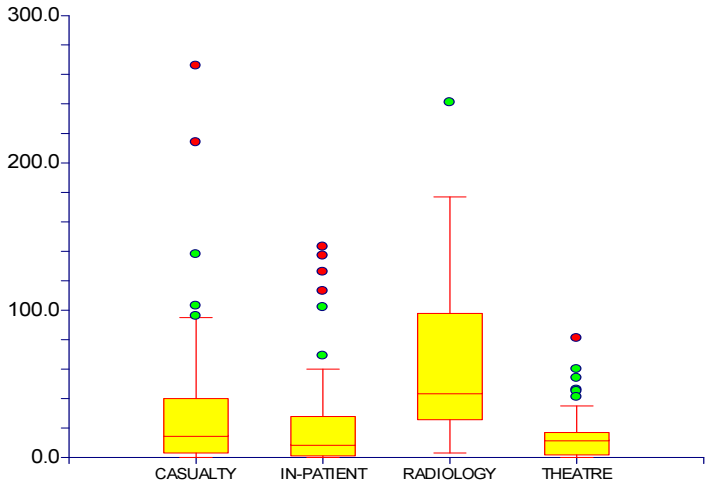

Figure 4.5 Box plot for total number of out-of-service days for four departments

MAINTENANCE SERVICES

There were no significant differences among the four departments in terms of number of out-of-service days required for maintenance (One way ANOVA, p = 0.82) (Table 4.3, Figure 4.6).

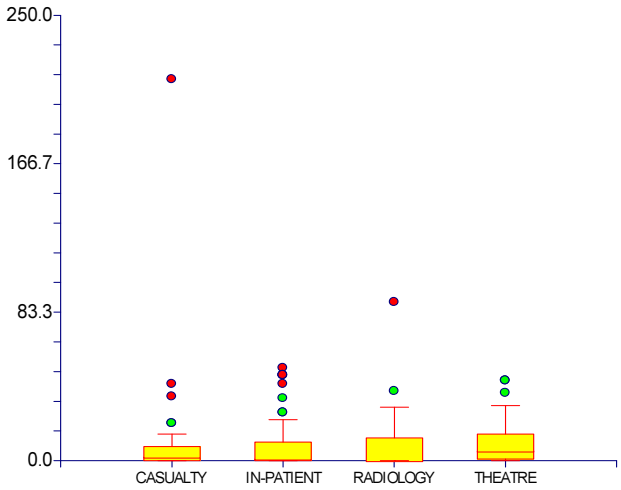

Figure 4.6 Box plot for number of out-of-service days for maintenance

CALIBRATION SERVICES

There were significant differences among the four departments in terms of number of out-of-service days for calibration (One way Analysis of Variance, $p<0.001$) (Table 4.3, Figure 4.7). The post-hoc test showed that the number of out-of-service days for calibration of CME in the Radiology department were significantly higher than the other three departments.

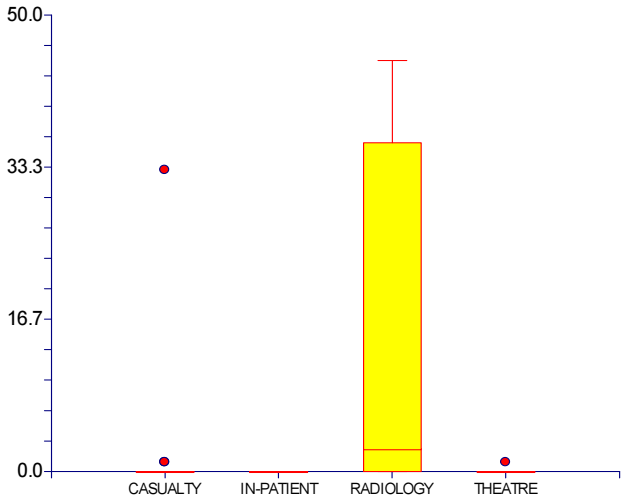

Figure 4.7 Box plot for number of out-of-service days for calibration

REPAIR SERVICES

There were significant differences among the four departments in terms of number of out-of-service days for repair (One way ANOVA, $p<0.001$) (Figure 4.8). The post-hoc test showed the number of out-of-service days for repair of CME in the Radiology department was significantly higher than the Surgical Theatre and In-patient departments. In addition, the number of out-of-service days for repair in Casualty/ OPD department was also significantly higher than in the Surgical Theatre.

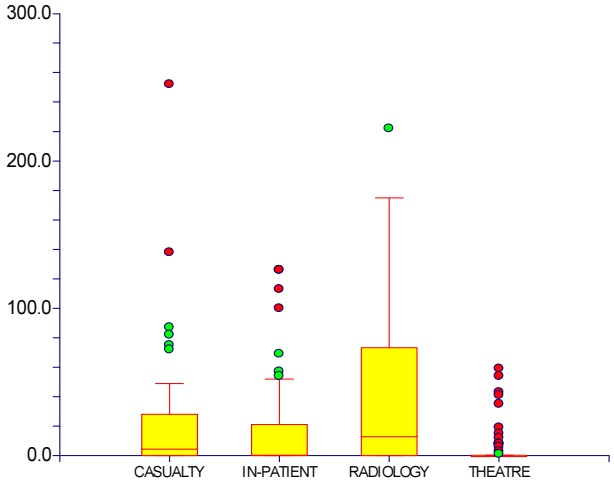

Figure 4.8 Box plot for number of out-of-service days for repair

4.2.2 EPISODES OF MAINTENANCE, CALIBRATION AND REPAIR SERVICES

Total episodes (number of times a CME sent for maintenance, calibration and repair) are described in Table 4.4 and Figure 4.9. There were no significant differences among different departments in terms of total episodes (One Way Analysis of Variance, p = 0.10)

Table 4.4 Number of episodes for all services

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	12	2	1-4
In-patient units	80	1	5	2	1-3
Radiology	18	1	11	3	2-5
Surgical Theatre	62	1	9	1	1-5
Total	**203**	**1**	**12**	**2**	**1-3**

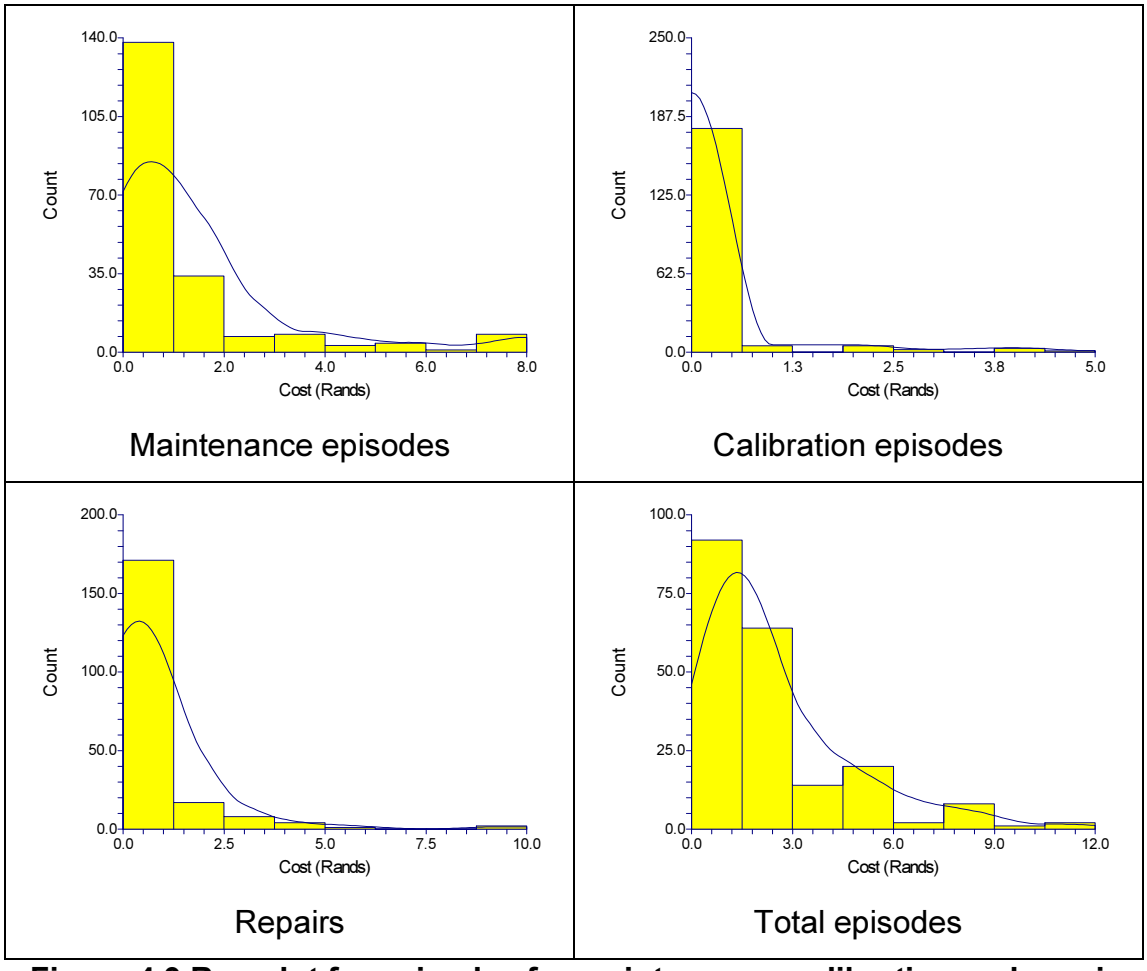

Figure 4.9 Box plot for episodes for maintenance, calibration and repair services

MAINTENANCE SERVICES

In Table 4.5, the number of episodes for maintenance was described. There were no significant differences in terms of number of episodes among different departments for maintenance of CME (One Way ANOVA, p = 0.20).

Table 4.5 Number of episodes for maintenance

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	4	1	1-2
In-patient units	80	1	4	1	1-2
Radiology	18	1	6	1	1-6
Surgical Theatre	62	1	8	1	1-4
Total	**203**	**0**	**8**	**1**	**1-2**

CALIBRATION SERVICES

The number of episodes for calibration was described in Table 4.6.

Table 4.6 Number of episodes for calibration

	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	40	1	4	-	-
In-patient wards	77	-	-	-	-
Radiology	18	1	5	2	1-3
Surgical Theatre	59	1	1	-	-
Total	**194**	**1**	**5**	**1**	**1-1**

REPAIR SERVICES

The number of episodes for repair was described in Table 4.7. There were no significant differences in terms of number of episodes among different departments for repair of CME (One Way Analysis of Variance, p = 0.21).

Table 4.7 Number of episodes for repair

Departments	Number of CME	Minimum	Maximum	Median	IQR
Casualty/OPD	43	1	10	1	1-2
In-patient units	80	1	5	1	1-1
Radiology	18	1	9	1	1-2
Surgical Theatre	62	1	3	1	1-1
Total	**203**	**1**	**10**	**1**	**1-1**

4.2.3 MAINTENANCE PLAN OF CAPITAL MEDICAL EQUIPMENT

176 (87%) out of 203 CME had a maintenance plan and only 27 (13%) were without maintenance plan (Figure 4.10).

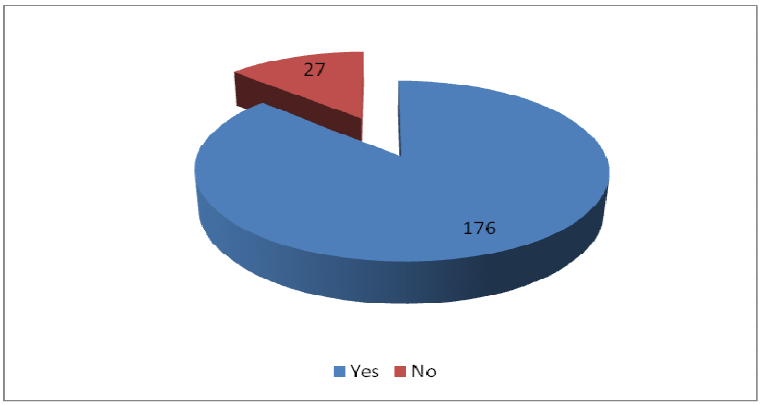

Figure 4.10 Frequency distribution of CME existence of maintenance plan

Figure 4.11 shows that out of 176 CME with maintenance plan, 71 (40%) was in the In–patient wards followed by 50 (28%) in the Surgical theatre. All CME in Radiology had maintenance plan. There was no significant differences among these four units in terms of the maintenance plan (Fisher's Exact test, p =0.16).

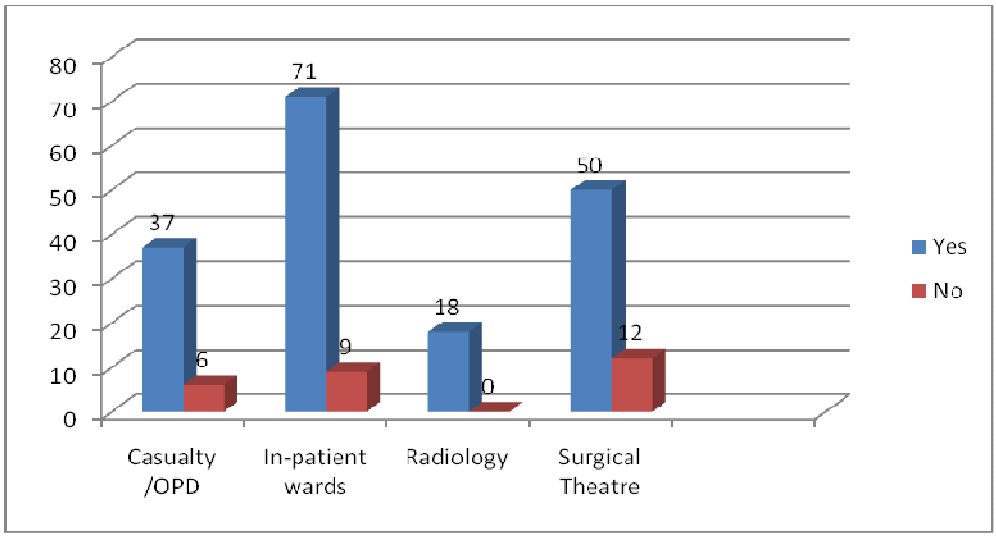

Figure 4.11 Frequency distribution of CME maintenance plan in four departments

4.2.4 TRAINING ON USE OF CAPITAL MEDICAL EQUIPMENT

Most of the initial training in the Hospital was given by the suppliers, 176 (87%) out of 203 CME and only 27 (13%) of initial training was given by other entities (such as manufacturer, in-house or multiple provider) (Figure 4.12).

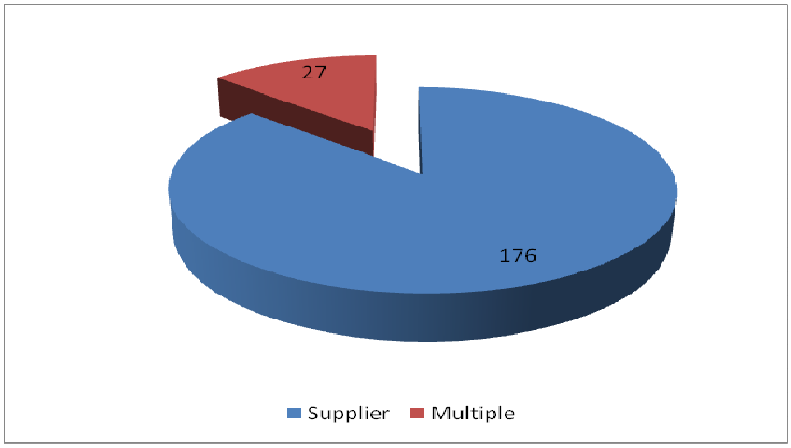

Figure 4.12 Frequency distribution of initial training on CME

Initial training per department was described in Figure 4.13. Suppliers gave most of the initial training to the In-patients wards (71, 41%) and Surgical theatre (50, 28%). These two departments had more CME than other departments.

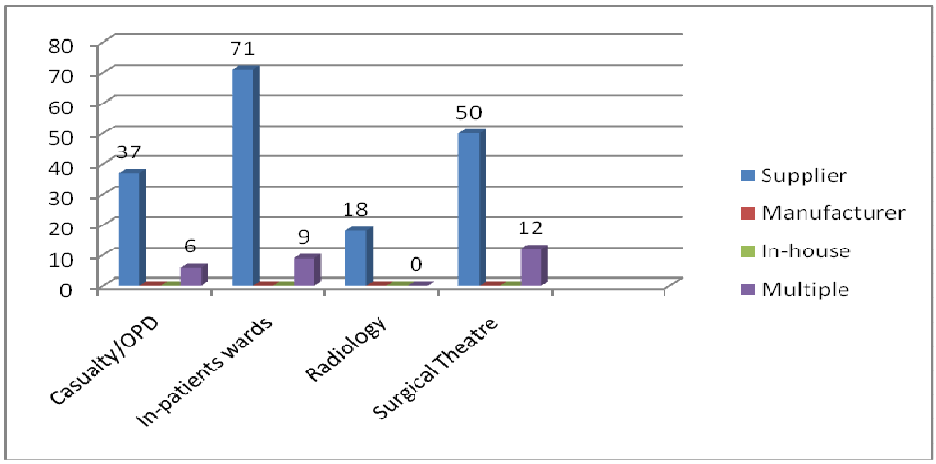

Figure 4.13 Frequency distribution of initial training on CME for four departments

4.3 THE LIFESPAN OF CAPITAL MEDICAL EQUIPMENT

The medians for the expected life span and actual life span were 10 years (IQR 8-10) and 7 years (IQR 5-10) respectively (Table 4.8 and Figure 4.14). The actual lifespan of the CME was significantly lower than the expected life span (Mann Whitney's U test, $p<0.001$). This implies that a significant number of CME did not reach their actual lifespan and could function without being replaced.

Table 4.8 Lifespan of CME (in years)

Life-span	Number of CME	Minimum	Maximum	Median	IQR
Expected life span	203	5	15	10	8-10
Actual life span	203	1	10	7	5-10

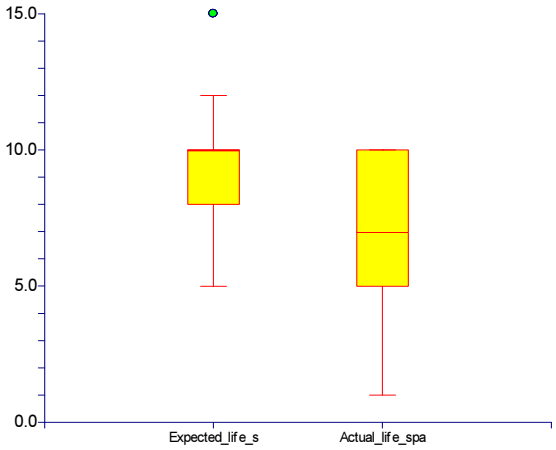

Figure 4.14 Box plot for expected and actual lifespans of CME

If the actual lifespan is less than the expected lifespan, it implies the equipment can be used safely without being replaced.

In Table 4.9, the expected and actual lifespans of the CME for the four departments are described. There were significant differences in expected and actual life span (in years) in Casualty/OPD (Mann Whitney's U test, $p < 0.001$), In-patient wards (Mann Whitney's U test, $p < 0.001$) (Figure 4.15).

The result shows that a significant number of CME in these two departments

did not reach their actual lifespan and could function without being replaced. On the other hand the CME in the Radiology and Surgical theatre departments would require replacement.

Table 4.9 Life span of CME per Department (in years)

	Department	Minimum	Maximum	Median	IQR
Expected life span	Casualty/ OPD	5	15	10	7-10
	In-patients wards	5	15	10	8.5-10
	Radiology	7	12	12	8-12
	Surgical theatre	5	15	10	10-12
Actual life span	Casualty/OPD	1	10	6	4-10
	In-patients wards	1	10	5	4-7
	Radiology	3	10	9	4.5- 10
	Surgical theatre	1	10	10	7-10

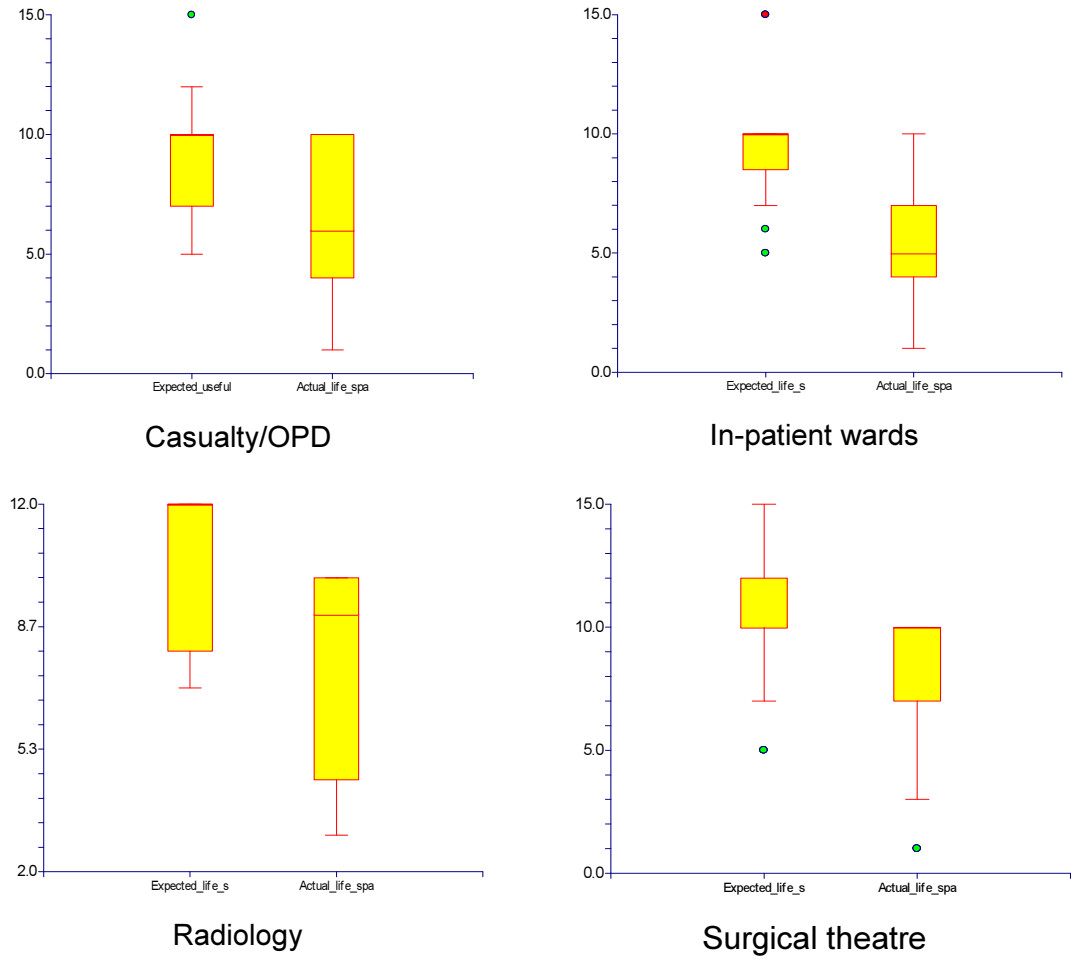

Figure 4.15 Box plot for expected and actual lifespans (in years) in four departments

4.4 COSTING OF CAPITAL MEDICAL EQUIPMENT

4.4.1 PURCHASING COST

The total purchasing costs for all four departments were R 8,217,760.36. The median for the purchasing cost for all four departments was R 18,500 (IQR R 9,690 – R 100,500) (Table 4.10, Figure 4.16). There were significant differences in the itemised purchasing cost (cost of each CME) among the four departments (One way ANOVA, $p<0.01$). The post-hoc test showed the itemised purchasing cost of CME in the Radiology department was significantly higher than the other departments.

Table 4.10 Purchasing costs of CME for four departments

	N	Minimum	Maximum	Median	IQR
Casualty/ OPD	43	R 5292	R138,681	R 15,527	R 10,277 - R 27,712
In-patients wards	80	R5,358	R 412,793	R 19,956	R 13,050 - R 27,561
Radiology	18	R6,500	R432,602	R90,310	R 17,000 - R168,720
Surgical theatre	62	R 5160	R 450,000	R 12,353	R 7,294- R 37,985
All departments	203	R 5,160	R450,000	R18,500	R9,690-R100,500

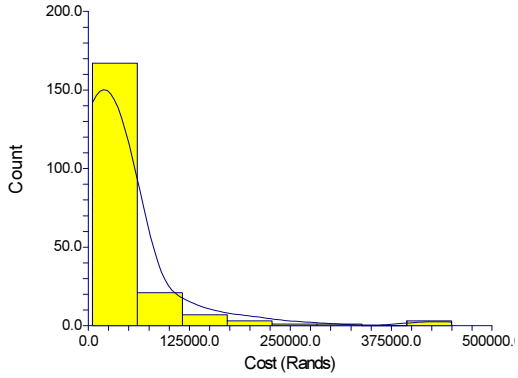

Figure 4.16 Box Plot of total purchasing costs (in Rands)

Total purchasing costs were highest in the In-patients department followed by Surgical Theatre, Radiology and Casualty/ OPD departments. (Figure 4.17).

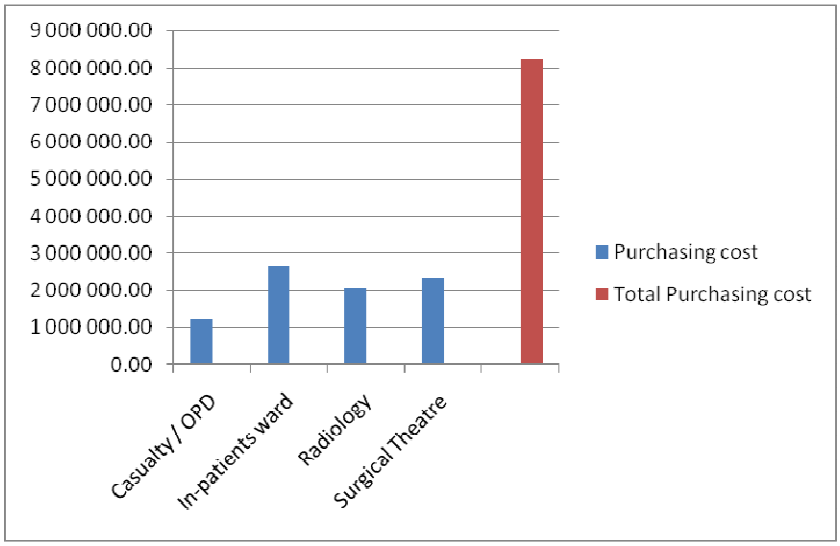

Figure 4.17 Total Purchasing costs for four departments

4.4.2 SERVICE COSTS

The service costs are described in Table 4.11. The total service costs for all four departments were R1, 454,566.85.

Table 4.11 Total service costs for CME during ten year period

Services	N	Minimum	Maximum	Median	IQR
Maintenance	130	R111	R 45,712	R 2,189	R 8,780 – R 59,830
Calibration	19	R 275	R 29,616	R 9,138	R 5,814 - R15,477
Repair	95	R 170	R 113,402	R 3,312	R1,482 - R7,792
All services	**187**	**R 111**	**R 126,497**	**R3,500**	**R1,250 - R10,075**

The median cost of calibration is quite high due to change in hospital policy about instituting regular calibration of all CME. The costs of different services (Maintenance, Calibration and Repair) for four departments are described in Table 4.12 (Figure 4.18). There were no significant differences in the cost of services among the four departments (One Way ANOVA, p =0.10).

Table 4.12 Cost of services for four departments

Services	Department	N	Minimum	Maximum	Median	IQR
Maintenance	Casualty/ OPD	26	R124	R24,274	R1,544	R996 – R3,770
	In – patients	48	R124	R 22,386	R1,800	R750 –R3,534
	Radiology	6	R3,055	R32,108	R5,510	R3,512-R26,655
	Surgical theatre	50	R111	R 45,712	R2,500	R537 – R9,219
Calibration	Casualty/ OPD	5	R700	R15,477	R8,190	R1,376-R12,838
	In-patients	43	R350	R13,134	R3,147	R1,350–R6,430
	Radiology	13	R3,665	R29,616	R9, 538	R8,638-R18,457
	Surgical theatre	1	R275	R275	-	-
Repair	Casualty/ OPD	27	R 70	R33,145	R3,954	R1,605 -R6, 796
	In-patients	43	R350	R13,134	R3,147	R1,350 -R6, 430
	Radiology	10	R 205	R113,403	R10,069	R1,278-R23,993
	Surgical theatre	15	R835	R10,557	R2,910	R1,760 - R4,884
Total costs	Casualty/ OPD	40	R124	R51,164	R 3,805	R1,299 - R9,149
	In-patients	71	R124	R29,617	R 3,079	R1,350– R6,569
	Radiology	18	R205	R126,496	R 18,457	R7,770-R34,199
	Surgical theatre	58	R111	R50,596	R2,500	R1,150-R10,086

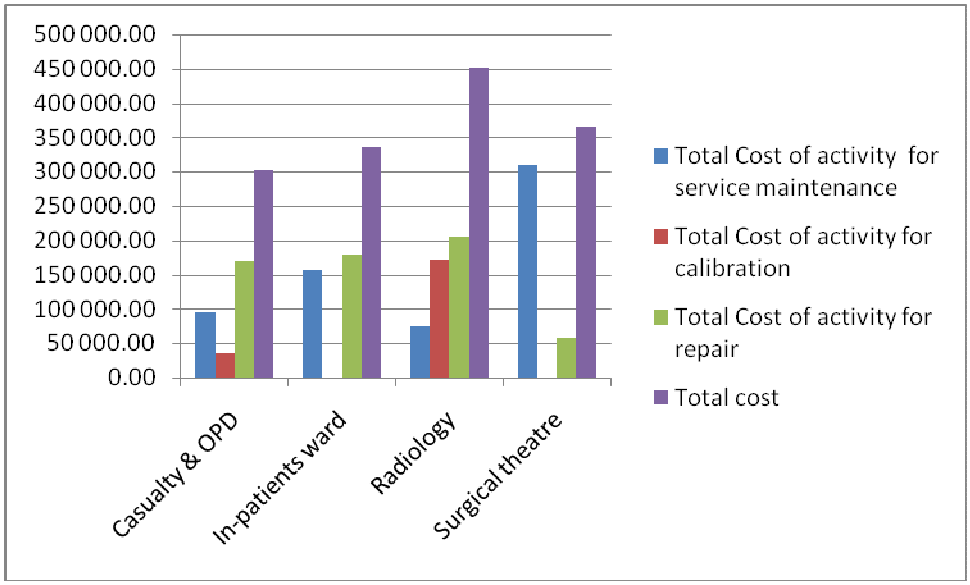

Figure 4.18 Costs of services for four departments

CHAPTER 5
DISCUSSION

This chapter focuses on discussing the results of the findings from the analysis of the functional state and costs of maintenance and repair of the CME at the DYD Hospital during the ten year study period.

5.1 THE PROFILE OF CAPITAL MEDICAL EQUIPMENT

Management of medical equipment includes assessment of the needs of an organization, followed by procurement, logistics of delivery and installation, inventory management, maintenance, safe use and training, and measurement of clinical effectiveness and ends with decommissioning (WHO, 2011; WHO, 2013). Although a district hospital uses low cost medical equipment in comparison to regional and national hospitals (Son, Thu, Tu, et al, 2007), the process still remains the same. It was not known how the current CME used in the DYD hospital was procured and any need assessment was done in the past as proposed by Vogt, et al (2002).

This was the first systematic study on medical equipment at this Hospital. The Hospital during the study period had 203 CME (defined as equipment with an original purchase price of more than R5000 (Gauteng Department of Health, 1994). The majority of them were in working condition (196, 97%), which was proportionately much higher than other studies done in developing countries (Malkin, 2007; Kanel and Pokhrel, 2009). However, based on the criteria stipulated in the Gauteng Provincial Administration Manual (1994), only a quarter of them (47, 23%) were in good working condition. One hundred and forty-four (71%) of them were in a fair condition requiring replacement within three to four years and only five (3%) was in poor condition. The Hospital condemned seven (3%) out of 203 CME (six from the Radiology department and one from the Casualty/OPD). The decision to condemn CME was taken into account not only the condition but also the costs of maintenance, calibration and repair. The Radiology Unit had a serious problem as a third of

its CME were condemned resulting in poor service delivery in this Unit. Notwithstanding the fact that there were policies and procedures with regard to the management of CME in Radiology, these policies and procedures were not always being followed. For example, the four CME in Radiology were condemned in April 2010 by the supplier (Tec Med Africa), but in March 2011 due to pressing service delivery needs these CME were still in use not condemned instead another company kept on maintaining them. Continued use of obsolete CME may result in higher costs, asset failure, and in some cases, health and safety implications.

It was incumbent for DYD Hospital that CME needed by staff to deliver services to patients was available as and when required. Therefore, the Hospital management should make a plan to replace these 11 CME (1 each from In-patient and Casualty/ OPD and three from Surgical theatre and six from Radiology), taking into consideration the age, condition and critical nature of use of these CME and their impact on service delivery (Temple–Bird, et al, 2005).

5.2 SERVICES OF CAPITAL MEDICAL EQUIPMENT

A hospital needs a policy on acquisition, maintenance and repair of medical equipment which should be implemented to reduce future problems arising from the unavailability of medical equipment at institutions (Vogt, et al, 2002). The availability of medical equipment depends on the out-of-service time (Tarawneh and El-Sharo, 2009) which in turn is influenced by regular and planned maintenance and repairs (Kainth, 2003; Meredith and Shafer, 2011). Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. The DYD Hospital introduced a planned maintenance policy for CME in 2006/07 resulting in a significant increase in number of out-of-service days.

The number of out-of-service days varied significantly among the four departments (In-patient, Casualty/ OPD, Surgical theatre and Radiology) and types of services (Maintenance, repair and calibration). Out-of service days

were significantly higher in Surgical theatre and Radiology Units (ANOVA, $p<0.001$), as these two units have complex equipment. Ideally, the out-of service days for maintenance should be significantly lower than those of repair. Out-of-service days for repair of CME in all four units were higher than that of maintenance, although not statistically significant. The number of episodes (number of times a CME sent for maintenance, repair or calibration) was not significantly different among the four departments. Even after introduction of a planned maintenance policy in 2006/2007, it was not changed. This was of concern and should be addressed by the hospital management. Hospital management should incorporate maintenance of CME as a part of routine instead of making it a separate and isolated function (Fredendall, et al, 1997). This would require development of maintenance policy and involvement of multi-disciplinary team comprised of end-users (health professionals) as well as maintenance engineers and technicians. The DYD Hospital recently introduced a policy to have maintenance plans for all CME and managed to cover 176 (87%) of them in line with the provincial policy (Gauteng Department of Health and Social Development, 2011).

On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994). This would ensure regular inspection, testing and maintenance intervals based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). In the DYD Hospital, most of the initial training was provided by the suppliers (176, 87%). It was not clear who were trained and whether follow-up training sessions were conducted to train newly appointed staff members. The hospital should organise regular training programme for all stakeholders as a part of continuous professional development activities.

5.3 THE LIFESPAN OF CAPITAL MEDICAL EQUIPMENT

The life-span of a CME depends on multiple factors such as planned maintenance at appropriate frequency, frequency of use, users; skills and

knowledge, surrounding environment (Kainth, 2003; Tarawneh and El-Sharo, 2009; Meredith and Shafer, 2011). As CME had to be replaced or upgraded at some point in time, it was important to identify the life expectancy of each CME and monitor its physical condition. This study found that the actual life-span of CME was significantly lower than the expected lifespan (Mann Whitney's U test, $p<0.001$). This implies a significant number of CMEs did not reach their life-span and a large proportion of them were in good (47, 23%) and fair (144, 71%) conditions. The Hospital CME acquisition policy should focus on those CME who are fair conditions as they require replacement in next 3-4 years. In addition a review of the purchase list should be done regularly for all items considering various aspects of the maintainability of the medical equipment as well as to identify shortfalls or surpluses of medical equipment in the various units in the Hospital (Waters, 2003; Grant, 2010).

Maintenance is not a separate and isolated function that makes repairs and performs assorted activities as needed but, a full partnership that strives together with other functions to achieve the strategic goals of the organisation and involves specialists such as maintenance engineers and technicians (Fredendall, Patterson, Kennedy et al, 1997). On-site training of local technicians on maintenance helps to solve equipment servicing problems in the organisation (Tudor and Gremill, 1994).

Replacement of medical equipment is planned taking into consideration the age, condition and critical nature of use. At the end of its life cycle it must be condemned, disposed and taken out of service (Temple–Bird, et al, 2005). Faulty or defective medical equipment must not be used regardless of how minor this is perceived. Inspection, testing and maintenance intervals should be based on manufacturer`s recommendation, risk levels and current organisational experience (Wang and Rice, 2003). Owing to the life span of CME, it can take several years before it needs to be replaced and at the time of replacement, CME might prove to be technologically obsolete. Management of hospitals should consider the acquisition of CME with care (Hugo, et al, 2006).

5.4 COSTING OF CAPITAL MEDICAL EQUIPMENT

Medical equipment is an important asset and is included in hospitals' budget cost estimates not only for procurement but also servicing these equipment. Although WHO suggested that it should account for 10% of the total hospital operational budget (WHO, 2010), in many developing countries such as India, only 2.5% of the district hospitals budget is set aside for machinery and equipment (Mavalankar, et al, 2004). The CME procurement and service costs incurred by the Hospital were primarily funded from the equipment budget allocated by the Department of Heath from the Province.

The total purchase cost of CME in the DYD Hospital during the study period was R 8,217,760.36 (approximately R 821,776 per year). The total purchasing costs for different units are as follows (a) In-patient unit: (Total R 2,632,551.03; Median R 19,956); (b) Casualty/ OPD (Total R 1,206,536.40; Median 15,527); (c) Surgical theatre (Total R 2,330,810.55; Median: R 12,353); and (d) Radiology (Total R 2,047,862.38; Median: R 90,310). Although the total purchasing cost in the In-patient unit was the highest, the median cost was the highest in Radiology unit due to the nature of equipment used in that unit.

The total service cost of CME in the DYD Hospital during the study period was R 1,454,566.85 (approximately R 145,456.68 per year), almost same amount for maintenance (R 635,476.86) and repair (R 611,206.15) and less for calibration (R 207,886.84). The service costs for different units are as follows: (a) Casualty/ OPD (Total R 196,024.20; Median R 3,805); (b) In-patient unit: (Total R 335,749.60; Median R 3,079); (c) Surgical theatre (Total R 366,415.40; Median: R 2,500); and (d) Radiology (Total R 451,047.10; Median: R 18,457). The total and median service cost in the Radiology Unit was highest among the four units.

Among the four units the total cost (purchasing and service) was the highest in

In-patient unit (R2,968,300.63) followed by Surgical theatre (R2,697,225.95), Radiology (R2,498,909.48), and Casualty/ OPD (R1,402,560.60).

The study showed that the Hospital spent a significant amount of resources on CME. A large portion of this resource was spent on repair. Therefore the Hospital management should perform a review of the purchase list for all items considering various aspects of the maintainability of the medical equipment. This should be followed by a comprehensive asset maintenance plan that showed the current condition and utilisation of CME, expected future demand and the cost of sustaining CME availability in the long run.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

In this chapter, conclusions and appropriate recommendations are made based on the findings of the study. Limitations and suggestions for future research are also included.

6.1 CONCLUSION

This was a cross-sectional study based retrospective record review that focused on the analysis of the functional state and costs of purchase and service of CME at DYD Hospital during a ten year period (1st April 2001 to 31st March 2011). In this chapter, conclusions and appropriate recommendations are made based on the findings of the study. Limitations and suggestions for future research are also included.

6.1.1 DESCRIPTION OF THE PROFILE OF CME ON THE HOSPITAL ASSET REGISTER

The Hospital during the study period had 203 CME (defined as equipment with an original purchase price of more than R5000). The majority of them were in working condition (196, 97%), which was much higher than other studies done in developing countries. Based on the criteria stipulated in the Gauteng Provincial Administration Manual (1994), only a quarter of them (47, 23%) were in good working condition and 144 (71%) of them were in a fair condition requiring replacement within three to four years and only four (3%) was in poor condition. In addition, the Hospital condemned seven (3%) of them during this period and six of them are from the Radiology Unit. This was a third of the total CME in that Unit resulting in poor radiology service delivery in this Hospital.

6.1.2 DESCRIPTION OF THE SERVICES OF CME

Service of CME includes (a) routine maintenance and (b) calibration and (c) repair. The DYD Hospital introduced a planned maintenance policy for CME in 2006/07 resulting in a significant increase in number of out-of-service days. Out-of service days were significantly higher in Surgical theatre and Radiology Units, as these two units have complex equipment. Out-of-service days for repair of CME in all four units were higher than that of maintenance, which is of concern and should be addressed by the hospital management. The DYD Hospital had recently introduced a policy to have maintenance plans for all CME and managed to cover 176 (87%) of them and hopefully it would assist in better maintenance and reduced repair time and cost. In addition, the hospital should organise regular training programme for all stakeholders as a part of continuous professional development activities.

6.1.3 DETERMINATION OF THE LIFESPAN OF CME

This study found that the actual life-span of CME (203) was significantly lower than the expected lifespan implying that a significant number of CMEs did not reach their life-span and a large proportion of them were in good (47, 23%) and fair (144, 71%) conditions. The Hospital CME acquisition policy should focus on those CME who are in fair conditions as they require replacement in the next 3-4 years. In addition a gap-analysis should be conducted to determine the state of CME and to identify shortfalls or surpluses of these medical equipment in various units in the Hospital.

6.1.4 DETERMINATION OF THE PURCHASING AND SERVICE COSTS

The total purchase cost of CME in the DYD Hospital during the study period was R 8,217,760.36 (approximately R 821,776 per year). The total purchasing costs varied among different units. During the same period, the total service cost was R 1,454,566.85 (approximately R 145,456 per year), almost same

amount for maintenance (R 635,476.86) and repair (R 611,206.15) and less for calibration (R 207,886.84).

6.2 LIMITATION OF THE STUDY

Firstly, the subject is hardly researched in South Africa and elsewhere. Therefore, the literature related to the subject is scanty.

Secondly, this study focussed on retrospective record review of records from a district hospital. However, the hospital had a good asset management system resulting in the generation of good quality of data.

Thirdly, the study focussed on a specific district hospital, therefore, its finding cannot not be generalised to other health facilities.

Fourthly, the researcher did not do the assessment. The assessment of CME requires specific skills of a clinical engineer, which the researcher do not have.

Lastly, the study only documented the information from the asset register; no physical verification was done to validate the findings of the study. In addition, no interviews were conducted to understand the impact of out-of-service CME, as it was beyond the scope of the study.

6.3 RECOMMENDATIONS

6.3.1 RECOMMENDATIONS TO THE HOSPITAL MANAGEMENT

There is a need for DYD Hospital to embrace CME maintenance as a high priority rather than Adhoc maintenance to avoid high costs of repairs and to reduce out-of-service days. The Hospital should establish a comprehensive asset maintenance plan that shows the current condition and utilisation of CME, expected future demand and the cost of sustaining CME availability in

the long run. The Hospital should also ensure that its medical equipment management unit is adequately staffed with the requisite manpower and a qualified Health Technology Officer is appointed.

All 203 CME should have maintenance plans in place and it should be made mandatory for different suppliers and manufacturers to provide training to technicians and staff followed by continuous professional development.

The DYD Hospital should develop an evidence based CME procurement system to ensure that a high quality and durable CME are purchased to prolong their life span.

The Hospital should compare the actual costs of CME (calibration, maintenance and repairs) against the budget allocation and any difference between actual and budget data should trigger a review of the reasons for the variance. Unexpected and expensive repair required for a critical CME can cause a substantial budget variance, as such, expenses of this type should be anticipated as much as possible so that, over time, the average level of expenses remains within the allocated budget.

A Provincial CME policy should be formulated as part of the Departmental Policy to compel institutions to periodically report on the functional state, maintenance and repair of CME. In addition, the Department of Health should allocate specific CME budget at hospitals and ring-fence it from other capital equipment budget.

6.3.2 SUGGESTION FOR FUTURE RESEARCH

Based on the findings of this study, the researcher would suggest that a following research should be conducted as a follow-up to this study:

- The study should be extended to other hospitals in South Africa.
- A comparative study should be done to verify information from the asset register and the actual state of the CME.

- A prospective study should be done to interview end-users to develop an understanding of the effect of CME on service delivery.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE CERTIFICATE AND LETTERS OF APPROVAL

Postgraduate Office, Faculty of Health Sciences

Wits Medical School, 7 York Road, PARKTOWN, 2193, Johannesburg • Tel: (011) 717 2108 • Fax: 086 622 9569 • e-mail: mathikhui.moshabesha@wits.ac.za

Dear Postgraduate Student

I take pleasure in informing you that your application for change of title has been approved by the Chair of the Faculty Graduate Studies Committee.

Kind regards

Mathikhui Moshabesha (Mrs)

Senior Faculty Officer Postgraduate Studies: Allied Disciplines

Faculty of Health Sciences

University of the Witwatersrand

7 York Road, Park town

Johannesburg, South Africa

Tel: +27 11 717 2108

Fax: +27 11 717 2119

E-mail: Mathikhui.Moshabesha@wits.ac.za

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Patrick Mbeko Sofohlo

CLEARANCE CERTIFICATE	M110810
PROJECT	An Analysis of the Functional State and Cost of Maintenance and Repair of Capital Medical Equipment at Dr Yusuf Dadoo Hospital
INVESTIGATORS	Patrick Mbeko Sofohlo.
DEPARTMENT	School of Public Health
DATE CONSIDERED	26/08/2011
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Dr Moreshnie Govender

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementi research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

Umyango Wezwmpilo no Kuthuthukiswa Komphakathi
Lefapha La Maphelo le Tshebeletso le Ntshetsopele ya
Department of Health & Social Development
Departmente van Gesondheid en Maatsplike
Ontwikkelia

health and
social development
Department: Health and Social Development
GAUTENG PROVINCE

To: Mr. P Sofohlo

From: Dr B Ikalafeng, Research Coordinator: Research and Epidemiology

Date: 21 September 2011

RE: Approval by GDH&SD on change in title

This serves as an acknowledgment to the change in title of Mr Sofohlo's research study which was previously titled: "Assessment of capital medical equipment management in a district hospital" and now is changed to: "an analysis of the functional state and costs of maintenance and repair of capital medical equipment at Dr. Yusuf Dadoo hospital"

The content of the research study is still the same and therefore approval is granted on the change in title.

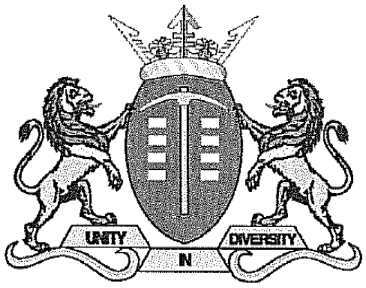
Kind Regards,

2011/09/21

Dr Ikalafeng

Research Coordinator: Research and Epidemiology

CONDITIONS OF APPROVAL OF A RESEARCH STUDY PROPOSAL



health and social development
Department: Health and Social Development
GAUTENG PROVINCE

Vision of the Department

"To be the best provider of quality health and social services to the people in Gauteng"

POLICY, PLANNING AND RESEARCH (PPR)
Enquiries: Siviwe Mkoka
Tel: +2711 355 3249
Fax: +2711 355 3675
Email: Siviwe.mkoka@gauteng.gov.za

CONTACT DETAILS OF THE RESEARCHER	
Date	04 April 2011
Tel number	(Mobile) +2783 302 7153 (Office/work) +2711 951 6161 (Fax) +2786 645 7730
Email	SofohloP@gpg.gov.za
Researcher /Principal Investigator (PI)	P.M. Sofohlo
Supervisor	Dr. M. Govender
Institution	University of Witwatersrand
Research title	**Assessment of capital medical equipment management in a district hospital**

This approval is granted only for a research study entitled **"Assessment of capital medical equipment management in a district hospital"** which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

Approval is hereby granted by the Gauteng Department of Health and Social Development for the above mentioned research study proposal for a study to be conducted within GDHSD domain. Approval is limited to compliance with the following terms and conditions:

1. All principles and South African regulations pertaining to ethics of research are observed and adhered to by all involved in the research project. Ethics approval is only acceptable if it has been provided by a South African research ethics committee which is accredited by the National Health Research Ethics Council (NHREC) of South Africa; this is regardless of whether ethics approval has been granted elsewhere.

   Of key importance for all researchers is that they abide by of all research ethics principles and practice relating to human subjects as contained in the Declaration of Helsinki (1964, amended in 1983) and the constitution of the Republic of South Africa in its entirety. Declaration of Helsinki upholds the following principles when conducting research, respect for:
   - Human dignity;
   - Autonomy;
   - Informed consent;
   - Vulnerable persons;
   - Confidentiality;
   - Lack of harm;
   - Maximum benefit;
   - and justice

2. The GDHSD is indemnified from any form of liability arising from or as a consequence of the process or outcomes of any research approved by HOD and conducted within the GDHSD domain;
3. Researchers commit to providing the GDHSD with periodic progress and a final report; short term projects are expected to submit progress reports on a more frequent basis and all reports must be submitted to the Director: Policy, Planning and Research of the GDHSD;
4. The Principal Investigator shall promptly inform the above mentioned office of changes of contact details or physical address of the researching individual, organisation or team;
5. The Principal Investigator shall inform the above office and make arrangements to discuss their findings with GDHSD prior to dissemination;
6. The Principal Investigator shall promptly inform the above mentioned office of any adverse situation which may be a health hazard to any of the participants;
7. The Principal Investigator shall request in writing authorization by the HOD via PPR for any intended changes of any form to the original and approved research proposal;
8. If for any reason the research is discontinued, the Principal Investigator must inform the above mentioned office of the reasons for such discontinuation;
9. A formal research report upon completion should be submitted to the Director: Policy, Planning and Research of the GDHSD with recommendations and implications for GDHSD, the Directorate will make this report available for the HOD.

This approval is granted only for a research study entitled **"Assessment of capital medical equipment management in a district hospital"** which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

AGREEMENT BETWEEN THE GAUTENG DEPARTMENT OF HEALTH AND SOCIAL DEVELOPMENT (GDHSD) AND THE RESEARCHER

Ms Sue le Roux

Director: Policy, Planning and Research, Department of Health and Social Development

Date:

Signature:

2/04/2011

Name and surname of Principal Researcher

Research/Academic Institution

Date: 2011/04/06

Signature:

3

This approval is granted only for a research study entitled "**Assessment of capital medical equipment management in a district hospital**" which will be conducted P.M. Sofohlo under supervision of Dr. M. Govender

APPENDIX B: DATA COLLECTION INSTRUMENTS

Tool 1: Profile of CME

Unique number	CME name	CME type	CME location	Purchase date	Purchase Price	Supplier name	Maintenance Plan	Initial training	Asset state	Date condemned	Life span

Tool 2: CME functionality (service maintenance, calibration and repairs)

Unique number	CME name	Department	Activity (Episodes of service maintenance)	Activity (Episodes of calibration)	Activity (Episodes of repairs)	Number of days CME out for service maintenance, calibration & repairs.	Cost of activity (service maintenance, calibration & repairs)	Name of the supplier

ANNEXURE C: LIST OF CAPITAL MEDICAL EQUIPMENT

Casualty and OPD (43 CME)

No	S/n	Full description	Classification	Department
1.	715PB	Bird Respiratory Ventilator	Respiratory Ventilator	Casualty
2.	716PB	Bird Respiratory Ventilator	Respiratory Ventilator	Casualty
3.	496EA	Medicare 4380 Baby Scale	Baby Scale	Casualty
4.	656KV	Weyer Infant Warmer Medical Trolley	Medical Trolley	Casualty
5.	657KV	Metal 1 Door & 1 Drawer Equipment Trolley	Equipment Trolley	Casualty
6.	FW619	Dkk Surgical Light	Surgical Light	Casualty
7.	099LX	Siemens E347E SV 900C Ventilator	Ventilator	OPD
8.	917KM	Welch Allyn Examination Light	Examination Light	Casualty
9.	KH757	Code master M1723A Defibrillator	Defibrillator	Casualty
10.	LC878	Nihon Kohden Tec7521K Defibrillator	Defibrillator	Casualty
11.	661MX	Metal 1 Door & 1 Drawer Equipment Trolley	Equipment Trolley	Casualty
12.	566DY	Fanem C186 Ts Infant Incubator	Infant Incubator	Casualty
13.	566DY	Cardio fax Gem 9022K ECG Machine	ECG Machine	Casualty
14.	565DY	Nihon Kohden 9022K ECG Machine	ECG Machine	Casualty
15..	738DY	Procare Auscultatory 100 Dinamap	Dinamap	Casualty
16.	UO201	Sony Lmd-1410 Patient Monitor	Patient Monitor	Casualty
17.	UO375	Engstrom Pro Ventilator	Ventilator	Casualty
18.	UO280	Tranpac 200D Ventilator	Ventilator	Casualty
19.	UO266	Mindray Vs-800 BP Monitor	Bp Monitor	Casualty
20.	448KV	Corometrics 170 Series Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
21.	258DM	Toshiba Capasee 11 Sonar Machine	Sonar Machine	Antenatal Clinic
22.	517EA	Tanita Baby Scale	Baby Scale	Antenatal Clinic
23.	KH579	TUV Mkco170-1530A Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
24.	LC842	Orchestra Mvp+Ms Infusion Pump	Infusion Pump	TB Focal Point
25.	VB612	Colin Bp8800 Blood Pressure Set	Blood Pressure Set	Termination of Pregnancy
26.	663MX	Procare Auscultatory 100 Dinamap Bp Monitor	Bp Monitor	TB Focal Point
27.	659MX	Dinamap Dpc121Xen Bp Monitor	Bp Monitor	Termination of Pregnancy
28.	293MZ	Procare Auscultatory Dpc321N-En Dinamap	Dinamap	Poly Clinic
29.	253MZ	Chison 8500 Sonar Machine	Sonar Machine	Termination of Pregnancy
30.	295MZ	Procare Auscultatory Dpc321N-En Dinamap	Dinamap	Poly Clinic
31.	KW995	Colin Next Bp-88S Patient Monitor	Patient Monitor	ARV Clinic
32.	789PA	Goldway Ut4000A Patient Monitor	Patient Monitor	TB Focal Point
33.	790PA	Goldway Ut4000A Patient Monitor	Patient Monitor	TB Focal Point
34.	771PA	Hospivac 350 Suction Unit	Suction Unit	Poly Clinic

35.	LC838	Orchestra Mvp+Ms Infusion Pump	Infusion Pump	TB Focal Point
36.	UO261	Philips Avalon Fm20 Foetal Heart Monitor	Foetal Heart Monitor	Antenatal Clinic
37.	004KV	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Rehabilitation
38.	031KV	Enraf Nonius Delft 419 Curapuls Shortwave Diathermy Esu	Diathermy ESU	Rehabilitation
39.	163KV	Madsen Orbiter 922 Audiometer	Audiometer	Rehabilitation
40.	257DM	Physio Control Lifepak 6 Defibrillator	Defibrillator	Rehabilitation
41.	145PC	Enraf Nonius 462 Curapuls Diathermy ESU	Diathermy ESU	Rehabilitation
42.	146PC	Enraf Nonius 462 Curapuls Diathermy ESU	Diathermy ESU	Rehabilitation
43.	KW552	Gsi 38 Auto Tymp	Auto Tymp	Rehabilitation

In-patients wards (80 CME)

No	S/n	Full description	Classification	Department
44.	024ZW	Metal 1 Level Phototherapy Unit	Phototherapy Unit	Maternity Ward
45.	122DM	Imed 916 Infusion Pump	Infusion Pump	Paediatrics Ward
46.	273DM	Med shield System 900 Boils Machine	Boils Machine	Maternity Ward
47.	282DM	Salter Baby Scale	Baby Scale	Maternity Ward
48.	279DM	Salter Baby Scale	Baby Scale	Post Natal Ward
49.	265KV	Sms B-Vac Suction Machine	Suction Pump	Female Medical Ward
50.	256DM	Isolette C86H Infant Incubator	Infant Incubator	Paediatrics Ward
51.	339LW	Seca 727 Baby Scale	Baby Scale	Paediatrics Ward
52.	401EA	Metal Examination Light	Examination Light	Paediatrics Ward
53.	405EA	Metal Examination Light	Examination Light	Paediatrics Ward
54.	408EA	Metal Examination Light	Examination Light	Paediatrics Ward
55.	648EA	Isolette C86H Infant Incubator	Infant Incubator	Maternity Ward
56.	872PB	Critikon 8100 Vital Sign Monitor	Vital Sign Monitor	Male Medical Ward
57.	659EA	Isolette C86 Infant Incubator	Infant Incubator	Maternity Ward
58.	662EA	Meco Pti Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
59.	HR096	Sms Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
60.	KH761	Hospilite Dkk De53090 Surgical Light	Surgical Light	Maternity Ward
61.	9553B	Module Mvp +Ms Is Syringe Pump	Syringe Pump	Paediatrics Ward
62.	910DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
63.	500DM	Metal 4 Glass Doors & 1 Drawer Medicine Trolley	Medicine Trolley	Male Medical Ward
64.	530DM	Metal 1 Door & 1 Drawer Medicine Trolley	Medicine Trolley	Male Medical Ward
65.	579DM	Metal Cardiac Trolley	Cardiac Trolley	Female Medical Ward
66.	909DO	Isolette Yp-90 Infant Incubator	Infant Incubator	Maternity Ward
67.	911DO	David Yp-90 Infant Incubator	Infant Incubator	Maternity Ward
68.	903DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
69.	908DO	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
70.	749DO	Fresenius Vial Mvp + Msuk Infusion Pump	Infusion Pump	Post Natal Ward
71.	358MZ	Criticare 506Dxn Bp Monitor	Bp Monitor	Male Medical Ward
72.	083ZW	Metal Examination Light	Examination Light	Paediatrics Ward
73.	092MZ	Wall-mounted Suction Valve	Suction Valve	Paediatrics Ward
74.	386MZ	Orthovac Suction Machine	Suction Machine	Paediatrics Ward
75.	397MZ	Hanau Med Examination Light	Examination Light	Paediatrics Ward
76.	664MX	Isolette C450 Infant Incubator	Infant Incubator	Maternity Ward
77.	660MX	Procare Dinamap 100 Bp Monitor	Bp Monitor	Post Natal Ward

78.	KW531	Colin Next Bp-88S Patient Monitor	Patient Monitor	Female Medical Ward
79.	000DY	Dinamap Dpc321En Bp Monitor	Bp Monitor	Post Natal Ward
80.	9870B	Isumed Infant Warmer	Infant Warmers	Post Natal Ward
81.	010DY	Oximax Pro 400V2 Dinamap	Dinamap	Maternity Ward
82.	259DM	Metal 1 Door Vacoliter Warmer	Vacoliter Warmer	Maternity Ward
83.	452DY	Sonicaid Team Care 12345678910 CTG Machine	CTG Machine	Maternity Ward
84.	819DY	Sonicaid Team Care 12345678910 CTG Machine	CTG Machine	Maternity Ward
85.	KW991	Aloka Ip-1233Dv Sonar Machine	Sonar Machine	Maternity Ward
86.	LC835	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
87.	LC840	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
88.	LC841	Orchestra Mvp + Ms Infusion Pump	Infusion Pump	Maternity Ward
89.	647MX	Optima Mis Infusion Pump	Infusion Pump	Paediatrics Ward
90.	9863B	Air Shields Infant Incubator	Infant Incubator	Paediatrics Ward
91.	9864B	Air Shields Infant Incubator	Infant Incubator	Paediatrics Ward
92.	557PA	Nt2A Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
93.	558PA	Nt2A Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
94.	843DO	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
95.	844DO	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
96.	9891B	Zoll M Series Defibrillator	Defibrillator	Paediatrics Ward
97.	LC903	Isolette C86 Infant Incubator	Infant Incubator	Paediatrics Ward
98.	879PB	Criticare 504 Plus Bp Monitor	Bp Monitor	Male Medical Ward
99.	LC925	Fresenius Uvp 5000 Volumetric Infusion Pump	Infusion Pump	Paediatrics Ward
100.	737DY	Procare Auscultator Dpc321N-En Dinamap	Dinamap	Paediatrics Ward
101.	958DY	Photizo 643 Phototherapy Light	Phototherapy Light	Maternity Ward
102.	757PA	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
103.	758PA	David Xhz90 Infant Jaundice Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
104.	560PA	Bionics Bpm-200 Pulse Oximeter	Pulse Oximeter	Paediatrics Ward
105.	595PA	David Yp-90 Infant Incubator	Infant Incubator	Paediatrics Ward
106.	783PA	Pc-900 Vital Sign Monitor	Vital Sign Monitor	Paediatrics Ward
107.	784PA	Aloka Ssd-3500 Sonar Machine	Sonar Machine	Maternity Ward
108.	787PA	Fanem C186 Ts Infant Incubator	Infant Incubator	Maternity Ward
109.	417LW	Lifepak 6 Defibrillator AED	Defibrillator AED	Female Medical Ward
110.	793PA	Volumat Agilia Infusion Pump	Infusion Pump	Paediatrics Ward
111.	794PA	Volumat Agilia Int Syringe Pump	Syringe Pump	Paediatrics Ward
112.	812PA	Auscultator Procare Dpc321N Dinamap	Dinamap	Maternity Ward
113.	615WL	Blt M900 Blood Pressure Set	Blood Pressure Set	Maternity Ward
114.	9889B	Sms Phototherapy Unit	Phototherapy Unit	Paediatrics Ward
115.	194PC	David Yp90A Infant Incubator	Infant Incubator	Maternity Ward
116.	195PC	David Yp-90A Infant Incubator	Infant Incubator	Maternity Ward
117.	UO265	Mindray Vs-800 Vital Sign Monitor	Vital Sign Monitor	Maternity Ward
118.	192PC	David Yp90A Incubator	Incubator	Post Natal Ward
119.	193PC	David Yp90A Incubator	Incubator	Post Natal Ward
120.	191PC	David Yp-90A Infant Incubator	Infant Incubator	Paediatrics Ward
121.	UO365	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward
122.	UO392	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward
123.	UO399	Avalon Fm20 Philips Fetal Monitor	Fetal Monitor	Maternity Ward

Radiology (X-Ray) - (18 CME)

No	S/n	Full description	Classification	Department
124.	506KV	Shimadzu Bf-11 Erect Bucky	X Ray Bucky	X-Ray Department
125.	517KV	Delayed Film Id Marker X Ray Identification Camera	X Ray Camera	x- Ray department
126.	621EA	Toshiba Kcd-10M-7At X Ray Machine	X Ray Machine	x- Ray department
127.	628EA	Toshiba Kcd-10M-6A1T X Ray Machine	X Ray Machine	x- Ray department
128.	721DR	Toshiba Kcd-10M-6A7S X Ray Machine	X Ray Machine	x- Ray department
129.	970EA	Target D850 Plus Dynatron Ultrasound Machine	Ultrasound Machine	x- Ray department
130.	550KV	Siemens Elema 6898589G025E X Ray Machine	X Ray Machine	x- Ray department
131.	553KV	Aloka Ssd-620 Sonar Machine	Sonar Machine	x- Ray department
132.	FY552	Conventional Pl-CW type X-Ray Cassette	X Ray Cassette	x- Ray department
133.	644MX	Classic Agfa X Ray Film Processor	X Ray Film Processor	x- Ray department
134.	9706B	Toshiba Kcd-10M-6A1T X Ray Machine	X Ray Machine	x- Ray department
135.	048SB	Toshiba Kcd-10M-6At X Ray Machine	X Ray Machine	x- Ray department
136.	UO203	Curix Film Id Marker X Ray Identification Camera	X Ray Camera	x- Ray department
137.	9901B	Shimadzu Collimator R-200 Portable X Ray Machine	X Ray Machine	x- Ray department
138.	005ZX	Shimadzu R-20J X Ray Machine	X Ray Machine	x- Ray department
139.	006ZX	Shimadzu Ch-200 Telescopic X Ray Machine	X Ray Machine	x- Ray department
140.	007ZX	Shimadzu QJC Erect Bucky	X Ray Bucky	x- Ray department
141.	010ZX	Fujifilm FCR IR 359 Digital X Ray Reader	X Ray Reader	x- Ray department

Surgical Theatre (62 CME)

No	S/n	Full description	Classification	Department
142.	121DM	Generic R-2.500 Suction Pump	Suction Pump	Surgical Theatre
143.	123DM	Hellige Servomed Anaesthetic Machine	Anaesthesia Machine	Surgical Theatre
144.	125DM	Servo 900C Ventilator	Ventilator	Surgical Theatre
145.	126DM	Sirecust 402 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
146.	127DM	Hellige Servomed Anaesthetic Machine	Anaesthesia Machine	Surgical Theatre
147.	128DM	M Stabler Suction Unit	Suction Unit	Surgical Theatre
148.	139DM	Scd5328 Sequential Compression Device	Compression Device	Surgical Theatre
149.	140DM	Hellige Smk230 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
150.	141DM	Hellige Smk230 Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
151.	145DM	Eschmann R-2.2500 Suction Unit	Suction Unit	Surgical Theatre
152.	161DM	Critikon Dinamap Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre
153.	163DM	Ohmeda 700 Ventilator	Ventilator	Surgical Theatre
154.	199DM	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Surgical Theatre

155.	306DM	Anzy Jsd400 Autoclave	Autoclave	Surgical Theatre
156.	306DM	M Stabler Sterilizer Machine	Sterilizer Machine	Surgical Theatre
157.	307DM	Mainline Steam Autoclave	Autoclave	Surgical Theatre
158.	360DM	Siemens Radio tom 804E Anaesthesia Monitor	Anaesthesia Monitor	Surgical Theatre
159.	361DM	Mf450 Aspen Diathermy Esu	Diathermy ESU	Surgical Theatre
160.	369DM	Storz Cold Light Fountain	Cold Light Fountain	Surgical Theatre
161.	383DM	Storz Cold Light Fountain	Cold Light Fountain	Surgical Theatre
162.	393DM	Atom Trans capsule V-80Tr Infant Incubator	Infant Incubator	Surgical Theatre
163.	398DM	Mf450 Aspen Diathermy Esu	Diathermy ESU	Surgical Theatre
164.	661LW	Steri-Vac 3M Gas Sterilizer	Gas Sterilizer	CSSD
165.	662LW	Steri-Vac 400G Gas Sterilizer	Gas Sterilizer	CSSD
166.	995DR	Neomed 3000A Ventilator	Ventilator	Surgical Theatre
167.	998DR	Metal 1 Drawer & 2 Levels Equipment Trolley	Equipment Trolley	Surgical Theatre
168.	FW621	Generic Surgical Light	Surgical Light	Surgical Theatre
169.	KH855	Meco 100/1 Infant Warmer	Infant Warmers	Surgical Theatre
170.	KH861	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
171.	KH862	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
172.	KH863	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
173.	KH865	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
174.	KH866	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
175.	KH874	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
176.	KH875	Hospilite Dkk De53090 Surgical Light	Surgical Light	Surgical Theatre
177.	HP793	Bear1 Ventilator	Ventilator	Surgical Theatre
178.	LC847	Metal Frame Adjustable Bed	Stretcher Bed	Surgical Theatre
179.	LC846	Metal Frame Adjustable Bed	Adjustable Bed	Surgical Theatre
180.	LC848	Metal Frame Adjustable Bed	Adjustable Bed	Surgical Theatre
181.	927DO	Steri-Vac 3M Gas Sterilizer	Gas Sterilizer	CSSD
182.	795DO	Warm touch 501-5800 Patient Warmer	Patient Warmer	Surgical Theatre
183.	KH867	Simed S100E Pulse Oximeter	Pulse Oximeter	Surgical Theatre
184.	399MZ	Metal Examination Light	Examination Light	Surgical Theatre
185.	372MZ	Nihon Kohden 9010K ECG Machine	ECG Machine	Surgical Theatre
186.	064MZ	Sms B-Vac Suction Machine	Suction Pump	Surgical Theatre
187.	453MZ	Contoura 267Kg Stretcher Bed	Stretcher Bed	Surgical Theatre
188.	665MX	Olympus Bf 20D Gastroscope	Gastroscope	Surgical Theatre
189.	697MX	Olympus CF 20Hl Colonoscope	Colonoscope	Surgical Theatre
190.	702DO	Blease 560 Boyles Anaesthetic Machine	Boyles Machine	Surgical Theatre
191.	654DY	Dinamap Pro 1000 Patient Monitor	Patient Monitor	Surgical Theatre
192.	141DY	Dinamap Dpc121X Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre
193.	196DM	AME Diascope2 Defibrillator AED	Defibrillator AED	Surgical Theatre
194.	9353B	Nihon Kohden Tec7521K Defibrillator	Defibrillator	Surgical Theatre
195.	9374B	Carl Equipment Trolley	Equipment Trolley	Surgical Theatre
196.	9357B	Meco MIW Infant Warmer	Infant Warmers	Surgical Theatre
197.	9357B	Medi Tool Mobile Suction Unit	Suction Unit	Surgical Theatre
198.	9772B	Colin Next Bp-88S Patient Monitor	Patient Monitor	Surgical Theatre
199.	410PC	Lateral Tilt Surgical Table	Surgical Table	Surgical Theatre
200.	9375B	Stryker Stretcher Bed	Stretcher Bed	Surgical Theatre
201.	UO367	Stryker Stretcher Bed	Stretcher Bed	Surgical Theatre
202.	UO368	Datex-Ohmeda Aespine 7900 Anaesthesia Machine	Anaesthesia Machine	Surgical Theatre
203.	UO264	Mindray Vs-800 Vital Sign Monitor	Vital Sign Monitor	Surgical Theatre