TO STUDY THE SYSTEM OF MAINTENANCE OF HOSPITAL SUPPORT SERVICE EQUIPMENTS AND THEIR UTILIZATION AT CANTONMENT GENERAL HOSPITAL, DELHI CANTT

INTERNSHIP AND DISSERTATION REPORT
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF
DEGREE OF POST GRADUATE DIPLOMA IN HEALTH AND HOSPITAL MANAGEMENT
BATCH 'G' (2014-16)

BY
COLONEL SREE KRISHNA
(PG/14/056)

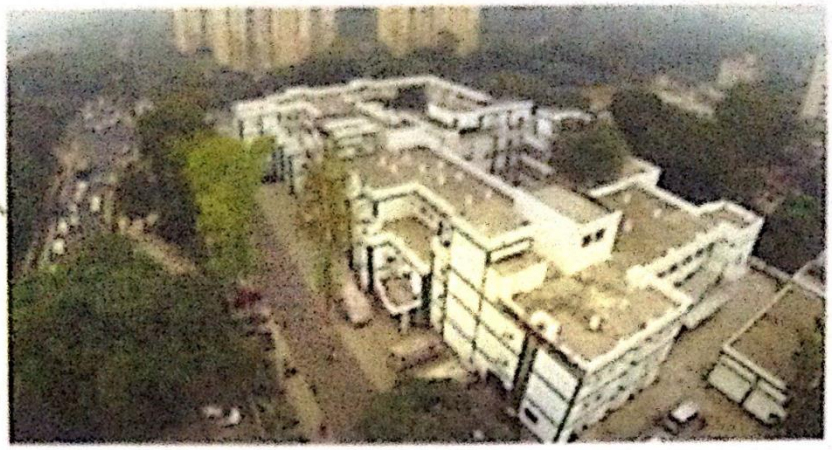
UNDER THE GUIDANCE OF

INTERNAL MENTOR
MRS KIRTI UDAYAI
ASSISTANT PROFESSOR &
ASSISTANT DEAN (ACADEMICS)
IIHMR DELHI

EXTERNAL MENTOR
DR M K HIRA
SENIOR MEDICAL OFFICER
CANTONMENT GENERAL
HOSPITAL,DELHI CANTT

International Institute of Health, Hospital Management and Research
New Delhi

Year 2016



TO WHOMSOEVER IT MAY CONCERN

This is to certify that Colonel Sree Krishna student of Post graduate Diploma in Hospital and Health Management (PGDHM) from International institute of Health Management and Research, New Delhi has undergone internship training at Cantonment Board General Hospital , Delhi Cantt from 24 Feb to 19 May 2016.

The candidate has successfully out the study **"To study the System of Maintenance of Hospital Support Services Equipments and their Utilization at Cantonment General Hospital, Delhi Cantt" ,** which was designated to him during the internship training and his approach to the study has been sincere , scientific and analytical .

The internship is in fulfilment of the Course requirements.

I wish him success in all his future endeavours.

DR Ashok Kumar Agarwal
Dean Academics and Student Affairs
IIHMR Delhi

Mrs Kirti Udayai
Assistant professor and Assistant Dean
IIHMR Delhi

CERTIFICATE OF APPROVAL

The following dissertation titled **"To study the System of Maintenance of Hospital Support Services Equipments and their Utilization at Cantonment General Hospital, Delhi Cantt"** is hereby approved as a certified study in management carried out and presented in a manner satisfactorily to warrant its acceptance as a pre requisite for the award of Post Graduate Diploma in Health and Hospital Management for which it has been submitted . It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made , opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

Dissertation Examination Committee for evaluation of dissertation.

Name	**Signature**
Dr. Manish Priyadarshi	
Dr. Nishikant Bele	
Kirti Udayai	Kirti Udayai

CERTIFICATE FROM DISSERTATION ADVISORY COMMITTEE

This is to certify that Colonel Sree Krishna, a graduate student of Post - Graduate Diploma in Health and Hospital Management has worked under our guidance and supervision . He is submitting this Dissertation titled **"To study the System of Maintenance of Hospital Support Services Equipments and their Utilization at Cantonment General Hospital, Delhi Cantt"** at IIHMR , Delhi, in partial fulfillment of the requirement for the award of the Post Graduate Diploma in Health and Hospital Management. This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph , report or book.

Mrs Kirti Udayai
Assistant Dean and Assistant Professor
IIHMR Delhi

May 2016

Dr MK Hira
Senior Medical Officer
Cantonment General Hospital
Delhi Cantt

19th May 2016

Cantonment General Hospital
Delhi Cantt

Dated : 19th **May 2016**

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Colonel Sree Krishna has successfully completed internship training in the Department of Operations from 24 Feb to 19 May 2016.

During the tenure of his association with the Organisation , we found him actively participating in Hospital activities and keen to learn different aspects of Operations and Administration in the Health care industry.

We have found him sincere , hard working and focused towards the assignments given to him.

We wish him all the very best for future endeavours.

Dr. Maninder Kumar Hira
Medical Officer
Cantonment General Hospital
Delhi Cantt-110010

Dr MK Hira
Senior Medical Officer
Cantonment General Hospital Delhi Cantt

Cantonment General Hospital

Delhi Cantt

Date : 19th May 2016

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Colonel Sree Krishna has satisfactorily completed his Internship and Dissertation in the Department of Operations from 24 feb to 19 May 2016. During his tenure , he has successfully completed the Project on the topic titled **"To study the System of Maintenance of Hospital Support Services Equipments and their Utilization at Cantonment General Hospital, Delhi Cantt".**

Throughout the training he has been a regular and keen learner . His performance during the training period was excellent.

Maj Gian Inder Kumar Hira
Senior Medical Officer
Cantonment General Hospital
New Delhi Cantt-110010

Dr MK Hira
Senior Medical Officer
Cantonment General Hospital Delhi Cantt

CANTONMENT GENERAL HOSPITAL

FEEDBACK FORM

Name of the Student : Colonel Sree Krishna

Dissertation Organisation : Cantonment General Hospital, Delhi Cantt

Area of Dissertation : Hospital Support Services, Equipment Management and Department of Operations and Logistics in Hospital

Attendance: Full

Objectives achieved: The desired objective has been achieved very well which would help in enhancement of Operational Efficiency

Deliverables : Adequate on all aspects of Operations and proficient Equipment Management.

Strengths: A sincere, dedicated, matured and balanced individual who is full of zeal, enthusiasm and passion for Healthcare Industry.

Suggestions for improvement: The Officer needs to continue with his professional and personal traits as displayed during internship for future success. Keep it up, best wishes always.

Signature of the Officer -in – charge/ Organisation Mentor

Place: Cantonment Board Hospital, Delhi Cantt

Date:

Place: Cantonment Board Hospital, Delhi Cantt

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled **"To study the System of Maintenance of Hospital Support Services Equipments and their Utilization at Cantonment General Hospital, Delhi Cantt"** has been submitted by the undersigned (Colonel Sree Krishna, Enrolment No. PGDHM/2014/056) under the supervision of **Mrs Kirti Udayai**, for the award of Postgraduate Diploma in Hospital and Health Management of the Institute carried out during the period from 2**4 February to 19 May 2016** embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

(Colonel Sree Krishna)

CONTENTS

ACKNOWLEDGEMENT

I express my gratitude and sincere thanks to Mrs Kirti Udayai, Assistant Professor and Assistant Dean , at International Institute of Health Management and Research, New Delhi, for her valuable guidance and co- operation in my Endeavour. I also express my sincere thanks to Dr Ashok K Agarwal, Dean Student affairs and Dr A K Khokkar , Director IIHMR for their esteemed support and guidance .

I am thankful to the management of Cantonment General Hospital at Delhi Cantt, New Delhi, for giving me the opportunity to carry-out Internship-cum-Dissertation in their esteemed hospital. I am deeply indebted to Dr Gurudev Singh, Chief Medical Officer (in charge) , Cantonment General Hospital, for his foresight and generous support, without which I wouldn't have been able to set my objectives for my Dissertation. I would also like to express my gratitude to the functionaries and the staff of all medical and non-medical administrative departments of the hospital who were extremely helpful in elucidating in detail, the nuances of their tasks and duties performed by them. My heartfelt thanks to Shri M S Reddy, Chief Executive Officer, Delhi Cantt for professional guidance at all stages. His incisive knowledge, precision and professional approach of continuous guidance has been the strongest foundation in this endeavour of the Study. I would be failing in my duty, if, I don't express my sincere gratitude to Brigadier Jai Singh, Sena Medal, President Cantonment Board and Station Commander, Delhi Cantt whose rich practical experience, vision, direction, and perfectionism was ultimate in success of this Study.

I am greatly thankful to Dr MK Hira, Senior Medical Officer, Cantonment General Hospital, Delhi Cantt, without whom this study would not have been possible. His cooperation, support, mentoring and guidance has been the strongest thread that put together this work. The Internship provided me with an opportunity wherein, I further improved my understanding of all Departments of a hospital and its functioning. The training schedule ensured that there was adequate in-build flexibility provided to me to understand detail nuances of hospital administration. Thus, the Internship-cum-Dissertation training has equipped me with an expertise which will ensure my appropriate employability as hospital administrator within the Army as well as in other tertiary care hospitals.

(Colonel Sree Krishna)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS / ABBREVIATIONS

S.NO.	ABBREVIATED FORM	FULL FORM
1.	CGH	Cantonment General Hospital
2.	AC	Air conditioning
3.	AED	Automated external defibrillator
4.	ACLS	Advanced cardiac life support
5.	AERB	Atomic Energy Regulatory Board
6.	AHU	Air handling unit
7.	AMC	Annual Maintenance Contract
8.	BARC	Bhaba Atomic Research Centre
9.	BLS	Basic life support
10.	BMW	Bio Medical Waste Management
11.	CCTV	Close Circuit Television
12.	CCU	Critical Care Unit
13.	COP	Care Of Patients

14.	CPR	Cardio Pulmonary Resuscitation
15.	CQI	Continuous Quality Improvement
16.	CSSD	Central Sterile and Supply Department
18.	FMS	Facility Management System
19.	HDU	High Dependency Unit
20.	HIC	Hospital Infection Control
21.	HMIS	Hospital Management Information System
22.	HRM	Human Resource Management
23.	ICU	Intensive Care Unit
24.	IMS	Information Management System
25.	IPD	In Patient department
26.	LAMA	Leave against Medical Advice
27.	MOM	Management Of Medication
28.	MRD	Medical Records Department
29.	MRI	Magnetic Resonance Imaging
30.	NABH	National Accreditation Board for Hospitals and Healthcare Providers
31.	OPD	Out Patient Department
32.	IV	Intravenous

33.	WHO	World Health Organization
34	Abd.	Abdominal
35	AI	Aortic insufficiency
36	AMA	Against medical advice
37	BMR	Basal metabolism rate
38	BP	Blood pressure
39	BUN	Blood urea nitrogen
40	Ca	Carcinoma
41	EKG, ECG	Electrocardiogram
42	EMG	Electromyogram
43	ENT	Ear nose and throat
44.	MD	Doctor of Medicine
45..	MHA	Master of Hospital Administration Master of Health Administration

SECTION I: INTERNSHIP REPORT

SECTION 1: INTERNSHIP REPORT

(24Feb-19May 2016)

Introduction

1. **Delhi Cantonment** (popularly referred to as **Delhi Cantt**) was established in 1914. Until February 1938, the Cantonment Board Delhi was known as the Cantt Authority. The area of the Cantonment is approx. 10,521 acres .The Delhi Cantonment is a Class I Cantonment Board.The Cantonment is governed by the Cantonments Act, 2006[1] while various policy letters and instructions from the Ministry of Defence pertaining to the area are issued from time to time. Although the board functions as a local municipal body, it remains under the administrative control of the Directorate General Defence Estates, New Delhi and Principal Director, Defence Estates, Western Command, Chandigarh.[2]

2. Delhi Cantonment falls in South West district of Delhi. All the four major transport modes are easily accessible to the residents of nearby regions. Other nearby areas include the airport, Dwarka, Dhaula Kuan, Tilak Nagar, Vasant Vihar, Naraina, JanakPuri, R K Puram, Shanti Niketan and Westend. Delhi Airport is within 5 km from Delhi Cantonment. Delhi Cantt. itself has a railway station. All the trains plying from Delhi towards Rajasthan or Gujarat do stop here. This region is also served by the Janakpuri/ Tilak Nagar metro station under Delhi Metro.

3. At the 2011 India census Delhi Cantt. had a population of 116,352. Males constituted 58% (67,703) of the population and females constituted 42% (48,649). Delhi Cantt. has an average literacy rate of 91.11%, higher than the national average of 79.9%: male literacy is 94.54% and, female literacy is 86.26%. In Delhi Cantt., 11.36% of the population is under 6 years of age[2] . This means that there is a need for healthcare facilities to cater for the needs of children's health.

4. The Cantonment Board consists of eight elected Members, three nominated Military Members, three Ex-officio Members (Station Commander, Garrison Engineer and senior executive Medical Officer), one representative of the District Magistrate. An officer of the Indian Defence Estates Services which is a central civil service is posted as the Cantonment Executive Officer (CEO) as well as the member secretary of the Board. The board is headed by the President Cantonment Board (PCB) who is the Station Commander and also presides over the meetings of the cantonment board. The Station Commander of the Army is the Ex-officio President of the Cantonment Board. At present **Brig Jai Singh** is the President of the Cantonment Board Delhi.

Cantonment Board Hospital(CGH),Delhi Cantt

5. Cantonment Board Hospitals have been raised in all Cantonments of the country to look after the civilian population living in and around the cantonments . These

hospitals come under the Local Cantonment Board headed by a Chief Executive Officer (CEO) who is an officer of Indian Defence Estates Service cadre of Civil Services and works under the administrative control of Director General, Defence Estates, Govt. of India, Ministry of Defence. **Sh. B Reddy Sankar Babu, IDES** is the Chief Executive Officer of Delhi Cantonment Board at present.

6. **One of the primary functions of the Cantonment Board is to provide the basic health cover to the civilian population of Delhi Cantonment Area.** The board has been performing this through Cantonment General Hospital located at Sadar Bazar, Delhi Cantt.

7. Cantonment General Hospital **(CGH)** provides the basic health cover to the civilian population of Delhi Cantonment Area.[4] The Hospital made a modest beginning from one of the barracks of the old Base Hospital building at Sadar Bazar, Delhi Cantt. The hospital was shifted to its present location in 1963 .The hospital is a **100-bedded unit (**under extension) at present. It provides general medical and primary, emergency care services including **Laboratory**, **X-ray** and Ante-natal to Post- natal **services.** The hospital is managed by the permanent staff consisting of a CMO, 4 GDMO, a dental surgeon and other doctors & specialists on contractual basis. It has a full-time **dental clinic ,** part-time **visiting specialist** of dermatology and ophthalmology. It has limited IPD services. It has in its premises a **Health Post of Delhi Government** which provides Maternal and Child Health Services including Antenatal Care and Immunization Services.

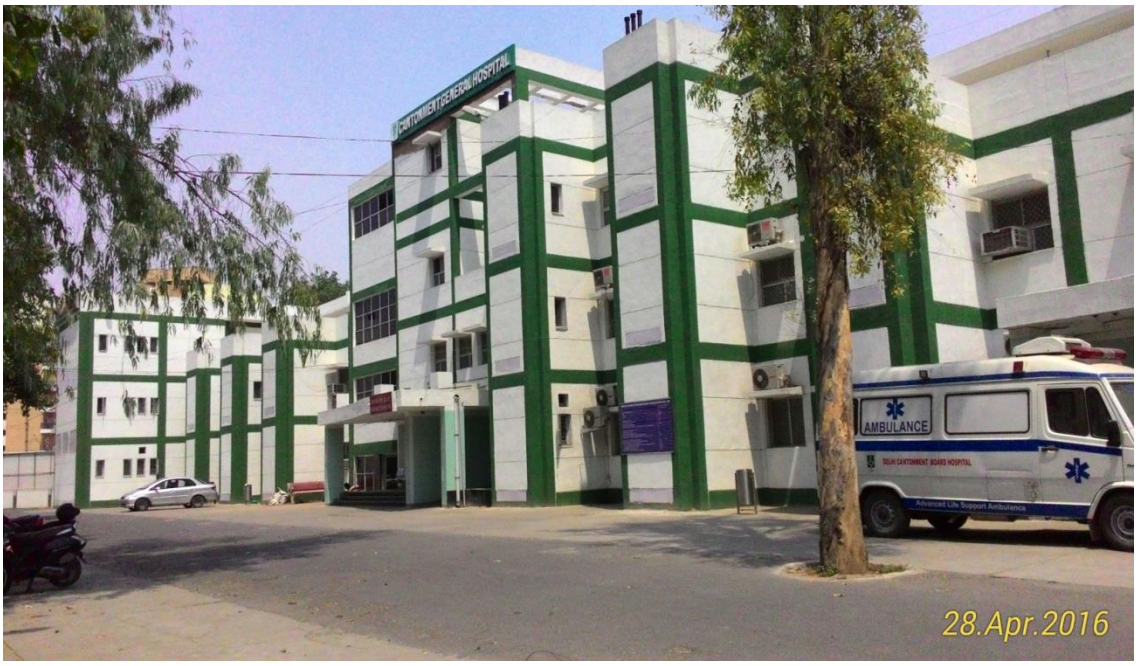


Figure1.1 : 100 Bedded Cantonment General Hospital

8. It also has the **DOTS Centre of Delhi Government** providing treatment of tuberculosis. An **AYUSH Clinic** run by Central Council for Research in Homoeopathy (CCRH) is also functional on daily basis. It is implementing all

the **National Health Programs** including Pulse Polio Program, School Health and Tuberculosis Control Program**.** [5]

Mission,Vision and Values

9. The hospital has not developed any mission, vision or value statement.

Layout of the Hospital

10. The General hospital is housed in a Three floor building with the following constitution:-

(a) **Ground floor** . Has the Reception and Registration centre , Emergency , Casualty room, Ortho , Gynecology , Ophthalmology , ENT ,Medical ,

Figure 1.2: Cantonment General Hospital Building - An over view

Psychiatric , Skin , Ayurvedic and Homeopathic OPDs , Minor OTt , Radiology (X ray & USG) , ECG room, Immunization and Injection room , Family planning Counselling room , Labour room , Physiotherapy room, a DOTS centre , main Pharmacy ,Dressing room and Plaster room

(b) **The first floor** has the Administrative block , Dental department , Path Lab , Pharmacy store , Ayurvedic store , Family ward (18 beds) and a conference room .

(c) **The Second floor** has the Major OT , VIP rooms(06 capacity) , Private wards (18 capacity) , Male ward (20 capacity) and CSSD.

(d) **The Basement** has the AC plant, Linen store , Furniture store , Pump house and Generator set

Figure 1.3: The Mobile Dispensary and Ambulance fleet of CGH

11. **Ambulances** - The hospital has two mobile dispensaries to cater for distribution of medicines and critical care in remote areas of the cantonment , it has two BSA and one ALS.

Staff

12. The hospital is headed by a CMO (Incharge) under whom are the following staff :-

(a) Permanent - Doctors - 04 , Nurses - 02 , ANM - 04 , Technicians - 02 , Pharmacist - 02 , Administrative staff – 13.

(b) **Contractual** - Doctors - 28 , Nurses - 35 , Technicians - 18 , Pharmacist – 04.

Outsourced Services

13. The hospital has outsourced the following services:-

(a) Security - 30 persons

(b) House Keeping and waste disposal - 60 persons

Services not catered for in the Hospital

14. The hospital has not catered for the following services :-

(a) Blood Bank
(b) Mortuary
(c) Laundary
(d) Dietary Services

(e) Manifold Services

Various Departments

15. Cantonment General Hospital provides care through the following Departments:-

- Orthopedics.
- Obstetrics & Gynecology
- ENT
- Skin
- Ophthalmology
- Medical
- Clinical Nutrition.
- Dentistry.
- Psychiatry
- Physiotherapy
- Health Check
- Radiology
- Path and Lab
- DOT centre
- AYUSH clinic

Observations and Recommendations

16. Internship in a Delhi Government hospital being administered by Cantonment Board was an excellent opportunity to learn. It gave you an insight into the healthcare delivery system moving inconsonance with Government structural and policy format. The hospital was being well administered under the present CMO . This internship provided an interactive platform to learn on all aspects of Hospital from Clinical to Administrative operations. All departments of CGH (including support services) were especially visited to conduct ground inputs of various types of equipment available ; their purchase procedure, source of funding, maintenance systems practiced ; functional status of equipment etc. Discussions were held with key personals concerned with running and maintenance of the equipment such as Store In-Charge / Holders, Functional In-Charge, Equipment Handlers (including respective Staff Nurses), Doctors, Head of the Departments and even CMO, to have an overall idea of the equipment management system including maintenance. The major observations and recommendations based on the survey and interaction during internship are elucidated below:-

(a) **Emergency Services.**

(i) For Emergency Department entry, separate entry may be planned which is not common for other patients entry to Hospital.

(ii) Emergency signage should be visible from the main road, since CGH is nearer to Airport, the services can also be utilized by serious travelling patient in vicinity.

(iii) Crash cart needs to be checked daily for regular testing.

(iv) Staff should be trained in BLS/ACLS

(b) OPD Services .

(i) Separate queue for differently able should be made available.

(ii) Separate and functional toilet availability for differently able.

(iii) Citizen charter and Patient charter are to be displayed in the OPD.

(iv) Waiting Area may have more chairs / space.

(v) Token system to be introduced for efficient management of Queuing.

(vi) OPD patient satisfaction survey is required to be done at regular intervals and documented, to enhance satisfaction.

(c) Laboratory Services.

(i) PPE need to be made available to the staff.

(ii) Staff should be made aware about the safety precautions especially Needle Stick Injuries.

(iii) % of redo cases is required to be monitored.

(d) Radiology & Imaging.

(i) Separate register to be maintained for reporting errors.

(ii) Separate register to be maintained for reports having clinical correlation with provisional diagnosis.

(iii) Procurement of all specification of X Ray films being required for Radio diagnosis be considered so that the patients do not have to go elsewhere for these tests.

(e) Wards.

(i) Training to be given to the nurses on BLS (CPR) at regular intervals and mock drills to be conducted to check affectivity.

(ii) Infection control practices need to be followed strictly as per the guidelines. Hospital Infection Control Committee needs to be earmarked and they need to brief all concerned regularly.

(f) Labour Room.

(i) A separate area should be demarcated for septic and aseptic deliveries.

(ii) APGAR SCORE should be used.

(g) Operation Theatre.

(i) HVAC system need to be installed

(ii) Defibrillator need to be purchased for the OT.

(iii) Pre operative checklist needs to be followed.

(h) Pharmacy.

(i) Proper receiving, segregation and storing area needs to be demarcated.

(ii) Refrigerator for storing medicines(2-8 degree C) need to be made available.

(iii) Proper provision for storing narcotic drugs need to be made available.

(iv) Items need to be labelled and stored alphabetically.

(v) Inventory control practices should be followed (ABC, VED, FSN,FIFO).

(vi) Drugs and therapeutics committee should be formed.

(vii) Hospital drug formulary should be available.

(viii) Desired % of drugs received from supply needs to sent for testing on periodic basis.

(j) Biomedical Waste Management.

(i) Isolation/barrier nursing facility should be available.

(ii) Visit required to be carried out by the hospital authorities to the disposal site and should be documented.

(iii) In-Service training sessions with respect to infection control, needs to be conducted for all the staff at least once in a year and documented.

(iv) Appropriate pre & post exposure prophylaxis should be provided to all concerned staff members.

(k) CSSD.

(i) Chemical, biological and bowie-dick Tests need to be performed.

(ii) All equipment needs to be utilized effectively by immediate installation.

(l) Human Resource Management.

(i) Manpower needs of the Hospital be re-assessed and staff / technicians adequately placed for effective equipment management.

(ii) Hospital HR Manual be created specifying charter of duties and responsibilities assigned to each individual staff / employee, for efficient functioning.

(iii) To implicate quality of ownership in employees, there is a need to increase the ratio of permanent vis-à-vis contractual staff.

(l) Miscellaneous.

(i) Mock drills with respect to fire fighting and disaster management needs to be periodically conducted and documented .

(ii) To streamline policy on equipment management, there is a need for creation of a Hospital Equipment Utilization Committee.

(iii) For providing intimate repair and maintenance, there is a need for creation of Hospital Technical Support Section / Central Workshop, adequately staffed with desired expertise and resources/spares.

SECTION II : DISSERTATION

TO STUDY THE SYSTEM OF MAINTENANCE OF HOSPITAL SUPPORT SERVICES EQUIPMENTS AND THEIR UTILIZATION AT CANTONMENT GENERAL HOSPITAL, DELHI CANTT

Executive Summary

17. Medical equipment in the hospitals is characterized by large range and variety, high rate of induction as well as obsolescence due to rapid advancement in medical sciences and technology. Increased dependence of medical professionals on these equipment both for diagnosis and treatment demands their high availability at all times. A rapid increase in technology has changed hospitals, from a predominantly people dependent, to a highly equipment dependent medical service. Medical support service equipment could be viewed as component of health care technologies, applied with the aim of achieving with the aim of achieving an effective and safe diagnosis or therapy and care. An appropriate deployment of technological innovation contributes to the improvement in the quality of health care delivered, the containment of cost and an increase allies to the health care system.

18. Hospital equipment, especially of new generation has got immense role in advancement of modern medical technology. The high technology health care system based on modern sophisticated equipment has both positive and negative aspect. Positive aspect of development of technology has improved the quality and increased the quantum of medical care tremendously. The access of better quality care has become easy. Negative aspect of modern technology has led the medical care cost escalation and clinical practice is becoming more and more dependent on technology and traditional clinical practices are getting obsolete.

19. Every hospitals holds a large number of equipment in support service area, which are used as frequently as possible and expected to function at their peak efficiency at all times. So long as the equipment functions, it poses no problem, but when it needed desperately to bring it back to the function, more so in the case of vital, scare, high cost and electro-medical equipment. Therefore, all effort is required to derive maximum benefit of equipment during life time. It further demands a constant care to avoid it's breakdown due to negligence, resulting into costly repairs with long down time that may adversely affect the quality of patient care. Maintenance is a combination of actions carried out to retain an item or restore it to an acceptance condition. It also ensures

equipment reliability, productivity, efficiency and safety . Preventive maintenance procedure assures availability of equipment without interruption.

20. The main objective of equipment maintenance is uninterrupted operation or service in a hospital. Maintenance is not merely a question of putting a machine in order when it breaks down but it requires continuous attention, so that machine does not go out of order and also it functions at a minimum cost. The maintenance provides safety and quality of work and life. It is not necessary only to earn profit, reputation, type and quality of care along with the patient's satisfaction but also for avoiding the hospital from legal hassles or implications.

21. Cantonment General Hospital (CGH) located at Sadar Bazar, Delhi Cantt provides the basic health cover to the civilian population of Delhi Cantonment Area. The hospital is a 50-bedded unit (under extension to 100 beds) at present, providing general medical and primary emergency care services including Laboratory, X-ray and Delivery services. The hospital is managed by the permanent staff consisting of a CMO, 4 general duty doctors, a dental surgeon and other doctors and specialists on contractual basis. It has a full-time dental clinic , part-time visiting specialist of dermatology and ophthalmology. It has limited IPD sevices. It has in its premises a Health Post of Delhi Govt which provides Maternal and Child Health Services including Antenatal Care and Immunization Services. It also has the DOTS Centre of Delhi Govt providing treatment of tuberculosis. AYUSH clinic run by Central Council for Research in Homoeopathy (CCRH) is also functional on daily basis.

22. A number of studies have shown that, of the equipment problems reported, approximately One-third arise from operator problems while one-third arise from minor, easy-to-solve technical problems (such as a blown bulb or fuse, or a loose power cord) and only one-third require more serious fault-finding procedures and special knowledge of the equipment. At least two-thirds (and maybe as much as 80%) of the problems could be corrected by properly trained equipment users. Leaving, at most, one-third of the problems which require especially trained maintenance personnel.

23. CGH, Delhi Cantt is also facing the problem of equipment maintenance. Resources are limited for any given hospital which is true to CGH also. Therefore, for the hospital to be effective and efficient, proper utilization of available resource is necessary to obtain best results. Hence, a need was felt for study of equipment management system

and their utilisation in support services in the hospital. This study has identified the gaps and recommended measures to overcome those shortcomings in equipment management format of CGH. This would lead to optimum utilization of the support services equipment in CGH, Delhi Cantt.

CHAPTER-1: INTRODUCTION

24. Medical equipment in the hospitals is characterized by large range and variety, high rate of induction as well as obsolescence due to rapid advancement in medical sciences and technology. Increased dependence of medical professionals on these equipment both for diagnosis and treatment demands their high availability at all times. A rapid increase in technology has changed hospitals, from a predominantly people dependent, to a highly equipment dependent medical service. Medical support service equipment could be viewed as component of health care technologies, applied with the aim of achieving with the aim of achieving an effective and safe diagnosis or therapy and care. An appropriate deployment of technological innovation contributes to the improvement in the quality of health care delivered, the containment of cost and an increase allies to the health care system.

25. Hospital equipment, especially of new generation has got immense role in advancement of modern medical technology. The high technology health care system based on modern sophisticated equipment has both positive and negative aspect. Positive aspect of development of technology has improved the quality and increased the quantum of medical care tremendously. The access of better quality care has become easy. Negative aspect of modern technology has led the medical care cost escalation and clinical practice is becoming more and more dependent on technology and traditional clinical practices are getting obsolete.[1]

26. Every hospitals holds a large number of equipments for its functional support, which are used as frequently as possible and expected to function at their peak efficiency at all times. So long as the equipment functions, it poses no problem, but when it needed desperately to bring it back to the function, more so in the case of vital, scare, high cost and electro-medical equipments. Therefore, all effort is required to derive maximum benefit of equipment during life time. It further demands a constant care to avoid it's breakdown due to negligence, resulting into costly repairs with long down time that may adversely affect the quality of patient care. Maintenance is a combination of actions carried out to retain an item or restore it to an acceptance condition. It also ensures

equipment reliability, productivity , efficiency and safety . Preventive maintenance procedure assures availability of equipment without interruption.

27. The main objective of equipment maintenance is uninterrupted operation or service in a hospital. Maintenance is not merely a question of putting a machine in order when it breaks down but it requires continuous attention, so that machine does not go out of order and also it functions at a minimum cost. The maintenance provides safety and quality of work and life.

28. It is not necessary only to earn profit, reputation, type and quality of care along with the patient's satisfaction but also for avoiding the hospital from legal hassles or implications.

29. In the present healthcare scenario, increasing operational efficiency and reducing costs, whilst improving service provided to the patient, are a constant challenge. Advances in engineering and information technology, particularly during the last few decades, have revolutionized medical care. The availability and utilization of various healthcare equipment, at all levels, in the health system for effective and efficient service delivery was amply emphasized in the Alma-Ata declaration at the International Conference on Primary Healthcare in 1978, which was later included in the strategy paper of Health for All by 2000AD.

30. The sophistication in the medical field has led to the development of specialized care centers in an attempt to provide high quality care. Medical equipment plays a very significant role in the healthcare delivery system. The equipment has become more complex and requires regular specialized maintenance and repair, which is very expensive.

31. Hospital equipment falls into an extremely wide spectrum ranging from a simple patient trolley to a hi-tech PET, MRI, and CT scanner. The term "equipment" in the context of a hospital, generally means any instrument, apparatus, tool, appliance, machine or any other related article, used for various preventive, diagnostic, therapeutic, supportive, and control procedures for day to day patient care activities.

32. Hospital equipment can be broadly classified into:-

(a) Biomedical equipment

(b) Laboratory equipment

(c) Ward equipment

(d) Service support equipment

(e) Utilities and hospital furniture

33. All these account for a major part of any hospital project cost, which could go up to almost 60 percent. Of this, biomedical equipment could account for nearly 50 percent of the cost. Keeping this in view, it is essential to ensure maximum utilization of the equipment with minimum downtime.

34. With the adaptation of proper maintenance techniques and management systems one can utilize resources optimally and reduce the breakdown and related maintenance workload. It should be an earnest endeavour of the management and users to optimize the equipment utilization to obtain maximum return on capital invested. In an era of cost-intensive medical care, every equipment being installed in healthcare institutions need to be fully and properly utilized.

35. An optimum utilization of equipment will result in:-

(a) Optimal patient handling and rapid turnover

(b) Minimum possible cost

(c) Quality patient care and satisfaction to both patient and healthcare provider.

36. Efficient equipment utilization should be ensured to optimize healthcare facilities. A substantial number of equipment in Indian healthcare institutions is of foreign origin. It is imperative that appropriate steps are taken in the planning, procurement, installation, and usage stages of this equipment to maximize utilization and optimize healthcare facilities. Utility of equipment which are not life saving in nature should be assessed by calculating the use coefficient. If, it is less than fifty percent, installing the equipment may not be economically viable.

37. Centralised Sterile Supply Department (CSSD) is the integral and one of the most important support services in a modern hospital. CSSD is the department which receives processes, sterilizes stores and distributes the equipment, sets, dressings, packs, etc. to different user departments of the hospital including wards, out-patient department, OTs etc. .

38. The Dietary service in hospital provides food service for staff, visitors, inpatients, outpatients, and ambulatory patients as appropriate. It also provides nourishment and snacks between scheduled meal services and caters for the special dietary needs of patients. Medical gas system is "An assembly of equipment and piping for the distribution of non-flammable medical gasses such as oxygen, nitrous oxide, compressed air, carbon dioxide, and nitrogen."

39. A Medical Gas distribution system involves a highly sophisticated life support network, which may supply medical air and oxygen for patient breathing, nitrous oxide for anaesthesia, medical air for driving orthopaedic tools and vacuum for suction. Medical gases must be delivered in a clean, safe, reliable manner at every point in the hospital where they are needed. Centralized Medical Gas pipeline system is today recognized as a basic life support requirement of a hospital. It helps to maintain hygiene in the high-risk areas like OT, ICU, Nursery, etc.

40. Blood Transfusion Services in a hospital refers to the entire gamut of activities which result in proper collection of blood from voluntary donors , processing of the same, including mandatory check for certain transmissible diseases and final issue of safe blood for therapeutic use in patients. Blood banks means a place or organisation or unit or institution or other arrangement made by such organisation / unit/ institution for carrying out all or any of the operations for collection , aphaeresis , storage, procuring and distribution of blood drawn from donors and / or preparation, storage and distribution of blood components.

41. Hospital Laboratory service plays a crucial role in the detection, diagnosis, and treatment of disease. The basic function of a laboratory services are provision of comprehensive and accurate analytical test results , assistance in confirming / rejecting a diagnosis , prognosis, and follow up therapy , detection of disease ,and training and research.[2]

42. Radio-Diagnosis is the medical speciality directing medical imaging technologies to diagnose and sometimes treat disease through use of radiography , fluoroscopy , radioisotopes and high voltage acceleration.

43. Laundry services constitute one of the most important supportive services in a hospital. The activities / services pertaining to washing / cleaning of linen come under ambit of laundry services. The main functions of laundry service are collection and receipt of soiled and infected linen, sorting, sluicing, disinfecting, washing, and ironing of the linen, repair of damaged linen, assembling and packing of linen and finally distribution of linen to the user departments.

44. Some people believe in-house maintenance departments can take care of everything themselves. However, this belief is over-confident, presumptuous, and costly in terms of equipment down-time and well-being. Some people believe out-sourcing all maintenance and repair to an outside service enterprise reduces the administrative workload. However this belief is fashionable, very expensive, and diminishes the technical know-how within the health service.

Need of the Study

45. A number of studies have shown that, of the equipment problems reported, approximately One-third arise from operator problems while one-third arise from minor, easy-to-solve technical problems (such as a blown bulb or fuse, or a loose power cord) and only one-third require more serious fault-finding procedures and special knowledge of the equipment. At least two-thirds (and maybe as much as 80%) of the problems could be corrected by properly trained equipment users. Leaving, at most, one-third of the problems which require especially trained maintenance personnel.[3]

46. Cantonment General Hospital (CGH), Delhi Cantt, is also facing the problem of equipment maintenance. Resources are limited for any given hospital which is also true for CGH, Delhi Cantt. Therefore, for the hospital to be effective and efficient, proper utilization of available resource is necessary to obtain best results. Hence, a need was felt for the study of Support Services equipment management system and their 19tilization in the hospital.

Equipment

47. The term '**Medical Equipment**' can be interpreted as including a wide range of instruments, equipment, machinery or apparatus used for medical and para-medical purposes. The literature provides us with a number of definitions for the term 'medical equipment'. Simply as being "... the equipment which may be found in hospitals, medical research and teaching institutions".[4]

48. This definition includes the entire range of mechanical, electrical and electronic devices used, directly or indirectly, for the delivery of health care. A more selective definition can be found in the relevant Health Equipment Information (HEI) publication of the Medical Devices Agency (MDA) of the Department of Health in London, which states that the term medical equipment comprises:-

..”any device, instrument, apparatus, implement, material substance, or other article (used singly or in combination), together with any accessory thereto, which is intended by the manufacturer for (a) diagnosis, prevention, monitoring, treatment or alleviation of human disease or injury, or (b) investigation or modification of human anatomy or of human physiological process; which does not achieve its principal intended action by pharmaceutical means, but which may be assisted in its functioning by such means.”[5]

49. Equipment are intended to diagnose, treat or monitor the patient under medical supervision, and which makes physical or electrical contact with the patient, and/or transfers energy to or from the patient, and/or detects such energy transfer to or from the patient

50. As per National Accreditation Board of Hospital (NABH) Medical equipment is any fixed or portable non drug item or apparatus used for diagnosis, treatment, monitoring and direct care of patient.

51. Medical device is an article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health

purpose. Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.[6]

52. "**Medical device**" means any instrument, apparatus, implement, machine, appliance, implant, in vitro reagent or calibrator, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the specific purposes of:-

(a) Diagnosis, prevention, monitoring, treatment or alleviation of disease

(b) Diagnosis, monitoring, treatment, alleviation of or compensation for an injury

(c) Investigation, replacement, modification, or support of the anatomy or of a physiological process

(d) Supporting or sustaining life

(e) Control of conception

(f) Disinfection of medical devices

(g) Providing information for medical purposes by means of in vitro examination of specimens derived from the human body and which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its function by such means.

53. An accessory is not considered to be a medical device. However, where an accessory is intended specifically by its manufacturer to be used together with the 'parent' medical device to enable the medical device to achieve its intended purpose. The definition of a device for in vitro examination includes, for example, reagents, calibrators, sample collection devices, control materials, and related instruments or apparatus. The information provided by such an in vitro diagnostic device may be for diagnostic, monitoring or compatibility purposes.

54. Single Patient Use Device is a medical devices that may be used for more than one episode on one patient only. The device may undergo some form of reprocessing between each use but must never be used on more than one patient.[6]

55. Single Use Device is a medical device intended to be used on an individual patient during a single procedure and then discarded. The item will carry the following marking on its packaging.

56. **Instrument** is that by means of which any work is performed, or result is effected; a tool; a utensil; an implant; a device; as, the instruments of a mechanic; astronomical instruments.

57. **Apparatus** is an appliance or device for a particular purpose: an x-ray apparatus. It is an integrated group of materials or devices used for a particular purpose e.g. dental apparatus.[7]

58. **Appliance** is a device or instrument designed to perform a specific function, especially an electrical device, such as a Chapatti maker , Grinder.

Hospital Equipment Planning

59. Hospitals have undergone a quantum change in concept and care provisioning from ancient days to present era. The information explosion and technological advances have revolutionized the medical care. Studies on medical equipment management have indicated at any given time in most of the hospitals non-functional equipment may account for 40-50 percent of all equipment procured by the hospital.[8]

60. Planning of the equipment are initial phase of the life cycle management of medical equipment. This phase must be carefully considered because this can greatly affect later use and maintenance ofequipment.[9]

61. **Need Assessment:** It is essential that a realistic analysis is done for the requirement of equipment in a health care institution. Prior to the identification and definition of needs for medical equipment, health authorities will have to agree on a well-defined and regularly updated policy for the delivery of Health Care in the country.

62. The policy documents and associated implementation strategy describe the medical functions at national, regional and district level hospitals and health centers. The requirements for physical assets, such as medical equipment, will have to be justified and be in agreement with those national policies. A second requirement is the availability of comprehensive and up-to date information about the existing stock of equipment. The discrepancy between 'what is' and 'what ought to be there' provides an accurate account of current requirements.

63. The following should be ensured while assessing the need for equipment:-

(a) Committee: Need assessment for equipment should be done by a committee of clinicians, administrators, representatives from the engineering and accounts section.

(b) Availability of similar technology in hospitals in the area proposed to be covered

(c) Resources / utilization forecast of needed equipment.

(d) Legalities with respect to export , financial transaction, penalty clause .

64. The essential of quality assurance in equipment planning is shown as below:-

(a) The latest technology is procured at the right cost.

(b) Warrantee and guarantee conditions are appropriately incorporated in the purchase orders.

(c) Preventive and break down maintenance measures are planned and adopted.

(d) Availability of post warranty repair at reasonable cost is ensured.

(e) Equipment should preferably have add an capabilities / up gradation feasibility.

(f) Consumables should be readily available.

(g) Use coefficient should be high and networking of healthcare facilities done to ensure optimal utility.

Procurement Phase

65. Procurement can be regarded as the process by which an item of equipment, which has already been selected, is purchased by the user. Procurement is a predominantly administrative exercise, such as obtaining the best possible deal from the various sources of supply and organising the transfer of the equipment to the importing country and to its final destination.[10]

66. The usual procedure for equipment procurement is to invite firms to submit tenders. A tender committee, or board, makes the final decision and awards tenders to successful applicants. Procurement proposals should cover restocking, expansion, spare parts, and wear and tear.[11,12]

67. Much as is the case for equipment selection, McKie advises that for all commercial transactions technical expertise should be called upon in order to guard the interest of the purchaser and user. The extent of technical expertise should match that of the supplier and manufacturer.[13,14,15]

68. Following procurement and the necessary logistical procedures (custom clearance, transport, etc.), resulting in the arrival of the goods at location, formal acceptance procedures must be in place. These acceptance procedures are needed to ensure that the entry of all equipment into service is properly controlled.

69. **Selection of right source:** Vendor selection must be done judiciously. Appropriate analysis must be done if selecting a foreign supplier. Principal and agent reliability, cost considerations, finalization of the mode of payment, after sales service are some of the parameters which require due consideration from buyers. Some of the factors to be taken into consideration when selecting equipment and suppliers are (i) Technical support from the supplier, (ii) Technical features of the equipment, (iii) The quality and completeness of equipment documentation, (iv) Installation procedures, (v) commissioning of the equipment, (vi) Price criteria, based on comparative lifecycle costing of the available alternative items of equipment, (vii) Length of the warranty period, and (viii) Delivery time. Adopting an acquisition policy along those lines results in equipment suppliers competing for purchase contracts. By making sure that the equipment suppliers are aware of the selection criteria, one ensures that an appropriate 'technical support package' will be included in their offers.

70. **Correct contract formulation**: A comprehensive, legally tenable contract should be done with the suppliers / manufacturers. Some of the salient features which should be considered while finalizing contracts are:-

(a) **Type of payment**: In case of imported equipment it should be pre-decided on the type of payment viz. through L/C, CAD or DAA. The latest bank rates for opening and transactions for Letter of Credit should be ascertained, to analyse the cost effectiveness for procurement.

(b) **Bank guarantee**: A successful tenderer should be required to furnish a contract performance guarantee bond in the shape of a Bank Guarantee for an amount equivalent to 10% of the Cost of the equipment towards the execution of

the Agreement and warranty period. The Bank Guarantee should be valid till the expiry of the warranty period. A fresh bank guarantee should be furnished by the tenderer for the AMC period amounting to 2% of the cost of the equipment

(c) **Penalty clauses**: Strict penalty clauses should be incorporated to ensure equipment functionality at all times especially of life saving and essential ones. 95 % uptime is desirable in all equipment. If the manufacturer / supplier are not able to ensure functionality of the equipment during the warranty period, even after 48 hours of receiving a complaint, a penalty @ 0.5% of the bank guarantee amount for each day for the first 07 days (commencing 48 hours after receipt of complaint) and 1% per day thereafter may be imposed.[16]

(d) **Composite cost**:- Whenever equipment is procured, it is imperative that the total cost should be estimated, i.e. cost of equipment, freight, insurance, agent commission, cost incurred in customs clearance, cost of accessories, etc. The mode of cost negotiated with the supplier i.e. C.I.F., C.I.F.C., F.O.R. etc. should be incorporated in the contract.

(e) **Warranty with spares**: Suppliers are now willing to offer warranty for a longer period of time. Warranty with spares for 2 years and an additional warranty for 3 years without spares is being accepted by suppliers.

(f) **Continuous supply of consumables**: Some equipment may need expensive consumables to be imported. Every effort must be made to secure as many consumables as possible to last for a minimum period of five years. Guarantee for at least 10 years availability of spares should be obtained from suppliers. Equipment may be offered at a very low price but the consumables required may have to be imported later at a phenomenal cost. It will be prudent to purchase more expensive equipment which can be operated with less expensive consumables which are available locally.

(g) **After sales service:** It is important to ensure continuous and an uninterrupted functioning of the equipment. Service contract must be conceived, planned at the time of purchase and incorporated in the AMC. Accepted norms for AMC are 1-4% of the cost of equipment. For high budgeted equipment an AMC for a longer period (5-10 years) should be considered.

(h) **Training of staff:** Training of staff to handle the equipment efficiently may range from training at site to training abroad depending upon the needs of the staff and institution. Timely and appropriate training of the staff for handling and operating the equipment should be provided free of cost by the supplier.

(j) **Foreign exchange:** Lifesaving equipment is exempted from customs duty. Foreign currency value keeps on frequently fluctuating. If it is envisaged that the lead time of the equipment to be procured is more than three months, it is advisable to finalize a forward booking where the bank undertakes to take care of fluctuations for a specific period by charging a premium.

Equipment Selection

71. A medical equipment selection team comprising doctors, nurses and technical and administrative personnel should be formed to select medical equipment. The strategies for hospital equipment should include scientific need assessment, appropriate procurement, maintenance, repairs, optimum utilization and timely replacement. Equipment availability, functionality, effective, efficient, utility assessment are the cornerstones in which the stores administrator plays a pivotal role in provision of satisfaction to staff, cost effectiveness to the hospital management and health care to the patients.[17]

72. Safeguards in Selection.

(a) Development of detailed specification

(b) Copy of technical details

(c) Credibility of supplier

(d) Warranty

(e) Annual Maintenance Contract with spares

(f) Space allocation

(g) Training of staff by the Company

(h) User's opinion

(j) Value Analysis[17]

Receipt and Inspection of Equipment

73. As and when equipment are received from the supplier, it has to be ascertained that they conform to specifications/ standards of the supply order. This process must be done timely, since in case they do not meet the requirements they must be sent back to the supplier. The procedure of the inspection has to be carried out sequentially by a committee and documentation done systematically.

Incoming Inspection

74. In general, inspections performed within the maintenance of equipment could mainly be classified into visual inspection, physical inspection, and functional infection. All newly received equipment should be kept separately till their inspection is carried on. In no circumstances these should be merged with existing stocks. A standing committee as under should be constituted for carrying out inspection at the hospital level:-.

(a) Officer in charge store
(b) Representative of concerned department
(c) Assistant store officer
(d) Representative from accounts department
(e) Chief nursing officer or her representative.

75. At least three members must be present for the inspection. On receipt of any equipment, these should be thoroughly checked and inspected with a view to ascertain the quantity, quality and correctness. Breakages, if any, may also be ascertained during inspection.

Inventory and Documentation System

76. Provides information to support different aspects of medical equipment management:-

(a) Maintaining of equipment service history

(b) **History sheet and Log book** It is essential that periodic scientific evaluation of the quality of performance of the equipment is carried out. This will aid is accessing the future need, planning acquisition and disposal of obsolete, economically non-viable equipment.

Maintainability

77. Maintainability is defined as the probability of restoration of a failed device or 'equipment or asset to operational effectiveness within a specified period of time through the prescribed maintenance operations. Maintainability is associated with the design of the assets to be maintained. It is a measure of the ease of maintenance. The parameter for expressing the maintainability is Mean Time to Repair (MTTR).

78. The concept of maintainability is different from reliability. Reliability is the probability that an asset or a system will operate satisfactorily for some determined period of time, under the working conditions for which it was designed. The parameters expressing reliability are Failure Rate (FR) or Mean Time between Failures (MTBF).[18]

79. The concept of maintainability was thus evolved to enable designers to provide effective support to maintenance of the equipment. This idea was thought of because of the complexity of design, the size and number of parts that make a system and, therefore, maintainability features form an important part of the system design today.[19]

80. The limitations of the maintainability are that, firstly, it cannot be put in complex machine systems because of design considerations and, secondly, it does not improve the performance of the equipment.

Prerequisites for Measurement of Performance

81. Now that we have understood the importance of measurement of maintenance performance, let us look the prerequisites for the measurement of performance. For an effective control on maintenance, the annual measurement of performance is essential. The following are the prerequisites and the steps that are useful in developing measures of maintenance performance:-

(a) Identifying of specific areas where the maintenance processes can have or has had an impact on the productivity, quality and customer satisfaction.

(b) Analyzing existing conditions of the down-time, production loss, and nature of repairs and breakdowns done, existing maintenance facilities, maintenance cost, breakdowns versus labour cost. These give an indication of the key areas to be considered for evaluation.

82. Certain maintenance costs are hidden costs or indirect costs, which are difficult to assess and measure. These costs are categorized to six big losses, namely:-

(a) Breakdowns and unplanned shutdown losses.

(b) Excessive set up, changeovers and adjustment losses.

(c) Idling and minor stoppages.

(d) Machines running at reduced speeds.

(e) Start up losses.

(f) Quality defects and its losses.

83. Evaluating the areas related to capacity constraints of the year because of maintenance, negative impact on quality of the product attributed to maintenance, breakdown resulting in not serving the internal customers properly

84. Some metrics that can be gainfully used as part of the evaluation process are:-

(a) Maintenance man hours spent during the year compared to hours used in production.

(b) Shut down, major overhaul, construction and renovations carried out during the year and the final analysis if done.

(c) Total Productive assets and their present conditions: If evaluation is done, take it as record, If not done capacity planner will have to evaluate and serve.

(d) Maintenance business operations of the year, its budgetary and cost controls.

(e) Shop level maintenance cost per unit produced during the year.

(f) Records about the Maintenance department and quality control interfacing.

(g) Continuous reliability improvement actions during the year and its results.

(h) Safety and regulatory compliance as per the statutory requirements.

(j) Maintenance man hours available as planned per unit of production.

(k) Maintenance cost as a ratio to the gross assets value in percentage.

(l) Maintenance cost spent as percentage of direct labour cost of the production.

(m) Absolute maintenance cost.

Performance monitoring

85. For effective management of the maintenance programme, it is important to measure performance. Most performance measures do not have a standard or benchmark to compare with. In such cases the manager should monitor performance over time, investigate any significant trends, and identify opportunities for improvement. It is also important to communicate regularly with colleagues who are managing similar programmes. By comparing performance data, managers can identify and take advantage of improvement opportunities. Those with the financial resources may consider subscribing to a benchmarking service that will support detailed performance monitoring.

Completion rate of assigned Preventive Maintenance

86. The completion rate is percentage of procedures completed. It can be measured at the end of an assignment period (e.g. monthly, bi-monthly or quarterly). A good completion rate goal is to be above 90%. This measure could also be calculated to evaluate the completion rate of each priority group, starting with the highest priority group. The highest priority devices should have the highest completion rate goal, e.g., over 95%, with lower priority groups having lower goals.

87. This indicator is used to measure the productivity and effectiveness of the IPM staff, the ability of the technical personnel, and the adequacy of the staffing levels. IPM completion rates for each technician must take into consideration the expected time it takes to complete an IPM procedure, so the technician is not overloaded, or under loaded, with work.

Equipment location rate

88. The proportion of equipment scheduled to be inspected in the assignment period but not located before the end of the inspection period is known as the equipment location rate. This indicator primarily measures the accuracy of the inventory database in the

CMMS system. It also provides an indication of the effectiveness of the policies to keep the inventory accurate, as well as measuring the quality of communications between clinicians and the medical equipment maintenance department, particularly when equipment is moved, loaned or put into storage.

Corrective Maintenance performance measures

89. In addition to the measures already mentioned, there are certain measures that may be recorded to specifically monitor CM performance. For example:-

(a) **Mean time between failures***:* The average time elapsed between failures.

(b) **Repeated failures**: The number of failures within a specified period of time.

(c) **Response time** *:* The time between a request for service and the start of repair.

(d) **Repair time:** The time between the start and finish of repair.

(e) **Downtime:** The percentage of time that a device is out of service.

(f) **Delinquent work orders***:* Work orders not completed within 30 days.

Performance improvement

90. For a maintenance programme, performance improvement applies to every aspect of the programme, with the ultimate objective of improving patient care. The performance improvement process has the following steps:-

(a) **Identify opportunities for improvement:** This is one of the outcomes of careful and thorough performance monitoring as described above.

(b) **Identify best practices:** These are actions that have been recognized within the profession as leading to improved performance. They are found in clinical engineering literature and through collaboration with professional colleagues.

(c) Improve performance: Performance improvement projects should be based on best practices. The aspect of performance selected for improvement should be closely monitored until the desired level of performance is achieved.

91. Specific changes should be measured systematically to determine if the changes improve performance and quality. This can be done by: a) carefully measuring the performance and quality indicators for several measurement periods (months or quarters); b) making a change in the way things are done; and c) continuing to measure the performance and quality.

92. If the new procedures demonstrate positive improvements then the change was an effective one. If indicators do not improve, revisit the original performance analysis, adjust accordingly and repeat the process. This systematic approach of managing programme performance improvement can have a very positive impact over a period of several years. Additionally by measuring the improvement in performance and quality after making changes to the system in which the technicians operate (e.g. install a remote workshop, purchase automated test equipment, upgrade to a CMMS system etc.), the cost of these changes can be justified, the changes will be well accepted by the staff, and further systemic changes can continue to be made.

Indices for measuring maintenance effectiveness

93. In the present healthcare scenario, increasing operational efficiency and reducing costs, whilst improving service provided to the patient, are a constant challenge. Advances in engineering and information technology, particularly during the last few decades, have revolutionized medical care. The availability and utilization of various healthcare equipment, at all levels, in the health system for effective and efficient service delivery was amply emphasized in the *Alma-Ata declaration* at the International Conference on Primary Healthcare in 1978, which was later included in the strategy paper of *Health for All by 2000AD*. The sophistication in the medical field has led to the development of specialized care centers in an attempt to provide high quality care. Medical equipment plays a very significant role in the healthcare delivery system. The equipment has become more complex and requires regular specialized maintenance and repair, which is very expensive. Hospital equipment falls into an extremely wide spectrum ranging from a simple patient trolley to a hi-tech PET, MRI, and CT scanner. The term "equipment" in the context of a hospital, generally means any instrument,

apparatus, tool, appliance, machine or any other related article, used for various preventive, diagnostic, therapeutic, supportive, and control procedures for day to day patient care activities.

94. All these account for a major part of any hospital project cost, which could go up to almost 60 percent. Of this, biomedical equipment could account for nearly 50 percent of the cost. Keeping this in view, it is essential to ensure maximum utilization of the equipment with minimum downtime. With the adaptation of proper maintenance techniques and management systems one can utilize resources optimally and reduce the breakdown and related maintenance workload.

95. It should be an earnest endeavor of the management and users to optimize the equipment utilization to obtain maximum return on capital invested. In an era of cost-intensive medical care, every equipment being installed in healthcare institutions need to be fully and properly utilized.

96. An optimum utilization of equipment will result in:-

- Optimal patient handling and rapid turnover
- Minimum possible cost
- Quality patient care and satisfaction

97. Utilization essentially means the use of the equipment to its full potential. Utilization index or use coefficient is one of the important parameters to monitor the functional status of the equipment. It is the parameter to assess the productivity of a service or an equipment.

Important Factors Affecting Utilization of Equipment

98. Medical equipment is expensive to procure and maintain. There are various factors which must be considered for their optimal utilization. The important factors are:-

(a) Training of the staff: Timely and appropriate training of the staff handling and operating the equipment is a prerequisite for effective and optimum utilization of equipment.

(b) **Equipment installed on turnkey basis**: It has been observed that costly equipment installed on turnkey basis have better utilization as equipment planning considers factors like civil, electrical, air--conditioning installation, etc., which are ensured by the firm. Thus the equipment when handed over to the hospital is fully functional. Prior to the commissioning of the facility, adequate numbers of personnel are already trained by the firm installing the equipment.

(c) **Preventive maintenance and after-sales services***:* Insisting on regular after-sales services of the equipment and a proper system of preventive maintenance, downtime of costly and essential equipment can be considerably reduced thereby increasing utilization. Normally the annual maintenance cost of equipment varies from 1-4 percent of the capital cost of the equipment. By ensuring availability of repairs, maintenance, and necessary spares, equipment utilization can be significantly increased.

(d) **Facility for back up power supply***:* As most of the vital and essential equipment are functional on electricity or chargeable battery supply, facility for back up power supply should be ensured. Some arrange-ment has to be made in the form of standby generator or if possible uninterrupted power supply (UPS) units.

(e) **Time scheduling of the hospital***:* Hospital timing should be scheduled in such a way that there is optimum utilization of the costly equipment. Usually in government hospitals, the facilities work only for 8 hours or one shift which amounts to 33 percent of utilization. If these facilities are made available for two shifts, high cost equipment may be utilized for 50-60 percent of their capacity.

(f) **Use coefficient:** Use coefficient is applied to assess the utilization of equipment, i.e., whether the equipment is optimally utilized or underutilized. Use coefficient of equipment may be measured by the following formula:

$$\text{Use Coefficient} = \frac{N}{M} \times 100$$

Where N = Average number of hours the equipment is used per day

M = Maximum number of hours the equipment can be used per day

99. If the is use coefficient is less than 50 percent, it is considered to be under utilized and hence a bad investment. However, life-saving equipment cannot be subjected to this kind of assessment.

(a) Awareness of the facilities: It is essential that the existing and prospective clientele is aware of the medical facilities available in a healthcare institution. To ensure optimum utilization, a marketing strategy should be evolved where services can be made known to the community to gain maximum benefit of the capital invested.

(b) Networking of special facility or skill*:* Facilities like, MRI, CT scan, ultra sonography, digital X-ray, etc., if underutilized due to paucity of workload, should be shared with other hospitals. Networking of resources would ensure optimum utilization of the costly equipment.

(c) Upgradeability: Most of the modern equipments function on microprocessor technology. It is imperative to buy the latest model. On introduction of a new model, if feasible, it should be upgraded rather than discarded. Equipment based on modular technology should be upgraded by addition of modules.

Measuring 'Maintenance Effectiveness'

100. The effectiveness of maintenance can be evaluated in terms of the maintenance cost incurred and equipment downtime.Several indices used for measuring maintenance effectiveness are computed based on information relating to cost of maintenance, available machine hours and down time, number of breakdowns, labour hours spent on both breakdown and preventive maintenance. These indices are given below:

Table 2.1: Indices for Measuring Maintenance Effectiveness

sr no	Indices	Formula
1.	Downtime index	Downtime time per week x 100 / available

		machine hours per week
2.	Breakdown maintenance index	Labour hours spent of breakdown maintenance x 100 / labour hours spent on all forms of maintenance
3.	Maintenance cost index	[(annual maintenance cost) x 100] / cost of production
4.	Frequency of breakdowns	Number of breakdown per week / available machine hours per week
5.	Available machine hours	Weekly working days x hours per day x number of machines
6.	Equipment availability	Operating time / operating time + maintenance time

Utilization Indices (to be calculated annually)

101. Use coefficient represents good utilization. Equipment with use co-efficient of less than 50 percent is regarded as bad investment. While it is mandatory to establish the need for a second piece of same equipment, U.C. may not be of much significance in the case of life-saving equipment.

102. Down time indices: Downtime is the period of time during which equipment is not in a condition to perform the intended functions. It is a summation of problem realization time by technician, diagnosis time by service engineer, spare procurement time by service agent, logistic time by service agent, and alignment time of spare parts in any equipment. The term downtime is used to refer to periods when a system is unavailable. Downtime or outage duration refers to a period of time that a system fails to provide or perform its primary function. Reliability, availability, recovery, and unavailability are related concepts. The unavailability is the proportion of a time span that a system is unavailable or offline. This is usually a result of the system failing to function because of an unplanned event, or because of routine maintenance.

103. The term is commonly applied to networks and servers. The common reasons for unplanned outages are system failures (such as a crash) or communications failures (commonly known as network outage).

104. **Unplanned downtime** may be the result of a software bug, human error, equipment failure, malfunction, high bit error rate, power failure, overload due to exceeding the channel capacity, a cascading failure, etc.

105. Downtime can be caused by failure in hardware (physical equipment), software (logic controlling equipment), interconnecting equipment (such as cables, facilities, routers,...), wireless transmission (wireless, microwave, satellite), and/or capacity (system limits).

106. The failures can occur because of damage, failure, design, procedural (improper use by humans), engineering (how to use and deployment), overload (traffic or system resources stressed beyond designed limits), environment (support systems like power and HVAC), scheduled downtime (outages designed into the system for a purpose such as software upgrades and equipment growth), other (none of the above but known), or unknown.

107. The failures can be the responsibility of customer/service provider, vender/supplier, utility, government, contractor, end customer, public individual, act of nature, other (none of the above but known), or unknown.

108. **Mean down time (MDT)** is the average time that a system is non-operational. This includes all time associated with repair, corrective and preventive maintenance, self imposed downtime, and any logistics or administrative delays. The inclusion of delay times distinguishes mean down time from mean time to repair (MTTR), which includes only downtime specifically attributable to repairs.

109. Mean Down Time key factors:-

(a) **System Failure**

(b) **Identification & Recovery Tim :.** First, the fact that the system is down must be identified, and maintainers notified & brought to action

(i) **Fault detection and isolation** ***:*** The problem must be identified and the faulty part identified.

(ii) **Parts Procurement** ***:*** Replacement parts needed (if any) must be obtained

(iii) **System Repair** ***:*** Faulty parts must be replaced or repaired.

110. Schedule Downtime.

(a) Preventive Maintenance. Preventive maintenance checks are often intrusive and require the system to be down (unless prognostics are used), e.g., checking oil in a car engine.

(b) System Upgrade ***:*** System downtime is usually required to bring new features to the system.

(c) Calibration ***:*** Many forms of mechanical or electronic equipment require periodic intrusive calibration.

(d) Other Administrative Actions

111. There are three main ways of reducing MDT:-

(a) Make the system repairable *:* If an item is repairable, it will be used for a longer time, and the user will become more familiar with its operation. This will decrease the MDT because the user will be able to detect abnormal operation sooner, and the system will be repaired before the problem becomes too serious.

(b) Let the user repair the system *:* By designing a system to be user-repairable, the MDT will be considerably decreased, as it will not have to be taken out of service for long periods of time while it is being repaired by the manufacturer (which of course includes time spent in transit to and from the manufacturer).

(c) Provide the user with a repair support system *:* The closer critical spare parts are to the system, the faster it will be able to be repaired, as this eliminates the delay involved in ordering parts from the manufacturer and waiting to receive

them. Also, the clarity of any instructions on how to repair an item will greatly contribute to the speed at which it is repaired.

112. Efficient equipment utilization should be ensured to optimize healthcare facilities. A substantial number of equipment in Indian healthcare institutions are of foreign origin. It is imperative that appropriate steps are taken in the planning, procurement, installation, and usage stages of these equipment to maximize utilization and optimize healthcare facilities.

113. Break Down Maintenance (BDM) is "Unplanned" corrective maintenance performed on equipment after the equipment has suffered a failure and has to be corrected during a break down of the equipment. Break down maintenance indicates a lack of planning.

Maintenance cost index

114. The Maintenance Cost Index (MCI) is cost of maintenance divided by the asset value.

115. Availability of equipment is the probability that a system or component is performing its required function at a given point in time, or over a stated period of time when operated and maintained in a prescribed manner. In other words, the proportion of total time that an item of equipment is capable of performing its specified functions. The general observation of availability is:

$$\text{Availability} = \frac{\text{Scheduled Uptime}}{\text{Scheduled Uptime} + \text{Non-scheduled Downtime}}$$

By taking different measures for uptime and downtime, different availability measures are obtained.

116. Available Hours

The total number of hours that a piece of equipment is capable of performing its specified functions. It is equal to the total hours in any given period minus all the downtime hours.

117. Frequency of breakdowns of mean time of failure reflects on the equipment condition. Increase in the frequency of break will help the management identify the

causes of the failures and take remedial measures to reduce the frequency of such failure. This is termed as design-out maintenance. This analysis, year to year basis, will indicate the effectiveness of design out maintenance action.

118. **Mean time to repair (MTTR)** is a basic measure of the maintainability of repairable items. It represents the average time required to repair a failed component or device. Expressed mathematically, it is the total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time. It generally does not include lead time for parts not readily available, or other Administrative or Logistic Downtime (ALDT). In fault-tolerant design MTTR is usually considered to also include the time the fault is latent (the time from when the failure occurs until it is detected). If a latent fault goes undetected until an independent failure occurs, the system may not be able to recover. MTTR is often part of a maintenance contract, where a system whose MTTR is 24 hours is generally more valuable than for one of 7 days if mean time between failures is equal, because its Operational Availability is higher. However, in the context of a maintenance contract, it would be important to distinguish whether MTTR is meant to be a measure of the mean time between the point at which the failure is first discovered until the point at which the equipment returns to operation (usually termed "mean time to recovery"), or only a measure of the elapsed time between the point where repairs actually begin until the point at which the equipment returns to operation (usually termed "mean time to repair"). For example, a system with a service contract guaranteeing a mean time to REPAIR of 24 hours, but with additional part lead times, administrative delays, and technician transportation delays adding up to a mean of 6 days, would not be any more attractive than another system with a service contract guaranteeing a mean time to RECOVERY of 7 days.

119. **Mean time between failures (MTBF)** is the predicted elapsed time between inherent failures of a system during operation.MTBF can be calculated as the arithmetic mean (average) time between failures of a system. The MTBF is typically part of a model that assumes the failed system is immediately repaired (MTTR), as a part of a renewal process. This is in contrast to the mean time to failure (MTTF), which measures average time to failures with the modeling assumption that the failed system is not repaired (infinite repair rate).

120. The definition of MTBF depends on the definition of what is considered a system failure. For complex, repairable systems, failures are considered to be those out of design conditions which place the system out of service and into a state for repair. Failures which occur that can be left or maintained in an unrepaired condition, and do not place the system out of service, are not considered failures under this definition. In addition, units that are taken down for routine scheduled maintenance or inventory control, are not considered within the definition of failure.

121. **Mean time to recovery (MTTR)** is the average time that a device will take to recover from any failure. Examples of such devices range from self-resetting fuses (where the MTTR would be very short, probably seconds), up to whole systems which have to be repaired or replaced.

122. The MTTR would usually be part of a maintenance contract, where the user would pay more for a system whose MTTR was 24 hours, than for one of, say, 7 days. This does not mean the supplier is guaranteeing to have the system up and running again within 24 hours (or 7 days) of being notified of the failure. It does mean the average repair time will tend towards 24 hours (or 7 days). A more useful maintenance contract measure is the maximum time to recovery which can be easily measured and the supplier held accountable.

123. Note that some suppliers will interpret MTTR to mean 'mean time to respond', and others will take it to mean 'mean time to replace/repair/recover/resolve'. The former indicates that the supplier will acknowledge a problem and initiate mitigation within a certain timeframe. Some systems may have an MTTR of zero, which means that they have redundant components which can take over the instant the primary one fails, see RAID for example. That said however, the failed device involved in this redundant configuration still needs to be returned to service and hence the device itself has a non-zero MTTR even if the system as a whole (through redundancy) has an MTTR of zero. But, as long as service is maintained, this is a minor issue.

124. **Reasons for Poor Equipment Performance**

(a) **Technology related Inherent complexity of medical devices**

(b) Lack of equipment standardization

(c) Equipment obsolescence

125. **Hospital-characteristics related Geographical location and size**

(a) Type of ownership

126. **Policy and context related Absence of public and private sector policies**

(a) Poor equipment conservation culture

(b) Weak infrastructure and organization

(c) Lack of trained maintenance staff

(d) Lack of trained equipment operators

(e) Weak technical support system

(f) Inadequate finances for equipment management

(g) Poor logistics support (transport, information)

(h) Poor donor practices

127. **Management-process related Poor equipment acquisition procedures**

(a) oor maintenance and repair procedures

(b) Poor equipment replacement procedures

(c) Poor management of human resources development

(d) Poor equipment performance evaluation procedures

(e) Poor management of foreign aid

Condemnation

128. The extent of equipment malfunction and down-time increases with the age of the equipment. Consequently the cost-effectiveness decreases with age. A technical report for the United Kingdom's health service suggests that the mean life of equipment is between

6and 10 years. Furthermore, one needs to consider the issue of equipment obsoletion due to technological and medical advances in this sector.[19]

129. With respect to the availability of replacement parts and consumables it is common practice that equipment manufacturers supply parts for out-dated equipment for up to five years after a particular model has been taken out of production.

130. The Medical Devices Agency states that equipment may have to be replaced for one or more of the following reasons, namely when it is:

(a) Worn out beyond economic repair
(b) Damaged beyond economic repair
(c) Unreliable
(d) Clinically or technically obsolete
(e) Spare parts no longer available
(f) More cost-effective equipment or clinical service is available

131. In order to avoid excessive downtime due to equipment absolution, it is imperative to replace medical equipment at predetermined intervals. The absence of a replacement policy invariably leads to unreliability and unpredictable performance of equipment. Periodic equipment acquisition should not only be concerned with adding new items to the current stock, but also apply to routine replacement of existing assets. The key issue is one of planned renewal of obsolete stock according to sound management principles, such as the anticipated lifetime of equipment and its current cost-effectiveness, rather than ad-hoc replacement of defective items. Cancellation and subsequent disposal of equipment which is no longer cost-effective, constitutes the final stage of a cyclical and continuous management process.

Replacement Decisions

132. Decisions to replace equipment are usually subject to the following conditions:-

(a) System does not have the capacity to meet the demand of performance or level of service expected of it.

(b) Obsolescence: a new product with better service, better performance and improved care becomes available.

(c) The system has high failure rates.

(d) System requires excessive repairs/maintenance.

Condemnations and disposal

133. Over a period of time certain equipment either become obsolete or viable economic repair or tends to occupy space in respective departments. This equipment need to be condemned and disposed off at regular intervals.

It has also been seen that the condemnations procedures are not being undertaken on a regular and periodical basis for the following reasons.

(a) Lack of adequate records

(b) The unwillingness and reluctance on the part of senior hospital authorities to take decisions for condemnations and disposal of equipment.

(c) In view of above – It essential that proper procedure should be laid down.

134. Minimum Criteria of Condemnations

(a) The equipment has become

(b) Non-functional and beyond economical repair.

(c) Non-functional and obsolete.

(d) Functional but obsolete.

(e) Functional but hazardous.

(f) Functional but no longer required.

135. Procedure for condemnations

(a) Purchase and maintenance records of all costly and sophisticated equipment should be maintained in the form of logbook.

(b) Identification data i.e. make model, date of purchase.

(c) Details of sources and reputations of suppliers.

(d) Availability of spares.

(e) Purchase cost.

(f) Details of Break down

(g) Repairs undertaken/expenditure.

(h) Custom clearance.

(j) Details of procurement / procedures.

Disposal

136. Any of the following procedure can be adopted for disposal of equipment after condemnations.

(a) ircular within Hospital ward, OPD

(b) Return to vendor

© Sell to other hospital

(d) Sell to scrap dealers

(e) Local Destruction

(f) Auction

Benchmarking of Equipment Utilization & Cost Effectiveness

137. Benchmarking focuses on certain processes and evaluates their relative performance and is a useful technique to highlight areas of strength and weakness in an organisation. For benchmarking following has to implement

(a) Review KPI's (Key Performance indicators)

(b) Identify and Label Assets and Sub-Assets

(c) Carry out Criticality Review

(d) Produce Generic Maintenance Check-off Lists

(e) Estimate Manpower Resource Requirements

(f) Improve Technical Library

(g) Provide CMMS / ERP (Computerized Maintenance Management System / Enterprise Resource Planning)

138. Cost-Effectiveness is a method for identifying interventions that achieve the greatest level of health impact per unit of expenditure. Effectiveness is typically measured in terms of improvements in health status. An important aspect of cost-effectiveness analysis is that it can be used to assess technical and allocative efficiency. The level of required maintenance depends on the operating environment, but the international average of maintenance costs ranges between 10-15 percent of the annual recurrent costs to uphold the hospital operation effectively .

139. To achieve cost effective maintenance, it is first necessary to implement a maintenance program using a staged process containing key detail steps. The process should ensure that all key steps are followed. Without clear definition of requirements, achievements and feedback, measurement is not possible. Measurement of effectiveness

through monitoring key performance indicators is only possible if each stage has been completed. Without measurement, management and optimization is not possible.

140. Many factors are thought to be responsible for the ineffectiveness of health care provision in developing countries all over the world. One consequence of the international recession, which started in the 1980s, has been that many countries throughout the world have had to reduce the rate of growth in government expenditure for social services, including health and education. Cutbacks in health sector expenditure have contributed heavily, among many other things, to low expenditure on medical equipment.

141. The international medical equipment industry is extremely diverse. The spectrum of available devices ranges from the most elementary mechanical apparatus, such as the hand operated table-top centrifuge, to the most sophisticated diagnostic and therapeutic equipment, such as computer tomography. It is estimated that the range of medical devices incorporates approximately 6,000 generic entities and an estimated 750,000 or more brands and models, ranging from simple articles to very complex systems. These devices are produced by an estimated 12,000 manufacturer's world-wide . World trade in medical equipment is dominated by three countries; Germany, the USA and Japan, who combined account for over half of total exports of both medical instruments and electro-medical equipment.

142. It is further estimated that currently developing countries account for approximately $5 billion, or 7 percent, of the $71 billion spent annually on medical equipment world-wide. Although precise figures are generally not available, a significant proportion of funding for medical equipment is provided by international donor organisations. The global estimate on medical equipment purchases includes medical and dental supplies, surgical instruments, electro-medical and X-ray equipment, diagnostic tools and implanted products. The huge discrepancy between the 'North' and the 'South', with regard to the availability of resources, will be obvious when one considers that low- and middle-income-economies represent some 85 percent of the world population. Considering the low per capita purchasing capacity for medical equipment in developing countries, it is crucial that existing resources are used effectively.

Systems Approach

143. Hospital has been considered as a system in which a breakdown in one functional area is bound to have a chain reaction affecting the other functional areas, because each functional area is a hospital is a subsystem whose malfunction or defect, reflects adversely on the total hospital system .Lack of system approach leads to poor hospital equipment maintenance and management. A complete equipment system includes organizational tool, staff, policies and procedures that will ensure that the equipment is adequate and serviceable. Traditionally the responsibility of inventory, distribution and maintenance of medical equipment is spread over a number of departments, each having many other functions. A complete equipment system should cover all the aspects, such as inventory, storage, installation, distribution, utilization, maintenance program spares and accessories, safety hazard training, product evaluation, standardization and cost effectiveness with a comprehensive approach. Such a system is responsible to a number of functional and organizational arrangements regardless of where the work is done or to whom the function is delegated because all policies, authorities and responsibilities are enumerated from the central control.[20]

144. A systems approach to maintenance involves setting up of objectives, planning, executing and controlling maintenance functions, not as an isolated function but as a part of corporate policies and strategies aimed at achieving well-defined overall goals of the organisation. This approach takes into account all relevant interacting functions, factors and facts both internal and external to the system.

Using Operations Research in Maintenance

145. Operations Research (OR) techniques based on mathematical models have been tried in USA and other countries for problem resolution in maintenance management. These techniques of executive's decision making involve identifying problem, derive alternative solutions, evaluate each alternative on a module, select best module, test and practice. OR techniques are used in preventive maintenance, preventive inspection, machine inference, machine maintenance, machine replacement and machine scheduling. Maintenance models in the overall management in industrial sector have proved their utility in economic resource utilization. OR models in preventive maintenance have proved that, part replacement at predetermined period is much more economical than the losses suffered during the breakdown maintenance.[21,22]

Automation and Computerization in Maintenance Management

146. Application of computers in inventory, distribution of equipment, recording history, repairs, and change of components and overall maintenance of equipment has opened a new era in planned preventive maintenance. Computer assisted preventive maintenance systems have been used in monthly scheduling of equipment and in risk management which provides ability for maintenance and safety of documentations.[23]

147. Principle of Maintenance Management

(a) **Objectives and Standards :** To extend useful life of assets; to assure optimum availability of plant and equipment for production; to assure operational readiness of all equipment for emergency use at all times; to provide safety of patients and personnel using and operating the facility.[2]

(b) **Economy and adequacy of resources :**(Time, staffing, equipment and materials)

(c) **Master maintenance plan:** To provide approach to the work of the department; a sound method of ascertaining validity of budgetary requests; a communication link between staff at different levels in the organisation; a co-operative, co-ordinated efforts of entire staff. Master Maintenance Plan should include the following:-

(i) Recruitment of skilled manpower preferably under the aegis of the manufacturer.

(ii) Arranging regular training program on maintenance and repair of equipment of the technicians and other concerned personnel.

(iii) Establishing a reserve / bank of spare parts and / or crucial components.

(iv) Establishing detailed records of the purchase procurement and maintenance of the equipment

(v) Periodic checks and repairs

(vi) Monitoring of annual maintenance contract for expensive and sophisticated equipment.

(vii) Developing a maintenance cell for administration & processing of activities related to maintenance and repair.

(viii) Establishing a nucleus of communication between this cell and supplier.

(ix) Follow up of the maintenance and repair services.

(d) <u>Operating expenses</u>: "If you can't maintain, don't built it".

(e) <u>Design and construction:</u> it should be durable, easy to maintain, easy to repair and replace..

(f) <u>Maintenance staff</u>: Hiring high quality technicians for sophisticated equipment; a good orientation program; adequate initial and in-service training for staff; good supervision and good communication.

(g) Planned Preventive Maintenance & Safety

<u>MAINTENANCE</u>

148. <u>Levels of maintenance.</u>

(a) **<u>1st level</u>**: by operator (day-to-day maintenance)

(b) **<u>2nd level</u>**: by in-house staff

(c) **<u>3rd level</u>**: by manufacturer, biomedical enginering, workshop

149. <u>Types of maintenance.</u>

(a) Preventive Maintenance

(b) Corrective Maintenance

150. <u>The planned maintenance can further be subdivided into:-</u>

(a) Preventive maintenance (PM)

(b) Scheduled maintenance (SM)

(c) Corrective maintenance (CM)

(d) Condition-based maintenance (CBM)

(e) Reliability-centred maintenance (RCM)

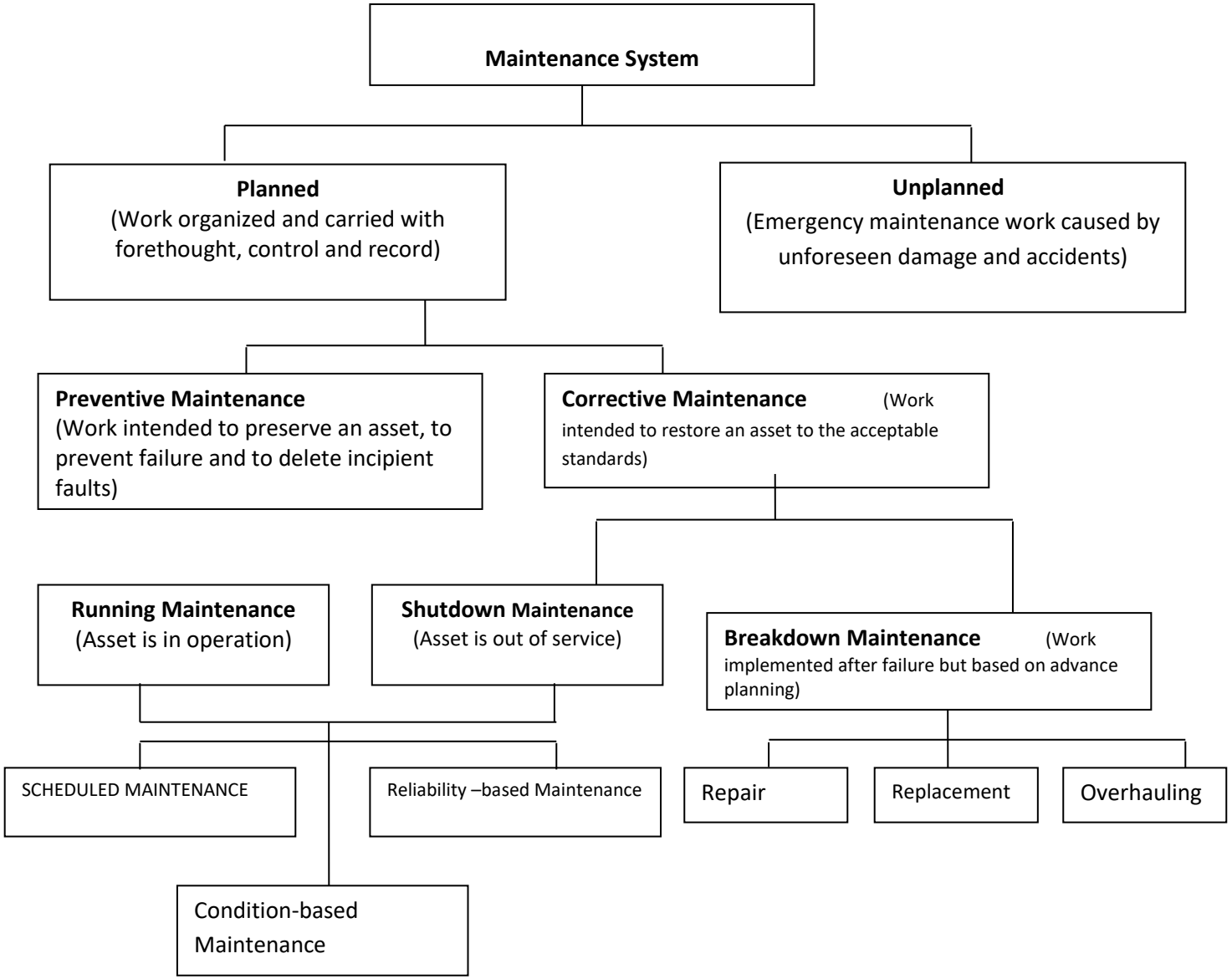


Figure 2.1: Different type of Maintenance system

Preventive Maintenance

151. Preventive maintenance is the utilisation of planned and coordinated inspections, adjustments, repairs and replacements in maintaining an equipment or plant. One of the main objectives of the preventive maintenance is to detect any condition that may cause machine failure before such breakdown occurs. This makes it possible to plan, and schedule the maintenance work without interruption in production schedule and thus improves the availability of equipment. Under this type of maintenance, a systematic and extensive inspection of each item of equipment (or the critical parts) is made at predetermined intervals.[25]Maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure of functioning of an item .It is done by systematic inspection, detection and correction of incipient failures before they develop into major defects. It also includes all actions taken at equipment inception/ design stages to reduce maintenance requirements.

152. The preventive maintenance is further divided into the following main activities:-

(a) Routine attention

(b) Routine examination

(c) Preventive replacement

(d) Inspection measurements

153. **Types of Preventive maintenance.**

(a) Scheduled Maintenance

(b) Predictive Maintenance

Scheduled Maintenance

154. In this type of maintenance work, the actual maintenance programme is scheduled in consultation with the production department, so that the relevant equipment is made available for maintenance work. The frequency of such maintenance work is pre-determined from experience so as to utilise the idle time of the equipment effectively. In this way, the where and when of the

maintenance work can be, approximated and most efficient use of the idle time can be made. This also helps the maintenance department to use their manpower effectively. If the schedule of maintenance is known in advance, the specialists for the same can also be made available during the maintenance period. Though scheduled maintenance is costly compared to breakdown maintenance, the availability of equipment is enhanced.

155. **Predictive Maintenance.**

(a) The type of monitoring or inspections is called 'Predictive Maintenance.

(b) In mechanical components, the frictional wear begins almost immediately after the component is put to use.

(c) Wear, corrosion, erosion and other forms of removal of material from the component, slowly reduce the available material and hence its strength. This decay causes component failure at some stage.

(d) Knowing the past wear-out behaviour of these components, it is possible to reasonably predict their failure.

(e) For inexpensive parts which are external, easily accessible and can be quickly replaced, change of parts even before actual failure occurs is advisable.

(f) For critical parts, continuous monitoring is required.

(g) On imminent failure, repairs can be undertaken in a planned manner to pre-empt total breakdown.[26]

156. **Indicators for Predictive Maintenance.**

(a) Unusual vibrations, noises, lack of smooth operation.

(b) Signs of excessive friction/overheating drop in equipment performance.

(c) Disturbed settings, viz loss of adjustment or alignment

(d) Visible deterioration like perished wiring, rust, corrosion etc.

157. **Safeguards for Preventive Maintenance.**

(a) Voltage stabilizers

(b) Area wise voltage stabilisation through UPS esp. in critical areas

(c) Separate lines where voltage fluctuation is considerable

158. **Advantages of Preventive Maintenance.**

(a) Reduction in down time of equipment

(b) Safety of equipment

(c) Effective and economic functioning

(d) Increased life of equipment

159. **Corrective Maintenance..** Corrective maintenance or breakdown maintenance is the remedial action performed after equipment failure to restore a system or an item to operational or serviceable condition:

(a) In-house maintenance

(b) Biomedical engineering

(c) Annual maintenance contract

Breakdown Maintenance and its Limitations

160. The basic concept of this type of maintenance is not to do anything as long as everything is going on well. Hence no work is done until a component or equipment fails or becomes inoperative. In other words, the work is called upon to be done in the case of an emergency failure, when necessary repairs are carried out to bring back the equipment to its original working condition. From the time machines came into existence, this type of maintenance is still in practice and being followed in many organisations. The equipment is allowed to run till it stops working and no efforts are made in advance to prevent the failure of parts. Therefore, breakdown maintenance occurs suddenly and all the repair and maintenance work pertaining to it

is only done when the equipment stops working. If this system is alone followed, it will lead to poor operational availability of the equipment as spare parts may not be readily available. Even though it may appear to be an economical proposition, work would greatly suffer if the machine is not restored to operational condition immediately. In this type of maintenance, during the repair time, no proper care is taken to know the real cause of the breakdown, which in turn may lead to frequent failures of the same kind with high-cost production systems being put in use, the limitations of the breakdown maintenance were realised and consequently other types of maintenance work were introduced. The most important of all was the planned preventive maintenance at that time. Now even much better maintenance functions such as condition monitoring are also available.[27]

Planned Maintenance

161. The planned maintenance is an organised type of maintenance which takes care of other aspects such as control and records required for this type of work under this type of maintenance, the work is planned before hand to avoid random failures. It decides not only the when and what of maintenance work, but also by whom it would be undertaken. To meet the requirements of the planned maintenance, first of all work-study has to be carried out to decide the periodicity of maintenance work. Time-study can also suggest ways and means of devising optimal maintenance schedules for the given system. Some factors that must be taken care of are as follows:-

(a) **Utilisation of equipment/service:** Here emphasis has to be on optimal utilisation of a machine/facility. Under utilisation or over utilisation is avoided.

(b) **Working conditions:** Due account is taken of the environmental factors such as humidity, temperature, and corrosiveness which may adversely affect the performance of the machine/facility.

(c) There may be some special factors that may affect the performance of the equipment, for example, pumping of sandy water. In centrifugal pumps, if sandy water has to be pumped, the material of the impeller should be given special consideration to obviate maintenance on account of recurrent breakdowns of an unsuitable material.

162. **Planned maintenance, therefore, involves the following types of jobs that are equipment specific:-**

(a) **Corrective Maintenance.** The use of planned preventive maintenance brings out the nature of repetitive failures of a certain part of the equipment. When such repetitive type of failures is observed, corrective maintenance can be applied so that re-occurrence of such failures can be avoided. These types of failures can be reported to the manufacturer to suggest modifications to the equipment. Corrective maintenance can be defined as the maintenance carried out to restore equipment that has stopped working to acceptable standards. For example, an engine may be in working condition, but does not take its full load because of worn-out piston rings. Thus if the piston rings are replaced, it will bring back the performance of the engine to the specified level. The corrective maintenance, if properly carried out, will eventually bring down the maintenance costs and there will also be a reduction in downtime of the equipment.[28]

(b) **Condition-based Maintenance.** This kind of maintenance is carried out in response to a significant deterioration in a unit or system as indicated by a change in a monitored parameter of the equipment or system based on its condition or performance. A condition-based maintenance policy is most suited for high capital cost equipment and complex replaceable

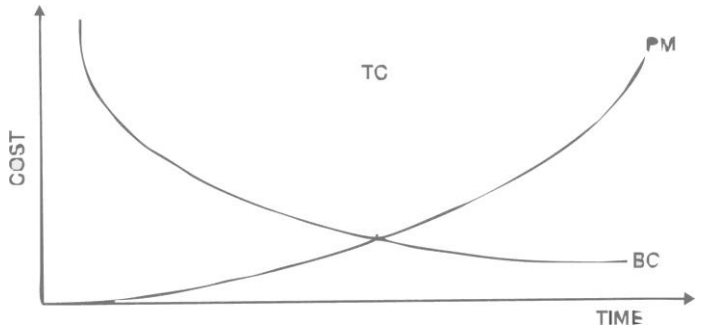


Figure2. 2: Balance of costs for maintenance. PM: planned maintenance cost, B C: breakdown maintenance cost, T C: total cost

(c) **Reliability-centred Maintenance(RCM)**. It is used to identify the maintenance requirements of equipment. The RCM establishes the functional requirements and the

desired performance standards of equipment and these are then related to design and inherent reliability parameters of the machine.

Benefits of Maintenance

163. The high involvement of capital cost in any production system calls for proportional returns from the equipment. This is only possible when the equipment keeps delivering its normal performance. It is often noticed that the maintenance schedules provided by the manufacturer do not yield the required results in terms of the production output and the life of the equipment. Thus it becomes necessary to properly maintain the equipment with extra caution and care in order to achieve the desired levels of production or service. The following benefits can be derived from a well-organized maintenance system:-

(a) The minimization of downtime

(b) Improvement in total availability of the system

(c) Extended useful life of the equipment

(d) Safety of the personnel.

164. The consequences of downtime can be very serious when the machine is working in a production line as its failure will shut down the total system. Following a proper maintenance schedule with adequate back-up supply of required spare parts can drastically reduce the downtime and thus improve the equipment availability. The normal wear and tear of equipment can also be reduced by proper maintenance. In certain cases, the safety of the personnel is of prime importance and this also can be assured by proper planned preventive maintenance.[29, 30]

Repair Protocols

165. The repair procedures must underline the following:-

(a) Repairing and servicing of sophisticated equipment only under the guidance of a skilled person.

(b) Develop the procedures for requisitioning repair services as and when a particular equipment breaks-down or stops working.

(c) If in-house facilities cannot repair particular equipment, then the procedure for its repair from outside agencies should also be developed.

(d) The downtime of each equipment should be specified and adhered to by the maintenance cell.

(e) The technical personnel involved should be trained either by the established institutions or by the Company supplying that equipment.

166. In order to provide efficient maintenance services in hospitals a routine plan and guidelines should be developed. This plan should focus attention on the various elements related to procurement and maintenance of hospital equipment in order to optimize and get the best out of the limited amount of money and other scare resources.

Repair Facility and Workshops

167. To organize an effective repair facility and workshop for the maintenance of biomedical equipment in Indian hospitals, knowledge of the nature, frequency and extent of repair and servicing normally required is a prerequisite. Unfortunately, limited information is available upon which one could plan the workshop repair facilities and the organizational set up. In developed countries, however, the majority (above 60%) of the repairs required is minor in nature and can be taken care of by routine preventive maintenance. It is essential to first create a detailed database for biomedical equipment, which will provide the necessary information to grade and quantify the repair and maintenance work so that workshop repair and maintenance work so that the workshop can be set up. In case of non-availability of the maintenance infrastructure for a new purchase that may be essential, necessary planning could be done either by incorporating a training clause in the purchase deal or by making another suitable arrangement at the time of purchase. Maintenance and transporting the equipment to a distant place for repair must be minimized as much as possible. Only in unavoidable circumstances

should the equipment be transported to any other place for repair .The upkeep of biomedical equipment from the management view can be broadly divided into two categories:-

(a) Regular preventive maintenance

(b) Occasional repairs.

168. The first is a routine affair and has to be attended to at regular intervals. The second, on the other hand, is an occasional requirement and needs to be attended to as required. A large percentage of the equipment breakdown, however, can be avoided by routine preventive maintenance alone. Experience in developed countries has shown that lack of preventive maintenance accounts for about 70% of equipment breakdown and failure. The preventive maintenance of biomedical equipment is an important and regular activity in hospitals. Medical personnel in India must insist on a management mechanism that ensured accurate and hazard less functioning of medical equipment just as they do for an aseptic operation theatre.

Problem Areas in Maintenance

169. The problem of proper equipment maintenance and management is highly complex. The complexity of problem arises from several factors. Modern medical devices are often dedicated ones. A modern hospital has many diverse specialties such as cardiology, neurology, neurosurgery, radiology, orthopaedics etc. And each one of them requires different and specialized equipment in India is imported. The equipment imported from different countries has varied designs and standards and this creates a difficult situation for equipment maintenance and repair. The difficulties arise because of several factors that exist in India. First, there is an acute shortage of technical hands both at the advanced and technician levels, which have suitable and adequate training in the maintenance and repair of this specialized 'high tech' equipment. Second, the local dealers in India by and large do not provide worth-while scale service or repair. At times even the service manuals and related literature are not supplied by the manufacturer. Third, there is an acute shortage (and sometimes non availability) of spare parts and components because the models of the equipment undergo frequent changes.

A large part to the medical equipment remains under-utilized due to lack of planning adequate repairs and maintenance, spare parts, poor after sales service by supplier/manufacturer, lack of trained personnel etc.[31]

170. The optimal use of equipment and its life can be improved by adopting a preventive maintenance schedule. Operation, Repair and Maintenance shall include:-

(a) The technicians using equipment should be familiar with its mechanics, circuit diagrams, and dangers if any.

(b) Manufacturer recommendations in using equipment should be strictly adhered to.

(c) The technician should be familiar with danger signals and usage of equipment should be stopped whenever it creates problem.

(d) The voltage consideration, water supply (if required) dust free atmosphere, air-conditioning (if required) etc., should be available as specified.

(e) The equipment should be on Annual Maintenance Contract preferably with the suppliers and in case of any break down, urgent action should be taken.

(f) The minor repairs of equipment should be taken up by the hospital workshop and records maintained.

(g) With Hi tech equipment, there is need to promote the organization of repair and maintenance under biomedical engineers.[32]

171. For equipment to be maintained properly the equipment data, equipment history card with details of repair and overhauls, instruction manners, inspection reports, periodic control report and codification of faults have to be maintained.[33]Following are the common problems seen in many hospitals :-

(a) Lack of expertise to maintain and use equipment.

(b) Mishandling leading to reduce life time of the equipment.

(c) Lack of essential spares or overstocking of accessories.

(d) Lack of preventive maintenance and inexperience in repair resulting in excessive down time of the equipment

(e) Lack of specific policies and infrastructure for maintenance of medical equipment.

172. Following actions may be taken to ensure proper maintenance of equipment:-

(a) Maintenance of equipment records, documentation of history and performance of equipment is very important.

(b) Any costly equipment should have two types of documents maintained:-

(i) **History Sheet**. Containing date of the model, purchase date etc., supplier's details, breakdown and downtime details, types of repairs and their costs.

(ii) **Logbook of maintenance and repairs.** This contains the following information:-

(aa) Warranty period and repairs carried out during that period.

(ab) Annual service contract after the warranty period

(ac) Expenditure incurred on annual service contract.

(ad) Details of preventive maintenance.[34]

173. Clearly, an inability to keep apparatus in running order will contribute significantly towards a decline in the usable stock of equipment, and will be very costly in terms of both lowered effectiveness of health services and increased pressure to make new purchases. It is without adequate funds. A typical maintenance control system has eight phases ; routine maintenance, non- routine maintenance, advance planning, daily scheduling daily activities, recording maintenance data, management reporting and accumulating personnel statistics.[35]

Factors Affecting Maintenance

174. To develop the data necessary for measuring and appraising maintenance performance, the following factors should be considered:-

(a) Examine the maintenance workload. How detailed this is to be must be decided by each manager.

(b) Establish a work order system for dispatching the work which is planned for a certain period.

(c) Re-evaluate planning techniques to determine whether the men will be perform the work as planned.

(d) Determine whether a record keeping is necessary to ascertain whether realistic and economic maintenance practices are being followed.

(e) Find the vehicle, the control system, which will provide the necessary feedback of performance data.

175. Develop reports will help in :-

(a) Maintaining production

(b) Controlling operations.

(c) Planning manpower requirements.

(d) Correcting or modifying work assignment.

(e) Evaluating personnel performance.

176. There is no point in buying a piece of equipment cheaply if, after few months, it breakdown through lack of maintenance and lies idle indefinitely because there is no one to repair it. It is wiser to pay a little more in the first place, if that is necessary, for equipment which can be maintained and kept running. It should not be regarded as bad practice or extravagant to accept a higher initial price if by doing so the risk of premature breakdown can be lessened, in fact, it is safe to assume that the price of good service may be higher initial cost.

The opportunity should be taken to ascertain how much equipment the firm has supplied; it is not unknown for a firm seeking business to claim that it had 'equipped' a particular hospital whereas, in fact, it had only supplied a very few items .[36]

177. In maintenance activities, time is important. Completion dates may be predetermined. The time when equipment has to go back on stream, the amount of money being lost by down time, the time when the next shift starts any of these might determine a completion date. Therefore, careful analysis of all the factors by charting and graphing operations will show where to place the emphasis, where to work the overtime, where to increase the crew size. If the sequence of jobs can be accurately planned then the completion time can be accurately predicted. A technical report for the health service in United Kingdom suggested that the cost maintenance is 6-10% of the capital value per year and that the average life of equipment is between 6-10 years. It means that, total annual cost of keeping equipment is running order would be 16-25% of the capital value including depreciation cost.[37]

178. An estimate for India indicates that yearly maintenance costs are 10-15% of the capital value per year. Thus at a conservative estimate, the cost of providing an equipment service is not less than 15%, of the capital value of the stock . With regard to rationalization of tendering, after-sales maintenance and training, the following conditions have to be fulfilled by persons wishing to submit tenders:-

(a) The supplier must have a local representative who can provide sales service.

(b) The local representative must have demonstrable capacity to service and maintain the equipment.

(c) The manufacturer must give a two year guarantee against faulty manufacture.

(d) The manufacturer or his local representative must install the equipment free of charge and commission.

(e) The manufacturer must maintain the equipment, free of charge, for six months to one year during which he must train the user's technicians in the maintenance of the equipment.

(f) The manufacturer must guarantee the availability of spare parts for each items of equipment during its projected life which may be up to ten years.

(g) Within the guarantee period, any equipment found to have a fault, that cannot be permanently rectified, is replaced at the manufacturer cost. Alternatively, the customer may opt for full.

(h) For each items of equipment, the user must be supplied with full technical information and with maintenance and repair manuals.[38]

Prioritization of Maintenance

179. Classification of equipment is important, in order to allot priorities and resources for maintenance. Equipment can be classified to suit functional, technological, and operational or storage requirements as under:-

(a) **Functional value**: Each item is given a number within its class and subclass on the basis of its functional value.

(b) **Technical value**: Verma Committee has classified equipment on the basis of utilization and technical value into the following categories:-

(i) **Type I :** Failure of such equipment effects functioning of the entire hospital. E.g. transformers and generators etc.

(ii) **Type II :** Items of daily use such as suction apparatus etc.

(iii) **Type III :** Sophisticated equipment such as X-Ray , echocardiography etc.

180. **Miscellaneous method of classification cost.**

(a) **ABC** based on annual consumption cost.

(b) **VED** (Vital, Essential, and Desirable) based on its value in the equipment.

(c) **HML** (High, Medium, Low) based on capital cost of the equipment.

(d) **SDE** (Scarce, Difficult, Easily available) based on availability of equipment.

181. After considering these factors maintenance can be planned and provided in the following manner:-

(a) **Unit maintenance**: Each unit, electrical, mechanical, civil or electronic, performs its own component of total maintenance work.

(b) **Specialized crew maintenance:** Each crew is trained to do a particular job such as repair of life, boiler or X-ray equipment etc. The crew moves from one unit to another to perform its specialized work.

(c) **Contract maintenance**: This is used because it may not be possible to carry out 100% and all types of maintenance by the hospital's own engineering staff especially for sophisticated equipment e.g., Apparatus cobalt, Image intensifier, CT scan, Linear accelerator etc.

182. **Maintenance services.**

(a) Need for in-house maintenance services for routine repairs of common equipment

(b) Maintenance cell establishment under a skilled person

(c) Recruitment of skilled manpower

(d) Bank of spare parts

(e) Establishing history sheet of each equipment group

(f) Master maintenance plan

(g) Monitoring of AMC for sophisticated equipment

Import of Goods/Equipment

183. **General Considerations.**

(a) **Licensing Authority**: Director General of Foreign Trade, New Delhi is the Licensing Authority for Imports, in India. Comes under the Ministry of Commerce.

(b) **Enquiry for Imports** :Consideration while floating trade inquiries are as under:-

(i) Description of goods

(ii) Quantity

(iii) Price

(iv) Mode of payment

(v) Delivery terms

184. Importer may specify his own terms and conditions about the mode of delivery .Import pricing-Various types of prices that are in vogue in the Import-Export procedures are as follows:-

(a) **Ex-factory-** price at which the goods would be delivered to the Importer at the gate of the factory by the exporter. All expenses for moving the goods from the exporter factory to the buyer's go down would be borne by the Importer.

(b) **Free on Rail (FOR) -** Exporter would deliver the goods at the quoted price at the railway station/organization's location specified by the importer

(c) **Free on Board (FOB) -** Price quoted includes all costs, including transport and other charges, incurred up to the time the goods are loaded onto a ship for transporting them aboard.

(d) **Cost and Freight (C&F) -** price quoted by the exporter includes the payment of freight charges up to a port in the importers country.

(e) **Cost, Insurance, Freight (CIF) -** Includes the cost of goods, insurance and freight.

(f) **Cost, Insurance, Freight, Commission (CIFC) -** cost of goods, insurance, freight plus commission for agent.

(g) **Terms of Payment.**

(i) **Advance payment basis** :Advance payment to a foreign supplier at the time of finalization of Import Order

(ii) **Letter of credit (L/C) basis** :Importer agrees to open a Letter of Credit in favor of the foreign supplier through a bank

(iii) **Cash against Document basis (CAD) :**Importer and exporter agree that the documents are negotiated with the bank on collection basis then it is called CAD

(iv) **Credit basis:**importer and exporter agree that in case of emergency or if required the supply of equipment can be done , later on payment will be done.

(v) **Import Insurance :** include Important factor in the purchase of goods and types of risks are normally involved in any import transaction as below :-

(aa) Loss of goods during transition from warehouse of the Exporter to warehouse of the Importer

(ab) Loss due to fire

(ac) Loss due to water seepage, rain etc.

(ad) Loss due to theft

(ae) Loss due to storm, negligence during transportation

(af) Political risks like war, foreign aggression etc

Strategic Planning in Equipment Management

185. As new scientific advances are considered for implementation, a clear understanding of the resource, economic, and technical implications must be developed by the hospital planning team. For enterprise risk management, negative risk would be any issue that could have an adverse impact on meeting the objectives of the organization. Positive risk would be those opportunities that are available to the organization for the enhancement of meeting objectives. Taken together, the management of positive and negative risk can be a beneficial tool in providing focus and direction in the development of strategic plans.[39]

Clinical Engineering

186. The American College of Clinical Engineering defines a clinical engineer (CE) as: "a professional who supports and advances patient care by applying engineering and managerial skills to health care technology." Clinical engineering is a subset of biomedical engineering. Whereas biomedical engineering is practiced primarily in academic institutions, the research laboratory, and manufacturing, clinical engineering is practiced in hospitals and other environments where medical device technologies are utilized. The purpose of the Clinical Engineering Handbook is to provide a central core of knowledge and essential information the clinical engineer needs to practice the profession.[40,41]

187. Clinical engineering began with the application of engineering principles to the economic solution of clinical problems. It relied heavily on a body of knowledge that drew on electrical and mechanical engineering, physiology, human factors, and chemistry.
As an interdisciplinary practitioner, the clinical engineer is something of a chameleon. To one person, the clinical engineer is an advisor on technology selection; to another, an incident investigator or patient-safety expert; to a third person, a partner in clinical studies.[42]The common denominator for clinical engineers is the patient, regardless of job description or employer. In every situation, however, the patient is always seen as the ultimate customer.[43]

What is Clinical Engineering?

188. A clinical engineer as:

"A person who adapts, maintains, and improves the safe use of equipment and instruments in the hospital,"

The American College of Clinical Engineering defines a clinical engineer as:

"A professional who supports and advances patient care by applying engineering and managerial skills to health care technology,"[44]

"a professional who brings to health care facilities a level of education, experience, and accomplishment which will enable him to responsibly, effectively, and safety manage and

interface with medical devices, instruments, and systems and the user thereof during patient care...,".

189. The Journal of Clinical Engineering has defined the distinction between a biomedical engineer and a clinical engineer by suggesting that the biomedical engineer:-

"**applies a wide spectrum of engineering level knowledge and principles to the understanding, modification or control of human or animal biological systems .**

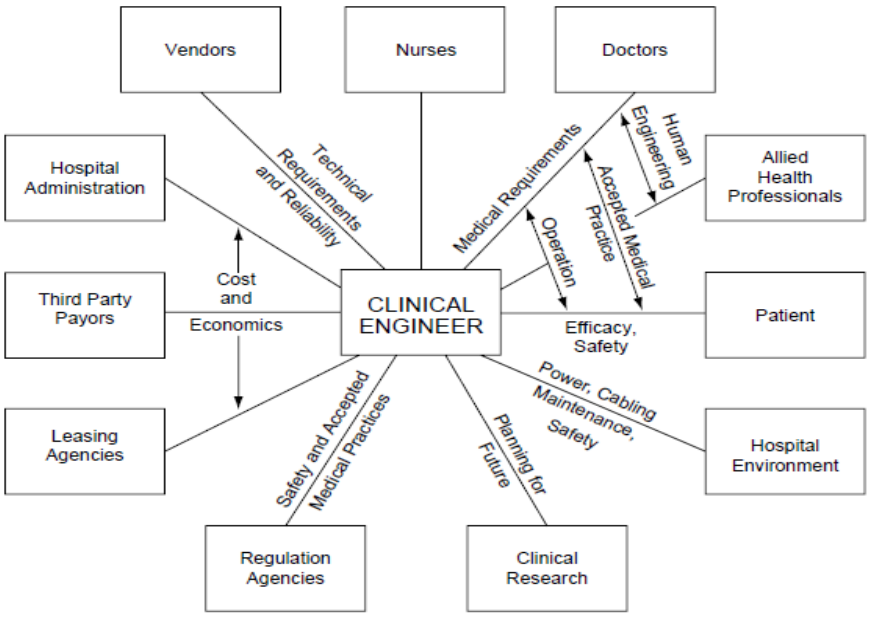


Figure 2.3 : Range of interactions of clinical engineer.

190. Core functions of a clinical engineering department can be summarized as follows:-[45]

(a) Technology management

(b) Risk management

(c) Technology assessment

(d) Facilities design and project management

(e) Quality assurance

(f) Training

Problems and Concerns in equipment management

191. Some of the common problems or concerns of clinical engineering departments include the following:-

(a) **Long lead-times** are required, to obtain needed spare parts. Although most departments try to stock some recommended parts, often the parts needed cannot be found in stock. To obtain a particular part, it may take from three months to a year, as sometimes it is not even in the vendor's stock or in the manufacturer's warehouse.

(b) Sometimes service manuals are not provided or are not even adequate, thus resulting in longer times to repair.

© **Adequate support from some vendors**, or even from manufacturers, is often not provided. For example, a vendor might not be prompt in solving the problem. Some local vendors might not even employ qualified service personnel to solve the problems.

(d) **Lack of full awareness** of some clinical staff about the roles of clinical engineering departments could result in lack of proper communication between users and the clinical engineering staff.

(e) Some types of equipment might have intermittent problems that could be caused by age, design problems, or the environment. This problem may occur in any health care institution and is addressed by technical departments throughout the world.

(f) Difficulty in finding well-qualified technicians or engineers often occurs.

(g) Difficulty in maintaining some equipment by in-house personnel because of the lack of standardization often occurs. Having many one-of-kind devices, each of which requires that the staff obtain special training for servicing, places an onerous burden on the training resources that are available to the department.

(h) Sometimes there is a lack of competent in-house training programs offered for users and clinical staff.

(j) Not enough trained local staff is necessarily available to meet hospital needs.

(k) The process of training staff is long.[46]

Enhancing Patient Safety : The Role of Clinical Engineering

192. Opportunities for enhancing patient safety exist within the health care delivery system. Individuals and groups throughout the system are actively pursuing these opportunities.

Health Technology Management

193. Health care systems everywhere face the **STEEP test of being Safe, Timely, Effective, Efficient, Equitable, and Patient-centred.** Meeting these current and perceived future challenges to improve health care content and delivery are often associated with using increasingly sophisticated technologies for diagnosis and treatment. Health care technology management activities offer a range of solutions to address these requirements and to improve quality while reducing cost.

194. The 2001 U.S. Institute of Medicine (IOM)[47] Report regarding 21st century health care in the United States suggests highest quality care would be achieved when:-

(a) All preventive, acute, and chronic care services are delivered accurately and correctly.

(b) All indicated services are delivered at the right time.

(c) Services not helpful to the patient or reasonably cost-effective are avoided.

(d) Safety hazards and errors that harm patients and employees are avoided.

(e) The patient's unique needs and preferences are respected.

195. The definition of health technology used by the World Health Organization (WHO) includes drugs; devices; medical and surgical procedures; the knowledge associated with these in the prevention, diagnosis, and treatment of disease as well as in rehabilitation; and the organizational and supportive systems within which care is provided.

Computerized Maintenance Management Systems

196. Computerized maintenance management systems (CMMSs) have evolved into a useful tool for providing technology support. Whether supporting a three-technician shop or an international service organization. Almost all medical equipment support organizations are using some type of CMMS in their operations. A CMMS can be classified broadly as internally developed (typically using commercial off-the-shelf (COTS) personal computer hardware and database software); commercial CMMS applications; or the newest approach—application service providers (essentially a web-based software rental service).[48]

197. Computerized maintenance management systems can provide the technology management staff with a wealth of information to help manage many technology support-related functions. Examples include the following:-

(a) Quantitative equipment reliability assessments can be made based on failure rate, down time, and repair and maintenance costs. These assessments can be used to determine equipment that should be replaced and that should assist in the subsequent vendor selection for the new product being purchased.[49]

(b) User/operator training needs can be identified based on trends in use error problems (e.g., problem not repeatable, incorrect settings, liquid spills, and physical damage).

(c) Scheduled maintenance can be prioritized based on the risk to the patient of an equipment failure and the maintenance needs of the device. CMMSs can be used to balance and manage this often large workload better.[50]

(d) Scheduled maintenance program effectiveness can be measured by the rate of problems identified (yield), parts replaced, equipment not found/not available as compared to the total number of inspections performed by risk priority, and again, used to manage this often very large workload.

(e) Work order systems can be used to prioritize repair requests and better manage downtime of critical systems.

Maintenance and Repair of Medical Devices

198. Maintenance and repair activity is required in order to ensure that devices are kept functioning within the limits imposed by the test criteria and to return devices to the required level of functioning after breakage or other failure. Additionally, safety and performance testing is required in order to identify unsafe or incorrectly performing medical devices that could pose a risk to either patients or staff. Such testing is usually performed at acceptance and then on a routine basis.[51,52]

Risk Management

199. The reality of many medical device management programs is that they are relatively under-resourced, particularly with the adoption of more, and more complex, technology. This presents a difficult situation. If scarce resources are allocated to yearly safety and performance testing, perhaps for mandatory or accreditation reasons, then the repair backlog may increase to a level where clinical service delivery becomes affected. Also, if the repair backlog increases, then maintenance activity will reduce, thus compounding the problem. In order to operate with limited resources, various techniques have been adopted to justify reduced safety and performance testing frequencies and to define maintenance requirements more precisely.[53] These techniques have included classifying the maintenance needs of items or protocols for justifying the extension of safety and performance testing intervals. These techniques rely either on some measure of device "criticality" +risk analysis or on sound statistical reliability data. Usually, insufficient data are available for valid statistical analysis, and these techniques then must be based on risk management techniques. Risk management typically involves developing a "matrix" with the probability of failure along one axis and the consequence of failure (from minor to major) along another. Devices can be placed in the matrix according to where they sit on each axis and ranked, allowing resources to be targeted at the highest risk items (i.e., those where both the probability and consequence of failure are highest). The rationale behind any technique adopted should always be documented.[54]

200. Staff training (both technical and clinical) can become more focused. Such a strategy seldom needs justification. For the maintenance and repair service provider or medical device

manager to have the most valuable insight into this process, they need clinical knowledge as well as technical familiarity with the devices being used. Pre-purchase estimation of projected maintenance costs needs to be considered, particularly as these costs often can exceed the capital cost of the equipment over its lifetime. With vigilance, areas where the current ownership practices are impeding efficient device management can be identified, and different practices possibly can be adopted. Any maintenance and repair service provider should be prepared to adapt to existing conditions.[55]

201. Other strategies to consider include balancing the level of support against available technical capability, both internal and external. In some countries, health care organizations find it almost impossible to obtain any technical support for their medical devices, while in other countries the capability and availability of such services are high. Scrutiny of all technical resources available to a given locality is essential in order to ensure that the highest quality and most cost-effective service are provided to the health care organization. There always will be new and different strategies to consider. Some of these will be brought about by changes to technology and improvements in device management techniques.

Strategy to Maintain Essential Medical Equipment in Developing Countries

202. Basic medical equipment is now widely used in the district health facilities of developing countries. This large volume of essential medical equipment is supporting primary healthcare to the general population. District facilities are numerous and widespread inmost developing countries. Maintaining this large volume of basic, essential medical equipment presents a special challenge.

Status of Maintenance in Developing Countries

203. Large cities in most developing countries now have maintenance workshops, often built on the grounds of major hospitals. Many of these workshops can repair complex medical equipment and offer adequate services to the major hospitals with which they are affiliated. They are fully occupied, however, in coping with the ever increasing numbers and complexity of medical equipment in major hospitals; therefore, their services cannot be easily extended to district health facilities. The growth of maintenance services simply is not keeping pace with the rate of deployment of medical equipment in these countries.[56]

The ministries (or departments) of health in developing countries, often lacking in equipment maintenance expertise, may believe or expect that the few established workshops have the capacity to resolve the equipment maintenance problems of the nation as a whole. In contrast, the technical staff in those workshops, traditionally confined to lower-ranking positions, rarely have the opportunity to develop a national perspective.

204. Their needs and objectives are usually to further their training in order to advance their high-technology skills; these goals are often justified, considering the complex equipment that they service. These conflicting expectations do not lead to an effective solution forth national needs in medical equipment maintenance. What, then, is an appropriate strategy to tackle this problem? Priority needs to be given to large-scale training of "basic" technicians and the establishment of smaller workshops in the districts to maintain essential medical equipment. This training task will take less time and cost to accomplish as compared with training technicians to maintain complex items or equipment, and it has a number of additional advantages described below. These issues are analyzed with the aid of an empirical model.

An Empirical Model

205. A country's medical equipment inventory can be represented by the pyramid shown in Figure 3.

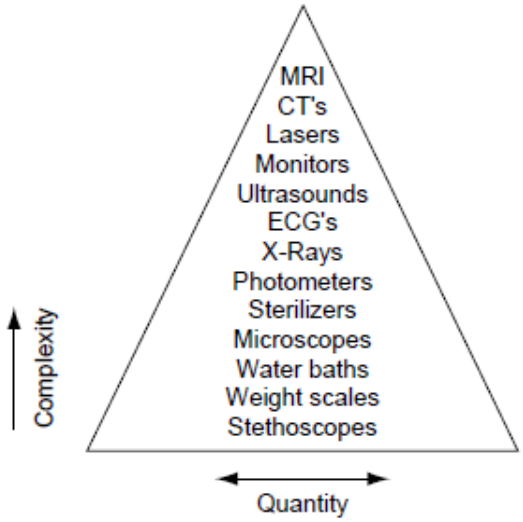


Figure 3 : Diagrammatic

Figure 2.4: Diagrammatic inventory of medical equipment

206. In Figure 3, height represents, in approximate order, equipment complexity, while width represents equipment quantity. The pyramid shape indicates that simple equipment greatly outnumbers complex equipment. For example, there are obviously more weights, scales, stethoscopes, and sterilizers than ultrasounds, lasers, and CT scanners. As the complexity of the devices increases, the numbers available decrease. The bottom half of the pyramid comprising devices such as sterilizers, microscopes, water baths, scales, and stethoscopes can be maintained by technicians with a minimal amount of training and cost.[57] The maintenance of the wide range of equipment identified in Figure 6 requires correspondingly wide range of technician skill levels, and the cost or time required to train a technician increases dramatically with the level of skills required. This situation is illustrated by the curve (co) in Figure4.

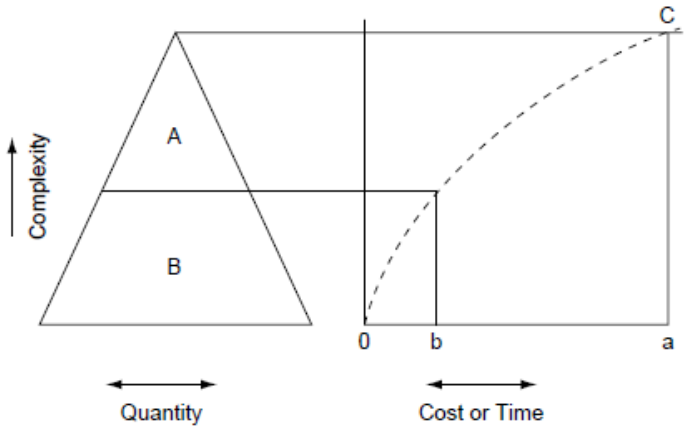


Figure 2.5:Relationship between complexity of equipment and cost and duration of training technician.

207. In Figure 4, the inventory of equipment is divided into complexity categories A and; *ob* represents the cost or time to train a basic technician to maintain the simple category B; *bear* presents the cost or time required to train a mid-level technician to maintain category A. This graphical comparison suggests that at a much smaller cost, or in a shorter period of time (*ob* compared with *ba*), technicians can be trained to maintain a larger quantity of basic essential medical equipment (B compared with A). The actual relationship between complexity and cost or time (curve *oc* in Figure 4) will not be exactly as illustrated, but in general, the idea of a rapid increase of cost or time with complexity is valid. If special attention is given to the maintenance of essential medical equipment in support of primary health care facilities, the population at large can benefit comparatively quickly in many developing countries.[57]

Development and Implementation

208. Given the current situation in many developing countries, the pyramid model suggests an appropriate strategy to attack the problem of medical equipment maintenance. This strategy calls for a priority in the training of technicians to maintain the relatively simple but plentiful essential medical equipment commonly found in district health facilities. This strategy requires less time, costs less, and delivers benefits to a larger population. Here lies a happy coincidence in which the easier way of doing things is also more economical and beneficial. The following further advantages can be derived from this strategy:-

(a) Mid-level technical expertise local trainers in existing workshops can be utilized.

(b) Because of less stringent prerequisites for selection, a larger number of candidates can be recruited for training, enabling a relatively rapid multiplication of technical human resources.

(c) Because of the large amount of similar equipment in use, it may be possible to carryout apprentice training on the job so that the trainees can provide actual services to health facilities.

(d) This strategy suits well the market economy that is now found in practically all countries around the world. Complex repairs can be done more cost-effectively by Company enterprises. Companies are obliged to have trained technicians to support the equipment they supply. In-house and Company services can be used to best advantage.

209. The loss of highly trained technicians could be devastating toa country that is striving to build up a maintenance service while coping with a shortage of technical personnel. By initially concentrating on training a large number of technicians to maintain basic, essential medical equipment, a pool of technically skilled people will be made available for services and for higher training. This can provide a more stable base to develop maintenance services further. The simplicity of the pyramid model can help nontechnical decision makers to grasp better the technicalities of equipment maintenance. Such a strategy would call for clinical engineers in developing countries to acquire management and training skills in order to lead or manage national medical equipment maintenance programs.

Outsourcing Clinical Engineering Services

210. Clinical equipment ownership results in a financial liability that extends far beyond the cost of equipment purchasing, installation, testing, and user training. Yet when properly defined and aggressively managed, a consolidated medical equipment service management program can create substantial cost savings for any health care organization, especially given the continued increase in new and replacement high-technology equipment purchases. Considering the fact that many capital acquisitions are of assets that have a useful life of seven or more years (especially when considering the asset's longevity through planned upgrades), it is not uncommon to expect an annual ownership (service) expenditure of 5% to 12% of the equipment's original purchase price, depending upon the mix of equipment modality. Choices as to the best way to provide for a consolidated medical equipment maintenance management program can typically be categorized into two types of program models: (1) in-sourced (in-house) and (2) out-sourced.

Outsourcing

211. What is out-sourcing? Essentially, it is the transfer of any defined business operation irresponsibility to another organization. In terms of clinical engineering, it could involve the transfer of responsibility for selected portions of equipment service, procurement, or program management to an external business entity or organization, all for one agreed upon or "not to exceed" price. It could involve transfer of the financial risk, with or without service staffing, as well. Typically the Company providing the outsourced service makes all service decisions and assumes responsibility for all outcomes (i.e., good and bad).[59]

Two Service Models

212. One key differentiating factor between the two program models of outsources and in-house relates to identification of the financial risk. It is important to realize, however, that most in-house (in-sourced) clinical engineering programs typically continue to utilize the services of external vendors, as it would be unusual for any single program to have sufficient internal resources to be able to perform100% of required services. Given the high number of inventoried devices typically contained within a clinical equipment management program, it would not be unusual for the in-house staff to service only 70%–80% of the equipment base, relying on external vendors, with their specialized expertise, to service the remaining items. Therefore an

in-house (in-sourced) program still contains some elements of an outsourced program.[63]For purposes of this discussion, an outsourced program is defined as one that is fully provided by non-hospital staff and whose management (the entire service function) is the responsibility of an external provider. Under a fully outsourced program, all staff is on the out-sourced vendor's payroll, and the vendor is fully responsible for all aspects of program management, performance, and financial outcomes. The hospital pays one price to one vendor, who then assumes all responsibility for paying for all subcontractors, staff salaries, parts, supplies, and overhead. While there are no requirements or regulations stipulating who can (or must) provide repair services on most medical equipment, certain countries and/or individual states may have guidelines relating to service, testing, or calibration of specific device types such as high-energy radiation treatment or mammography systems.

Why Outsource?

213. The reasons why many organizations consider use of an out-sourced program typically include the following:-

(a) Desire to reduce the number of employees who are directly on the hospital payroll. Many organizations have management goals to reduce the total number of employees (full-time equivalents [FTE]) to meet required staffing benchmark levels based on total number of employees per occupied bed.

(b) **Cost savings**. Many outsourced programs are sold and justified on the total program cost, which is shown to be less than the actual or estimated cost of the organization's current in-house programs. This is especially true when the majority of the equipment base, such as for a radiology service program, comes from one vendor or manufacturer who has access to parts and labour at their internal cost.

(c) Access to resources that are not readily available to the organization (e.g., trained staff and parts). Many outsourced programs are provided by equipment manufacturers who have direct access to parts, supplies, and software products directly or indirectly related to the equipment base of the program being outsourced. In addition, most outsourced programs have developed custom policies, procedures, and software systems that can be rapidly installed at a low cost.

(d) Short-term solution to a problematic in-house program. Many in-house programs are short staffed or have employees with limited expertise and service capabilities. The outsourced vendor may have underutilized staffing resources in the local geographical area who can be assigned full- or part-time to assist in implementing or providing routine support to the organization.

(e) Reduced internal overhead related to invoice processing. Given the high cost of processing individual purchase orders for parts, supplies, and individual vendor repair services, an outsourced program can have an indirect impact on the hospital's cost if the internal overhead need to process these invoices and related paperwork can be eliminated or reduced.[59]

214. When selecting an outsourced service provider, it is important that all program components be identified in writing and made part of the contractual agreement. Issues related to on-site, dedicated staffing, parts sources, scheduled preventive maintenance, backup support, external OEM vendor assistance, data ownership, reporting, equipment relocations, upgrades, software, test equipment, user training, committee participation, and total budgetary responsibilities also must be clearly defined.

Maintenance Insurance

215. The concept of maintenance insurance works on the premise that, by bundling together the service contract budgets of multiple items, one can lower the overall program cost by averaging the T/M service cost needs of all items.[60] Using actuarial service cost data on multiple types of equipment, the maintenance insurance program establishes an estimate of T/M costs for each item, including preventive maintenance (PM) costs, then adds in an overhead and profit margin. Under the ideal program, the equipment user then continues to call in their previously used OEM for service when needed, then either pays the bill itself and waits for insurance reimbursement or submits the bills directly to the insurance carrier for payment.[61]

216. Over the years, variations on the insurance program concepts have been implemented, such as:-

(a) Inclusion of a rebate or shared savings component to reward the hospital in working with the insurer to minimize the annual service costs

(b) Reimbursement to the hospital when allowing their ₹in- ₹house staff to perform a portion of the maintenance (at in-₹house ₹labour costs of 1500–3500 per hour instead of paying the OEM rates of6000–10000 per hour)

(c) Provision of a first-dollar versus stop-loss limit-based program Provision of on-site clerical and/or technical staff to assist with management of the program, and its paperwork

(d) An arrangement whereby the insurer pays the service vendor directly

(e) Multiyear agreements whereby the annual program premium cost increase is capped

(f) Ability to add and delete individual items via a pro-ration schedule

(g) Telephone support assistance in locating alternate parts and labour sources

Vendor and Service Management

217. A good working relationship with manufacturers is necessary to ensure proper after-sales technical support by way of such items as documentation, service, parts supply, upgrades, and recalls. On the other hand, it is wise not to be limited to only one or a very few suppliers nor to become too reliant on the manufacturers. The proper relationship starts at the equipment planning stage and not when service problems first appear. Ways in which the clinical engineer can relate to the vendor (i.e., the original equipment manufacturer [OEM]) at the planning stage will be described.[62] Relationships with OEMs throughout the life of the equipment will be optimal if terms and conditions are clearly delineated at the procurement stage. The way to write an effective purchase agreement containing all the necessary conditions will be presented. Throughout the life cycle of the equipment, the responsibilities of the clinical engineer, such as performing thorough incoming inspection, and the responsibilities of the OEM, such as providing clear and comprehensive service manuals, will be described. If the OEM is to play a

major role in equipment service, agreements for this should be arrived at during the procurement stage as part of maintenance planning and implementation.

218. Examples of the OEM's expectations of hospitals and health authorities will be given. After device acquisition and expiration of the warranty, the hospital must arrange for on -going service for that device. Maintenance management techniques such as auditing existing agreements, identifying equipment serviced, identifying costs, and identifying services provided will be provided .[63]

Service Contract Terms and Conditions

219. The following is a checklist of terms and conditions to look for in the service contract:-

(a) Cancellation clause

(b) Guaranteed prorated rebate

(c) Payment

(d) Renewal

(e) Access to equipment

(f) Contract length

(g) Exclusions

(h) Indemnification

(j) Parts kits/stock

(k) PM specification

Negotiating

220. Everything is negotiable. The following is a summary of the types of items that one should consider as being open to negotiation when entering an equipment purchase ora service contract agreement. One might find it helpful to create one's own contract. A contract addendum

can be attached to the equipment purchase contract or the vendor's service contract that all must sign. Significance aspects are as under:-

(a) Try to negotiate future service contract pricing at equipment purchase. (This allows for future budgeting, should you choose to sign a service contract after the warranty.)

(b) Choose payment terms that meets your needs, such as paying up front or in instalments.

(c) Be sure to evaluate different service contract options (e.g., parts only, labour only, or preventive).

(d) Maintenance, normal business hours, full service.

(e) Where possible, consider several service contractors (not just the manufacturer).

(f) Prepare for vendors threatening that you will "have to wait longer for service if you don't have a contract."

(g) Beware that vendors might try to go directly to the device users in order to try to pressure you to sign a service contract.

(h) Consider the use of maintenance insurance.

(j) Examine closely what is included in the contract (for example, parts, hours, consumables, and up time).

(k) Negotiate your terms and conditions:-

(aa) Vendor service representatives must sign in with clinical engineering upon arrival at the hospital.

(ab) Service representatives must leave copies of all service reports, including labour hours, travel hours, and parts used.

(ac) Establish and enforce vendor response times (by telephone and on-site).

(ad) Cancellation clause

(ae) Avoid automatic renewal

(af) Carefully consider committing to multiyear service agreements

Support Resourses to be Negotiated for In- House Services

221. The following are support resources that an in-house service organization requires in order to properly provide service to medical devices. During the procurement process, negotiations should result in these items being supplied along with the equipment purchased:-

(a) Theory of operation/schematics

(b) Parts lists

(c) Troubleshooting guide& PM procedures

(d) Diagnostic software

(e) Training: live, computer-based, video, or teleconference; on-site or factory

(f) Training (should be the same as vendor service representatives receive and should be available for the individual specified by the hospital)

(g) Service tools

(h) Spare parts

(j) Technical support assistance: Negotiate to reduce cost of service contracts by utilizing first-response screening and troubleshooting by in-house clinical engineering or other in-house personnel and by entering into a shared risk contract.

Partnerships with Vendors

222. A good relationship with the vendor will enhance the cost-effective utilization of the technology acquired. Understanding the Company's dynamics and knowing its products and personnel yields more successful assessment activities and improves the overall acquisition process. Good relationships make it easier to resolve safety, installation, reliability, and

maintenance problems. After the useful life of the product is over, a maintained good relationship invariably will improve the equipment replacement planning process.

Vendor Characteristics

223. The CE and vendor should be comfortable in a give-and-take relationship. Vendors who have the hospital's interest and success in mind are preferable for long-term relationships. Vendors come in all sizes and shapes. Some are good and some are bad. [62]One should cooperate with and help to build up the good ones that exhibit the following characteristics:-

- Low down time
- Respect for the customer
- Information provided when requested
- Good technical skills
- Good reputation
- Few callbacks and problems
- Good communication
- Dependability
- Quick repairs

224. **Bad vendors have the following characteristics and should be avoided:-**

- No (or inadequate) service documentation
- Manufacturer parts only
- Non-cancelable service contracts
- Remote support only
- Will not work with maintenance insurance, third parties, or in-house support
- Upgrade requirements for support
- Do not return telephone calls

Breakdown of Medical Equipment Maintenance

225. **Expenses.** A typical management report would include such a graphic as shown in Figure 5, the expenditures of the principal users of medical device technology by percent of the total costs. Several guidelines that will help the clinical engineer to know whether costs are in line with national averages have been developed. For example, the following are estimates of the maintenance costs ($/bed/year) for hospitals of various sizes:-

(a) 0–75 beds =₹$1200/bed (60,000)

(b) 76–200 beds =₹$1500/bed (75,000)

(c) 201–400 beds =₹$2250/bed (1,12,500)

(d) >400 beds =₹$2800/bed (1,40,000)

226. Additional factors must be taken into account when managing equipment service, such as customer satisfaction and the quality of service. Such information can be obtained by means of customer surveys. Current service arrangements that have flexibility are targets for additional cost reductions.[36]

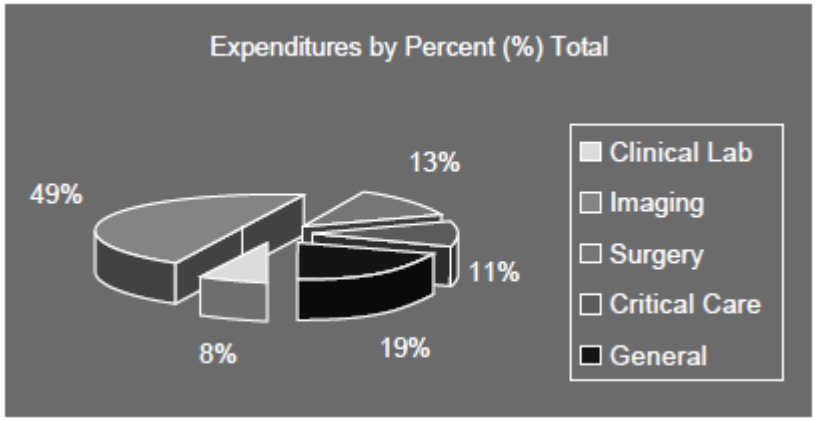


Figure2.6:Expenditure of various clinical departments as a percentage of total hospital cost.

Healthcare Technology Replacement Planning

227. Equipment replacement planning is an important part of the technology planning process. Immediate benefits include dramatically reducing emergency purchases of replacement equipment and improving the safety and effectiveness of clinical technology. Administration (including finance) and clinicians have a better appreciation of the value of clinical engineering through the objective and rational recommendations made in the equipment replacement report.[64]

Healthcare Equipment Donations

228. Many developing countries are increasingly dependent on donor assistance to meet the equipment needs of their health care systems. However, because not all important parameters are

taken into consideration, donations sometimes do not achieve their intended objectives, and could even constitute an added burden to the recipient health care system. There is therefore a need to improve the process of equipment donation, to the mutual benefit of both donors and recipients. These guidelines address this issue, but are not an international regulation. Instead they are to be used to develop national or institutional guidelines; by governments and organizations dealing with health care equipment donations. And although intended for application everywhere, there is a deliberate emphasis on developing country health systems.

Donation of Medical Device Technologies

229. Most charitable organizations donate medical equipment that is unsuitable for its intended use. Most recipients receive donated medical equipment that is unsuitable for the institution. Donors fail to ensure that donated equipment is functional, meets standards of safety and performance, has adequate spare parts and accessories available, and is the type of technology that the recipient wants, needs, and is able to operate and support. Most recipients do not adequately describe their medical requirements, available financial support, facilities preparation, or available utilities. By following checklists that company guidelines for donation and receipt of medical equipment, substantial waste and inefficiencies can be eliminated. The American College of Clinical Engineering (ACCE), the World Health Organization (WHO), and several other health care organizations have been leaders in the development of donation guidelines (ACCE, 1995; WHO, 1997; FAKT, 1994).[65,66,67]

Rationale for Donations

230. For decades, developed countries have donated used medical equipment to less-developed countries. This recycling of goods accomplishes several important objectives. In developed countries, it helps to keep hospital corridors clear of obsolete equipment and reduces the amount of waste that ordinarily would go to landfills. Frequent equipment turnover also increases the rate of introduction of new technologies. Not insignificantly, donations give a benefactor a good feeling and a belief that that needy people in some faraway country are being helped. Financial advantage through tax deductions also contributes to a donor's sense of well-being. In developing countries, physicians gain quicker access to sophisticated technologies and, most importantly, less-privileged patients gain wider access to better health care . In some

countries, nearly 80% of healthcare equipment is funded by international donors or foreign governments (WHO, 1987).[68]

Rationale for Guidelines: Frequently Encountered Problems

231. Unfortunately, not all donations achieve their goals. Much donated equipment is not or cannot be used by the recipients. It is estimated that as much as one third of all donations do not achieve their eventual goals, wasting precious time and resources. In Sub-Saharan Africa, up to 70% of equipment lies idle due to mismanagement of the technology acquisition process, lack of user training, and lack of effective technical support[12]. Many factors contribute to this reality. Some donors are so anxious to get rid of their unwanted hardware that they pay little attention to the equipment's condition, availability of parts, documentation, supplies, and operator training in the recipient country. In atypical hospital's obsolete equipment storage area, only one in ten devices might be functional.

232. Perhaps more ominously, in some cases, donated equipment has been recalled in the donor country by the medical device regulatory body of that country. Some international relief organizations are forced to concentrate on volume rather than on the quality of donated goods in order to gain publicity and to please corporate donors. On the other side, many recipients do not carefully screen what they ask for nor invest enough time and resources to plan and support what they get. Sometimes they are spoiled by the notion that they always can ask for another one and can discard what they do not want or failed to maintain. Finally, the lack of communication between the donor and recipients before the shipment of goods is probably the single most important reason why many donations do not work out well.

233. In most cases, donations circumvent the selection and procurement systems of the recipient country, where such systems exist. As a result, little consideration is taken of actual local requirements, the number of user staff and their capability, and the level of technical expertise of available maintenance personnel. Further problems relating to equipment calibration and operation, purchase of consumables, and availability of spare parts can transform the donated equipment into a liability rather than an asset to the recipient institution. Some used equipment is repaired or refurbished before it is donated. Care must be taken, however, and it

must be realized that beauty often is only skin-deep .The “Spray and Pray” refurbishing method of painting advice to make it look new without doing adequate maintenance or repair of the item.

234. WHO propounds the following core principles for equipment donations:-[69]

(a) Health care equipment donations should benefit the recipient to the maximum extent possible. This implies that all donations should be based on an expressed and validated need and that unsolicited donations are to be discouraged.

(b) A donation should be given with full respect for the wishes of the recipient and their authority within the health system and should be supportive of existing health policies and administrative arrangements.

(c) There should be no double standards in quality: If the quality of an item is unacceptable in the donor country, it is also unacceptable as a donation.

(d) There should be effective communication between the donor, the recipient authority, and whenever possible the end user before, during, and after the donation.

Suitability for Donation

235. Suitability for donation and the following sections comprise a description of the donation process, taken directly from the ACCE guidelines. Prior to making equipment available for donation it is crucial that the potential donor make a critical evaluation of it. It is not only a waste of precious resources to move useless and unsafe equipment from one place to another; it also undermines the good will and trust that everyone is trying to build.

Safety, Specifications, and Standards

236. All medical equipment should meet or exceed existing safety and performance specifications provided by the manufacturer. Equipment that has non-functional subsystems can be donated, provided that those subsystems are clearly identified and labelled.

Obsolescence

237. A minimum of two years of manufacturer’s sales and technical support should be available. This support should include repair parts; accessories (either reusable or disposable);

and troubleshooting, repair, and maintenance assistance. Obsolete equipment or equipment for which replacement parts are unavailable should be shipped only if they are designated for parts only.

Appropriate Technology

238. In considering the provision of medical equipment to developing countries, potential donors should favour the following desirable characteristics in such equipment:

(a) Simplicity of operation
(b) Minimal number of accessories required
(c) Availability of necessary operating supplies (particularly disposable) in the recipient country
(d) Standardization with other equipment in the local
(e) Ease of maintenance
(f) Tolerance to hostile environment

Table 2.2: Medical Equipment Donation Action Checklist

ACTION	DONOR RESPONSIBILITY	RECIPIENT RESPONSIBILITY
Suitability for Donation • General Quality • Safety, Specifications and Standards • Obsolesce • Appropriate Technology	Evaluate unnecessary equipment prior to offering it for donation	

Evaluation of Potential Recipients • Clinical Need • Readiness to Absorb the Technology Human Resources Environment Material Resources Maintenance Resources Financial Feasibility	Request information from potential recipient and evaluate it to determine likelihood of success for donation	Submit information to potential donor using request form
Pre-Donation Planning • Installation, Operation, and Maintenance Requirements Installation Requirements Operation Requirement Maintenance Requirement Special requirements Pre-Donation Recipient Preparations	Provide data to recipient	Use donor's data to prepare personnel and infrastructure
Donation Implementation • Assembly, Packaging, and Shipment • Customs Clearance, Unpacking, Installation, and Maintenance	Donor's responsibility	Recipient's responsibility
Follow-Up Evaluation	Analyze and improve procedure	Provide feedback to donor

Quality in Equipment Management

239. Techniques are presented for improving the quality of health care delivery and technology management practice, in particular. Quality can be measured and improved through:-

(a) Appropriate quality culture and QI infrastructure

(b) Prioritized QI initiatives based on impact (disease burden), improvability (quantified gap between current and evidence-based best practice), and inclusiveness (broad relevance and reach)

(c) Appropriate QI indicators and tools

(d) Performance feedback and other methods

(e) Using best science for care (evidence-based medicine) and CE practices

240. Some applications of these techniques include medical equipment quality-assurance and improvement programs, regulatory-compliance programs, customer-satisfaction surveys, patient safety, and improving cost-effective use of technology resources. These applications will be demonstrated through several case studies. A typical array of QI indicators that may be used in HTM are in Table 4. This is typically an on-going, hospital-wide process that is the responsibility of the entire staff at all levels. It empowers employees to make changes that improve care and service outcomes.

Table 2.3:Clinical Engineering Quality Indicators.

Inspection and preventive maintenance	**Repair**
Type/number of devices scheduled for service	Down time (Up time)
Type/number devices inspected	Specific equipment failure
Type/number of devices that failed an inspection	Number of repairs
Type/number: on demand service	Average time per repair
Type/number found with physical damage	Down time due to repairs
Type/number of no problem found	Repair turnaround time
Type/number serviced more than once in 7 days	Response time for repairs
Type/number involved in incident	Repeat repairs
Type/number requiring abnormal labor and parts	Repair delayed due to parts
Inspection failed	orders
No inspection-equipment not located or in use	Down time associated with parts

Users User related problems Percentage of user errors Number of user errors Number of repaired costs caused user misuse or abuse Frequency of repairs by user errors Frequency of user errors on same shift or same unit	orders Mean time to repair Miscellaneous complaints Incident investigation Equipment recalls

241. **Process quality.**

(a) Use as per laid down instructions

(b) Avoid over use and misuse

(c) Preventive and corrective maintenance

242. **Outcome quality.**

(a) Cost benefit analysis

(b) Breakeven point review

(c) Utilisation review

Equipment Audit

243. A retrospective evaluation of quality of performance of equipment in a hospital by an Equipment Audit Committee based on documented records of the equipment at the time of purchase and its subsequent maintenance. It is the periodic evaluation of the quality of performance of the hospital equipment.[70] Advantages of Equipment Audit includes it helps in standardization of the equipment and provides a satisfactory mechanism to assist at the time of condemnation of equipment .it also provide an objective method for future procurement of equipment. It evaluates concurrent performance and utilisation.

244. **Committee for Equipment Audit should comprise of the following :**

(a) Medical Superintendent or representative from Hospital administration.

(b) User Department Head or a representative detailed by the department.

(c) Head of Maintenance Cell

(d) Chief Nursing Officer or her representative.

Virtual Instrumentation- Applications to Healthcare

245. Virtual instrumentation allows the development and implementation of innovative and cost-effective biomedical applications and information-management solutions. As the health care industry continues to respond to the growing trends of managed care and capitation, it is imperative for clinically useful, cost-effective technologies to be developed and utilized. As application needs surely will continue to change, virtual instrumentation systems will continue to offer users flexible and powerful solutions without requiring new equipment or traditional instruments.[71] Virtual instruments and executive dashboards allow organizations to effectively harness the power of the PC to access, analyse, and share information throughout the enterprise. Various institutions have conceived and developed "user-defined" solutions to meet specific requirements within the health care and insurance industries. These dashboards support general operations, help hospitals manage fluctuating patient census and bed availability, and empower clinicians and researchers with tools to acquire, analyse, and display clinical information from disparate sources. Decision-makers can easily move from big-picture analyses to transaction-level details while at the same time safely sharing this information throughout the enterprise to derive knowledge and to make timely, data driven decisions. Collectively, these integrated applications directly benefit health care providers, payers, and, most importantly, patients.

GLOBAL HOSPITAL IN2050—A VISION

246. Three aspects (country and culture, provision of services, and environment of activities) configure one cube (i.e., three-dimensional grid) representing our impressions of current health issues. The components of the cube will be developed according to the development of technology, improvement of education, and changes in social structure. For instance, the development of information technology will influence the availability of health services in less-developed areas. Societal consciousness of the global environment will increase awareness of what is necessary to make it more healthful. As this cube looks like the fortune-teller's crystal ball, we may call it the "crystal cube" through which the future is visualized.[72]

247. Preventive methods, biomedical treatment methods, medical equipment technology and communication systems will continue to develop. No limits are in sight. Less-expensive technical solutions for developing countries are needed, and they are necessary to the implementation of new methods globally. This could open new possibilities for the health care technology industry. The growing functional and administrative networking of hospitals, the global tendency toward evidence-based medicine, and the implementation of quality systems will harmonize medical services globally.

248. Perhaps in 2050 we can speak on Global Medicine in the Global Hospital. The facilities will be more human in design and will meet health care needs regardless of the culture of its occupants. Finally, global efforts to improve the environment of Planet Earth may very well reduce demands for health care in general. Generally, it is very difficult to forecast our future. Lewis wrote his book *Profiles of the Future* in 1958 and showed us a chronological timetable of the future until the year of 2100, together with one of the past, back to 1800. He forecast what would happen 40 years after 1960. He anticipated human emigration to other planets, artificial intelligence (AI), global libraries, wireless energy, ocean mines, and an extended feeling of time passing. In addition, he predicted several achievements by 2050 (e.g. gravity control, memory recorder, and human hibernation). Clarke limited his work to the fields of natural science and technology, but it is amazing to find his ideas to be more or less accurate and in accord with our current views. This reveals that the forecast of our future is not impossible.

249. The efforts of the World Health Organization and the United Nations must be universally endorsed as pathways through which the health of our global population will advance. With the recognition of organizations that have global profiles, monetary and human resources can be

prioritized and equitably distributed.[88] Advances in communication technology will facilitate dissemination of medical knowledge. Finally, we should recognize that even today's medical technology made available to developing countries in 2050 will represent a major advancement in the delivery of health care. What is known as the "community hospital" in the Western world today could tomorrow improve the quality of life of those living in areas in central Africa, India, and South America. Speculation is endless, but the concept of universal health care is not.

EQUIPMENT MAINTENANCE MODEL FOR HOSPITAL

250. An effective medical equipment maintenance programme consists of adequate planning, management and implementation. Planning considers the financial, physical and human resources required to adequately implement the maintenance activities. Once the programme has been defined, financial, personnel and operational aspects are continually examined and managed to ensure the programme continues uninterrupted and improves as necessary. Ultimately, proper implementation of the programme is key to ensuring optimal equipment functionality. This model has been developed to ensure that medical equipment is acquired, stored, deployed, maintained and decommissioned in such a way that the risks inherent in its use are minimised and that its ownership represents good value for the hospital.

251. The delivery of modern hospital services depends heavily on medical equipment, whether for life support, for diagnosis, for patient monitoring, or for the delivery of therapies. The hospital should recognise that the risks associated with the ownership and use of medical equipment can only be controlled by managing the whole life-cycle of the equipment. This must include:-

(a) Identification of clinical need
(b) Evaluation and selection of Equipment
© Tendering and purchasing
(d) Training of equipment users
(e) Provision of appropriate infrastructure and services
(f) Proper storage and disposition of equipment, including equipment libraries
(g) Appropriate prescribing of equipment to patients and End Users

(h) Repair and maintenance

(j) Safe and legal disposal

Roles and Responsibilities

252. All staff are responsible for ensuring that equipment is used and stored properly and that problems are reported in such a way that the Trust is able to learn from them. Specific responsibilities are detailed below.

Chief Executive / Director of the Hospital

253. The Chief Executive / Director have overall responsibility for the safe and effective use of medical equipment. In particular this will necessitate:-

- Ensuring that the roles defined below are allocated appropriately
- Ensuring that there are regularly updated policies in place for medical equipment management, decontamination and incident reporting, and that these polices are in line with latest safety guidance, and acknowledged best practice.
- Ensuring that there are appropriate distribution and control arrangements and other safety alerts and guidance.

Medical Equipment Head

254. The designated Medical Equipment Head of Operations will have the delegated authority of the Chief Executive to:-

- Develop and implement Medical Equipment Management Policy.
- Report to the hospital board on medical equipment matters
- Ensure that all CMTs nominate Equipment Managers
- Chair the Medical Equipment utilisation committee

Medical Equipment Utilisation Committee

255. The Medical Equipment Utilisation Committee should comprise of the Medical Superintendent or representative from Hospital administration , Head of Maintenance Cell , Chief Nursing Officer or her representative, Representative medical consultants and representatives of Clinical Effectiveness, store officer and the representative from Department of Medical Physics and Engineering (MP&E).

256. Its responsibilities include:-

- Advising the medical equipment utilisation head on the development of Equipment Management Policy
- Formulating, and monitoring the implementation of, procedures in support of the overall objectives of the medical equipment management policy.
- Monitoring the management of following medical equipment within the hospital with consideration to clinical effectiveness, safety, efficiency, cost effectiveness and affordability:-

  (i) Developing and monitoring the implementation of purchasing policies for medical equipment which support the objectives of the equipment management policy.

  (ii) Establishing and managing the necessary working groups and sub-committees in support of these objectives, including those related to equipment assessment, safety selection, purchase, standardisation, use of equipment libraries and clinical user training.

  (iii)Liaising with the hospital Drug and Therapeutics Committee and other appropriate committees and groups in support of the policy objectives.

  (iv)Reporting to the hospital's Integrated Quality structure through the Clinical Effectiveness and Patient Safety Committee.

Department of Medical Physics and Engineering

257. Members of the Department of Medical Physics and Engineering are involved in many aspects of equipment management. Their particular responsibilities are:-

(a) Collaborating with clinical users and the Supplies department to carry out pre-purchase evaluation of equipment.

(b) Checking and testing equipment on loan for demonstration or any other purpose, and recording indemnity, service history and other information .

(c) Arranging for the safe disposal of equipment according to appropriate hospital procedures. Correct disposal procedures must be followed, whatever the value of the asset, to minimize the risk arising from the hospital's continuing product liability for

discarded assets, and, in collaboration with the Facilities department, that waste disposal legislation is complied with.

(d) Promoting and participating in clinical user training.

(e) Reporting incidents involving medical equipment .

(f) Providing specialist advice on health and safety issues relating to medical equipment, especially for devices using ionising radiation or where electrical safety is concerned.

(g) Maintaining a database of all equipment and its maintenance.

(h) Managing and operating medical equipment libraries (Equipment Pools).

HEAD OF CLINICAL ENGINEERING

258. The Head of Clinical Engineering is employed within the Department of Medical Physics and Engineering to manage in-house equipment maintenance services. In terms of this policy the main responsibilities of the role are:-

(a) To fill the role of Technical Supervisor as defined .

(b) Provide expert advice on equipment management and maintenance issues .

(c) Develop and promote an evidence-based risk-aware approach to equipment management.

(d) To take responsibility for final decisions relating to electrical safety of medical equipment in exceptional or non-straightforward situations where expert guidance is needed.

HEAD OF STORE DEPARTMENT

259. The Supplies department is intimately involved in the management of the equipment life-cycle. In particular the Head of Supplies has responsibility for:-

(a) Ensuring the hospital does not purchase or hire equipment which does not carry a CE mark indicating compliance with the Medical Devices Directive.

(b) Co-operating with clinical users and appropriate staff from the Department of Medical Physics and Engineering in the pre-purchase evaluation of equipment.

(c) Calculating whole-life costing for proposed equipment purchases and negotiating contracts so that equipment variety can be reduced while still delivering best value.

(d) Arranging commercial and legal aspects of the disposal of equipment according to appropriate Trust procedures.

(e) Ensuring that User and Technical Training are negotiated as part of any equipment purchasing process.

(f) Ensuring that all appropriate procedures have been followed before orders are placed for equipment.

INFECTION CONTROL COMMITTEE

260. It is the responsibility of Infection Control to:-

(a) Establish appropriate standards and procedures for decontamination of equipment.

(b) Provide specialist advice on issues relating to infection control and decontamination of equipment.

ALL STAFF PRESCRIBING OR ISSUING EQUIPMENT TO END USERS

261. It is the responsibility of all staff prescribing or issuing medical equipment to end users to ensure that:-

(a) The prescription of equipment is by prescribing professionals who should be suitably qualified and experienced staff.

(b) Those responsible for issuing equipment do not do so without an appropriate prescription from a prescribing professional.

(c) The patient or carer has received training in how to use the device.

(d) The training is supported by written guidance. The manufacturer's instructions should provide some information but this should be tailored to the needs and understanding of the individual patient or carer.

ALL EQUIPMENT USERS

262. It is the responsibility of all staff using medical equipment to:-

(a) Ensure that they have received adequate training to ensure the safe and effective use of the equipment.

(b) Ensure that single-use devices are not re-used and that equipment and devices are not modified.

(c) Liaise effectively with Medical Physics and Engineering, reporting faults accurately and ensuring information concerning incidents is available to Medical Physics and other maintenance staff.

(d) Ensure that all equipment in use, whether purchased or loaned, has passed through proper acceptance procedures.

(e) Report equipment-related incidents using the appropriate hospital procedures, ensuring that the make, model and either the asset number, equipment number or serial number of the item of equipment concerned is noted on the form.

(f) Clean and decontaminate all equipment as far as practicable before it leaves the ward or clinical department. When work is to be carried out by the Department of Medical Physics and Engineering the decontamination certificate in the requisition book must be completed. Where it is suspected that contamination may have penetrated the casing of the equipment, maintenance staff **must** be informed of this. Further advice can be obtained from the Infection Control department.

(g) Arrange for proper procedures to be followed when equipment is decommissioned.

263. Maintenance by end user should be done as below :-

(a) **<u>Plan the tasks.</u>** The maintenance tasks are placed in daily and weekly checklists. This will help in planning time for them to be carried out. In most cases, for daily tasks the beginning of the working day will be best, but any time will suit as long as the job is done. For weekly tasks, it may be easier to allocate a different day for each type of equipment, in order to spread the load through the week. A simple timetable with the person responsible can be used as a reminder.

(b) **<u>Display the lists.</u>** The maintenance checklists are designed to fit on a single page per section. This makes it easy to print or copy them and display them near the equipment. The lists will only be useful if they are easy to see, so placing them on the equipment or on a wall nearby will be best. Each page could be covered with plastic laminate or taped inside a plastic wallet. The same could be done with the troubleshooting checklists, or these could be stored nearby for when needed.

(c) **Record the work.** It is normally helpful to have some way of recording when maintenance has been done. This will tell colleagues or the next shift that the daily check has been carried out, or remind the user themselves that the weekly job has been done. It can also be helpful to show supervisors and patients that care is being taken of equipment .

Recommended Resources

264. The user should not be left on their own. Once a piece of equipment is installed, commissioned and accepted and once the user has been fully trained in operation, they will need the following resources to carry out the use and maintenance of the equipment well:-

(a) **Manuals in a fluent language** :Operator manuals are essential and should be specified at time of purchase. It is often also possible to obtain service or technical manuals, which should be held by the maintenance department.

(b) **Scheduled Maintenance** : A schedule of regular visits by qualified maintenance personnel will be needed. This might be managed by the maintenance department or senior hospital management. Whether the maintenance is in-house or outsourced, a system of reminders to prompt the work will be needed.

© **Repair Services** : The user will need to be able to call on a repair team when things break. Smaller items of equipment will be serviceable by the hospital team, whereas large scanners etc will require specialist outside services.

(d) **Contract Management** : The purchase contract should have details of what warranty services are available and contact details to call in these services. Either stores or administration should monitor performance against these contracts and plan for cover on expiry of any agreement.

(e) **Consumables supply** : The needs for consumables should have been specified during the procurement process, so that necessary supplies are available from the start of equipment use. A schedule of restocking will need to be developed, so that there is never a gap in services.

(f) **Spares Supply**: Technical advice will be required to decide which spares should be stocked on site and which should only be purchased when needed. As a general rule, it is recommended to keep spares likely to be needed for two years operation on site and to have these supplied with new equipment.

265. As a guide to technical personnel requirements, the How to Manage Guide Ziken International. TALC, St Albans suggests the following number of posts:-

Table.2.4: Recommended No. of Biomedical Engineer / Technician in Hospital

	100 BED HOSPITAL	16 – 50 BED HOSPITAL	15 OR FEWER BED HOSPITAL
Biomedical Engineer	1	0	0
Biomedical Technician	2	1	0
Assistant Technician / Artisan	3	2	1

Effective Maintenance Strategy

266. It is essential that we plan the resources required for maintenance. Planning will need to be made for both repair work and also for planned preventive maintenance. The following will also promote effective maintenance:-

(a) **User as well as service manuals** : In procurement it should be made mandatory for the vendors to provide the following:-

(i) Training to technicians and operators.

(ii) Providing user / operating manuals.

(iii) Providing service / maintenance manuals

(b) **Receipt and incoming inspection** : Incoming equipment should be carefully checked for possible shipment damages; compliance with specifications in the purchase order; and delivery of accessories, spare parts and operating and service manuals.

(c) **Inventory and documentation** : A proper entry should be made in the inventory register. The inventory record should contain the serial number and date of receipt as well as date of completed inspection.

(d) **Installation and final acceptance** : Installation should be done by the vendor and training should be provided at this stage to the user as well as to the maintenance technicians.

(e) **Equipment history record** : There should be an equipment history record sheet to track the performance of the equipment. This sheet should note down the date of installation and commissioning, preventive as well as corrective maintenance records.

(f) **Maintenance :** Proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment. Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy.

(g) **Condemnation of old and obsolete equipment** : The life cycle of medical equipment will vary from 5-10 years. If the equipment is declared obsolete by the vendor it may not be possible to get spare parts. Even if the parts are available it can become too expensive to obtain them and the equipment is no longer economical to repair. Condemnation of equipment should be well planned and the necessary steps should be taken in advance to arrange replacement.

Types and approaches to Maintenance of Medical Equipment

267. There are two types of maintenance:-

(a) **Corrective Maintenance (or Repair) :**This is done to take corrective action in the event of a breakdown of the equipment. The equipment is returned repaired and calibrated.

(b) **Planned (or Scheduled) Preventive Maintenance :**This work is done in a planned way before repair is required and the scheduled time for the work circulated well in advance. It involves cleaning, regular function / safety tests and makes sure that any problems are picked up while they are still small. The choice of approach for Preventive and Corrective Maintenance depends on the complexity of equipment .

(c) **Maintenance by in-house trained technicians**: The majority of the problems are relatively simple and can be corrected by a trained technician. Simple repairs and inspections are less costly when done this way. Vendors should provide training to in-house technicians at the time of installation and commissioning.

(d) **Maintenance by manufacturer or third party** : For specialized and advanced equipment, the vendor should provide maintenance services through a combination of on-call services and a maintenance contract negotiated at the time of the purchase. It will rarely be economical to provide this level of service in-house.

Planned Maintenance of Medical Equipment

268. Planned preventive maintenance is regular, repetitive work done at scheduled intervals to keep equipment in good working condition. The activities under preventive maintenance involve routine cleaning, calibrating and adjusting, checking for wear and tear and lubricating to optimize working efficiency and to avoid breakdown. Also consumables replacement like the fitting of new of filters etc. is done as part of this work. Effective planning for preventive maintenance involves proper selection of the equipment to be included in the plan. Decisions must be made on what to include in order to reduce costs. Inexpensive units can be replaced or repaired if they break down, so need not always be included. The overriding consideration is cost effectiveness as under:-

(a) **Setting up a complete system.** When many items of equipment are under the care of a single biomedical department, it is better to keep the planned preventive maintenance computerized with a programmed schedule. This will require:-

(i) **An equipment inventory :**All equipment in the hospital should be recorded on cards or in the computerized database. All relevant information about the equipment must be entered, including its location, records of repair and maintenance and manufacturer details. A reference number is written on each item.

(ii) **Definition of maintenance tasks** : These tasks can normally be established by consulting the manufacturer's literature.

(iii) **Establishing intervals of maintenance** : The frequency of these tasks must be decided. A heavily used item must be cleaned and checked more frequently than one which is used less often; however, minimum standards must be set. The frequency suggested in the manufacturer's manual can be used as a guide, but the amount of actual usage should determine the maintenance procedure required.

(b) **Personnel :** The biomedical team will normally monitor the Preventive Maintenance Programme as under:-

(i) **Reminder system** : It will be necessary to develop a reminder system, so that staff are prompted to carry out tasks when they are due. A card index / calendar system or a computer programme can be used.

(ii) **Special test equipment** : A biomedical team should have a range of test equipment to check the correct functioning of equipment and its compliance with electrical and other safety standards.

(iii) **Technical library** : A full technical library should be available.

(iv) **Surveillance** : After the programme has been set up, periodic surveillance must be carried out to ensure that records are legible and that all entries are being made.

(v) **Planning User Maintenance Task**

(c) **Installation of equipment.** Many common problems with medical equipment can be avoided if it is properly installed. If the right equipment arrives in working order with the right parts and manuals then a long and useful life is more likely.

(d) **Roles and responsibilities.** Each person in the chain of equipment supply has a particular role and responsibility to fulfill. This applies right from when the need for new equipment is identified to the time when it is used. The following should be used to remind each of their responsibilities and to check their performance:-

(i) **Specifier**- Make sure the specification is clear and thorough

(ii) **Purchaser** - Select, order and pay correctly, inform receiver of dates and details

(iii)**Supplier** - Check supply against specification, install on time, provide training

(iv)**Carrier** - Inform receiver before delivery, deliver safely and completely

(v) **Receiver** - Prepare site for installation, check delivery against specification

(vi)**Local technical staff** - Ensure equipment is correctly installed, learn maintenance checks required

(vii)**Stores** - Ensure equipment is complete, report to purchaser, enter into inventory

(viii)**User** - Ensure installed in the right place, check function, get and use user manuals

(e) **Checklist.** When equipment arrives, it will be necessary to record the fact and to check that everything has been supplied that was ordered. It will also be necessary to check that the equipment is supplied in the right way. The following list will help to record all details, and on the following page a single sheet of checks can be copied or printed for each item of equipment to ensure correct installation is carried out.

INVENTORY NUMBER . . . . . EQUIPMENT LOCATION . . . . . .
ACCEPTANCE DATE . . . . . WARRANTY EXPIRY DATE . . . .
MAINTENANCE CONTRACT WITH . . . .
EQUIPMENT TYPE . . . . . .
NAME OF EQUIPMENT . . . . . .
TYPE/MODEL . . . .
ORDER NUMBER . . . . . SERIAL NUMBER . . . .
COST . . . . . DATE RECEIVED . . . .
MANUFACTURER . . . . . SUPPLIER/AGENT . . . . . .
ADDRESS . . . . . .ADDRESS . . . .
. . . . . .
PHONE . . . . . PHONE . . . . . .

Table.2.5:Acceptance Checklist

ACCEPTANCE CHECKS			
ON DELIVERY			
	Yes / done	No / not done	Corrected if applicable

a) Representative of supplier present?			
b) Correct number of boxes received?			
c) After unloading, are boxes intact?			
d) If damaged, has this been stated on the delivery note and senior management informed?			

ACCEPTANCE CHECKS			
ON UNPACKING (refer to invoices, shipping documents and original specification)			

	Yes / done	No / not done	Corrected if applicable
a) Is the equipment intact and undamaged?			
b) Equipment complete as ordered?			
c) User/operator manual as ordered?			
d) Service/technical manual as ordered?			
f) Spare parts as ordered?			
e) Accessories and consumables as ordered?			

ACCEPTANCE CHECKS

ON INSTALLATION (refer to manuals given by company)			
	Yes / done	No / not done	Corrected if applicable
a) Was installation carried out satisfactorily?			
b) Were all parts present and correctly fitted?			
c) Were technical staff present as learners?			
d) Was the equipment demonstrated as fully working?			
e) Were staff trained in operation of the equipment?			

Work Order System for Corrective Maintenance

269. When a malfunction occurs with a piece of clinical equipment that is encompassed within the programme of the clinical engineering department, the user department shall notify clinical engineering by telephone, on-line/web request, inter-departmental mail or bringing the device to the clinical engineering office.

Purpose

270. To provide guidelines for the receipt and processing of clinical engineering service requests.

Procedure

271. Upon receipt of the request, a work order will be initiated. This includes priority designation and delegation of the work order to a technician for completion. Both will normally be determined by the appropriate clinical engineering manager. Input from users is encouraged with regard to priority assignment. **The priority categories are as follows**:-

(a) Emergency urgent.

(i) This describes situations of dire need and severe safety concerns for patients, visitors or staff. The lack of immediate action could lead to severe consequences for the hospital and/or potential loss of life or disability.

(ii) Emergency requests are accepted by phone or verbally and will be addressed by the chief biomedical engineer.

(iii) Under such circumstances, documentation will be completed at the earliest possible opportunity.

(iv) Should an outside vendor be required to rectify the problem, the chief biomedical engineer will test and evaluate the equipment upon return, prior to being taken into service.

(b) Urgent.

(i) This category is used for failures that require immediate attention because the operation of the hospital/facility is compromised.

(ii) A work order can be hand-carried to the clinical engineering department.

(iii) The response to the request will be as soon as possible, only an emergency request will pre-empt this work order.

(c) **Routine.**

(i) This describes an action that needs to be taken, but the situation does not compromise the primary function of the hospital/facility.

(ii) Routine work orders can be sent through the hospital/facility interdepartmental mail system.

(iii) The requesting department will be notified once the order has been received and the work has been scheduled.

(d) **Deferred.** Routine requests may be deferred based on workload or priority. No work order may be deferred for more than 10 normal working days without the approval of the clinical engineering manager.

272. Information to identify the equipment, the respective department and to describe the problem should be provided on the work request, by the person originating the request for service, or by the technician. This may include the following:-

(a) Inventory identification number

(b) Cost center (usually the user department)

(c) Equipment description

(d) Telephone number

(e) Name of contact

(f) Location of equipment

(g) Description of the problem

273. Upon completion of the work, the technician will complete the work order within one day, including all information relating to the service request. All work orders are dated and logged for record keeping. In the event that a work order cannot be completed in the requested time, or within twelve business days, the technician will notify the request originator or department manager and inform them of the reasons that the equipment repair will be delayed, and provide them with an estimated time of repair. It is the responsibility of each clinical engineering technician to follow-up on such situations as needed and personally contact the request originator or department manager if necessary. Corrective actions identified during preventive maintenance. The clinical engineering department performs preventive maintenance

procedures on a timely basis as part of the hospital's equipment management plan. Corrective actions arising during preventive maintenance procedures will be documented appropriately.

Procedure

274. **When No Problem found during preventive maintenance of a medical device**

(a) Once the preventive maintenance procedure is performed, the technician will complete the preventive maintenance work order form.

(b) The technician will affix an updated maintenance sticker, or other record of inspection, on the device. If the PM work request is completed in a month later than the scheduled month, the technician will date the sticker to correspond with the month the work request was completed.

(c) The technician will return the device to service.

275. Problem found during preventive maintenance of a medical device

(a) If a problem is determined to be minor, the preventive maintenance procedure can be completed and the device cannot be returned to service (e.g. a power cord has a cut in the covering), the technician should follow these steps:-

(i) Perform the preventive maintenance procedure.

(ii) Complete the PM work order form.

(iii) Affix an updated sticker on the device.

(iv) If the PM work request is completed in a month after the scheduled month, the technician will date the sticker to correspond with the month the work request was completed. The due date should reflect the next due date based upon the last due month and the appropriate interval for the device.

(v) Initiate a corrective work order request, affix a label to the device indicating it is out of service and inform the user department of the delay in return to service of the device.

(b) If a problem is determined to be minor, the preventive maintenance procedure can be completed and the device can be returned to service (e.g. a hose bracket for an anesthesia machine is broken or a cosmetic label has fallen off).

Disposal of Equipment

276. Healthcare institutions must ensure that there are proper procedures in place for condemnation and disposal of equipment that is unserviceable or that is no longer required. This will take old and potentially unsafe equipment out of service, make sure hazardous materials are properly treated and make storage space available.

277. Equipment may be declared surplus, obsolete or unserviceable if it is:-

(a) **Surplus to Requirement** : Where a surplus piece of equipment remains serviceable, management should be informed. It may be decided to store the equipment, auction it or use it elsewhere.

(b) **Unserviceable or unreliable** : If equipment cannot be repaired (either no parts available or not economical to repair) or it cannot be maintained properly it should be scrapped and replaced.

(c) **Obsolete :** When equipment is not usable because parts are out of date or the clinical technique is no longer recommended it should be scrapped.

(d) **Damaged through negligence or abuse** : Where abuse of equipment is suspected, this should be reported to management and the equipment taken out of use .

(e) **Beyond its prescribed life period** : Such equipment should be reported to management and the condemnation committee. They should take into account any period of storage in addition to use, examine the condition of the equipment to see whether the item could be put to further use and if not they will declaring the item obsolete/surplus or unserviceable as appropriate.

278. **The Condemnation Committee.**

The condemnation committee should have five members including one nominee from Finance department. Once they have passed equipment for disposal, a report will be prepared. In order to ensure unwanted items of equipment do not cause unnecessary waste of space, it is important that equipment disposal is done as quickly as possible but not later than six months after the decision for disposal.

279. **User responsibilities in equipment disposal.**

To ensure that equipment is disposed of in a timely and safe manner, users are advised to:-

(a) Keep management informed of equipment status :e.g. report when parts are replaced, report when equipment is unreliable.

(b) Be aware of hazards involved when equipment is disposed: e.g. warn of the presence of mercury, asbestos etc.

(c) Assist in planning for replacements: e.g. comment on helpful or unhelpful features or suppliers.

(d) Keep the asset register up to date : e.g. report when equipment arrives new or is replaced.

(e) Request regular maintenance work if it is delayed: e.g. send reminders to service / maintenance group when work is due .

(f) Inform maintenance dept of any issue as soon as possible ; e.g. report promptly any work done or spares required.

CHAPTER 3 : AIM & OBJECTIVES

Aim

280. The present study is being conducted to assess the system of maintenance of Hospital support services equipments and their utilization at Cantonment General Hospital (CGH), Delhi Cantt.

General Objective

281. To study the system of maintenance of hospital support services equipment and their utilization at Cantonment General Hospital, Delhi Cantt.

Objectives

282. To Study the system of maintenance of various hospital support service equipment.

283. To Study the utilization of equipment in various support service area of Cantonment General Hospital, Delhi Cantt.

284. Verify gaps if any and develop a model maintenance program for optimum utilization of equipment.

CHAPTER-4 : METHODOLOGY

285. Based on the specific objectives, a study is being planned to assess the overall equipment maintenance programme of support services at Cantonment General Hospital, Delhi Cantt.

286. **Plan of the Study.** The study is being planned in two parts:

(a) Retrospective .

(b) Prospective.

287. **Retrospective study** would be done by studying the documents and records pertaining to repair, maintenance and utilization of support services equipment.

288. **Prospective study** would be done by on the spot observation and interviews with key personnel of the respective areas of study as under:-

(a) **Study Setting**. The study is being planned at Cantonment General Hospital, Delhi Cantt.

(b) **Study Design**. Cross-sectional , Descriptive.

(c) **Study Population**. Select support service equipment at Cantonment General Hospital, Delhi Cantt.

(d) **Study Sample**. Support service equipment in Cantonment General Hospital, Delhi Cantt.

289. Inclusion. Equipment procured for support services with respect to Radiology, Laboratory Medicine, CSSD Deparments during the period from Year 2011 to 2016. The support services equipment from the Cantoment General Hospital, Delhi Cantt were selected to ascertain on ground functional status and its utilization in the hospital. These play a pivotal role

in patient care to overall improve the services of hospital. All the equipment taken in study is in midlife of 4-6 yrs and in these equipments the wear and tear has already commenced. Such study on hospital equipment has not been done in Cantoment General Hospital, Delhi Cantt, since inception. The study includes the following:-

(a) Diagnostic equipment including medical imaging machines, used to aid in diagnosis. Examples are ultrasound and X-Ray machines..

(b) Medical laboratory equipment / automates to help and analyze blood, urine, genes, and dissolved gases in the blood.

(c) CSSD equipments which receives processes, sterilizes stores and distributes the equipment, sets, dressings, packs, etc. to different user departments of the hospital including wards, out-patient department, OTs etc. This department plays a phenomenal role against spread of hospital infection.

290. Exclusion. Outsourced equipment / facility.

Phases of the Study

291. The study was carried out in following phases:

(a) Phase I : Discussions with key personnel concerned with the running and maintenance of the equipment were carried out to have an overall idea of maintenance system of equipment. All department were visited to understand the maintenance programme of equipment and their functional status.

(b) Phase II : The various letters, memos and requests for maintenance of equipment from various clinical departments were also studied.

(c) Phase III : Functional status was assessed and utilization coefficient of the select equipment calculated.

(d) Phase IV: Data was tabulated in excel 2007 , inferences were drawn.

292. **Expected Outcome.**

(a) Overall on- ground assessment of the maintenance and utilization of support services equipment.

(b) Overall utilization index and down time index of support services equipment.

(c) Recommendations for improvement will be given based on the derived shortcomings.

(d) Develop a model maintenance program for optimum utilization of equipment after finding gaps thereby increasing the life of the machines.

293. Time Frame 24 Feb to 19 May 2016

Assessment of Functional Status of Equipment

294. Two Cross sectional studies were undertaken and the functionality were tabulated as under:-

Table4.1: Functional status of Equipment

Sr.no	**Equipment Name**	**Date of 1st inspection** **F / NF**	**Date of 2nd inspection** **F/NF**	**% Functional**	**% Non-Function**

Assessment of Utilization Index of Equipment

295. Cross sectional studies were undertaken and the utilization were tabulated as under:-

Table 4.2: Utilization Index status of the Equipment

Sr. No	**Equipment Name**	**N = Average number of hours the equipment is actually used per day**	**M = Maximum number of hours the equipment can be used per day.**	**Utilization coefficient** $\text{Use Coefficient (U.C)} = \frac{N}{M} \times 100$

Where N = Average number of hours the equipment is actually used per day. M = Maximum number of hours the equipment can be used per day.

Assessment of Downtime Index of Equipment

296. Cross sectional studies were undertaken and the Downtime were tabulated as under:-

Table4.3: Downtime Index & Breakdown Maintenance Index

Sr.No.	**Equipment Name**	**Down time Index** Downtime per week x100 / Available machine hour per week	**Breakdown Maintenance Index** Labour hour spent on breakdown maintenance x 100 / Labour hour spent on all maintenance (preventive + breakdown maintenance time in hrs)

Available machine hours = [(weekly working days) x (hours per day) x (number of machine)].

Downtime per week: Total downtime in a year / number of week in one year

Each time labour hr spent on repair = …… hrs(mechanic spent on repair)

Preventative maintenance: …… hrs each day (spent each day)

Weekly working days: …… days (total number of working days)

Hours per day: …….. hrs (machine runs)

Number of machine: calculated for single machine.

The term downtime is used to refer to periods when a system is unavailable. Downtime or outage duration refers to a period of time that a system fails to provide or perform its primary function.

CHAPTER 5 : OBSERVATION, ANALYSIS AND DISCUSSION

MAINTENANCE SYSTEM IN CGH, DELHI CANTT

297. The CGH is a government hospital under Delhi Cantonment Board (autonomous body) with a status of a university. Total bed strength of CGH is 24. During 2015-2016, OPD load was 3.1 lakhs , Kishori load of 23569, Senior Citizen load of 22682 and 1235 admissions., occupancy rate of 41.6 % , average period of hospital stay was 2 days..

298. The patient care services were offered in outpatient's department, inpatient department, and emergency department . Supportive services like CSSD, Laboratory, Diagnostic services etc were common for all. All the Departments were delivering the quality of medical care to the patients with the help of qualified, experienced doctors, technical staff and modern equipment.

GENERAL SURVEY OF MEDICAL EQUIPMENTS IN CGH

299. All departments of CGH (including support services) were visited to survey the various types of equipment available ; their purchase procedure, source of funding, maintenance systems practiced ; functional status of equipment etc. discussion were held with key personals concerned with running and maintenance of the equipment such as Store In-Charge / Holders, Functional In-Charge, Equipment Handlers (including respective Staff Nurses), Doctors, Head of the Departments and even CMO, to have an overall idea of the equipment management system including maintenance. General information collected during discussions with key personals concerned with equipment running and maintenance are mentioned below:-

300. The CGH has many number and types of equipment (including support service equipment) distributed in different departments. Equipment having simple technology and low cost (weighing machine in stores and wards, microscope in laboratory) to modern sophisticated and high cost (X Ray Intensifier, Ultra Sound Machine, Laparoscopy set etc) have been made available in the Departments. These equipments have been purchased by the Hospital on demand from various sources such as head of the department, specialists and consultants concerned. Some of the minor equipments like wheel-chairs(used) have been donated by patients and their associates. However, all the equipment available in the hospital were not in use. Some of them

are not in use due to installation problem, out of order state and due to some other procedural reasons.

301. On the discussion with the user and concerned, it was brought to the notice that the equipment available are mainly maintained by outside agency such as manufacture and third party on annual maintenance contract or visit basis. These equipment are being used as long as they continue to work. Practices of preventative and breakdown maintenance system needs further stream-lining.

302. At many a places the preventative maintenance was not carried out for routinely used equipment. Users have mixed reaction on their satisfaction for on-going maintenance programme. A large number of users do not know the equipment maintenance protocols. Other key issues involved in the equipment management such as schedule of maintenance, availability of spare parts, availability of maintenance services in time and response time of the equipment, training programme for the users, log book / equipment history sheet maintenance, availability of operating manual were also discussed with the person concerned. The major issues which emerged during the survey, which requires more in-depth information are as under:-

Demand Generation

303. Usually demand for the equipment is generated from

(a) Head of Department.

(b) Concerned Specialist.

Equipment Procurement

304. In CGH, procurement is based on:-

(a) Necessity of the equipment

(b) Availability of funds

Approval for Procurement

305. **Technical / Administrative Approval:** Technical approval is taken to justify the need and specification of the equipment. Technical approval is given by a "specification committee" comprised of as under:-

(a) **Less than Rupees One lakh Value of Equipment (by Local Purchase Committee Under Powers of CMO).**

(i) CMO.

(ii) Concerned doctor / specialist from departments.

(iii) JE, Cantt Board.

(iv) AS, Cantt Board.

(v) Store-In-Charge..

(b) **More than Rupees One Lakh and less than Ten Lacs Value of Equipment.**

(i) CMO.

(ii) Concerned Specialist of Department.

(iii) Store I C.

(iv) GDMO.

(v) Engineer, Cantt Board.

(vi) SEMO, Base Hospital.

(c) **More than Rupees Ten Lacs Value of Equipment.**

(i) CMO.

(ii) Engineer, Cantt Board.

(iii) Two Representatives from HSCC.

(iv) Concerned Specialist from Department.

306. The above Specification Committees will also evaluate the tenders and make comparative Statements which will be signed by the Account Officer concerned and sent to Store Officer. The administrative approval is also given by the above mentioned Committee. After recommendation the approval is given by CMO (for purchase of equipment with value of maximum Rupees One Lakh) and CEO, Cantt Board (for purchase of equipment with value of more than Rupees One Lakh).

307. **PURCHASE PROCEDURE.**

(a) Notice inviting tender for less than Rupees Ten Lacs equipment in two local newspapers.

(b) Notice inviting tender for more than Rupees Ten Lacs equipment in two National newspapers.

(c) Rate enquiry – to limited firms

(d) Proprietary item – without tender or rate enquiry.

(e) Two bid system of tendering resorted.

(f) Firstly, technical bid is opened. Based on suitability of the technical parameters, respective vendors / bidders are called for display of their sample equipments. Then, detail technical evaluation is done by the medical expert team.

(g) Secondly, financial bid is vetted out based if the equipment meets the laid down technical criteria and parameters.

(h) Thirdly, based on best quoted rate for the desired equipment (meeting technical criterion) orders for procurement are placed to respective vendors / suppliers.

(j) All GFR rules are followed while purchasing the equipment..

308. **Source of Funding .**

(a) Hospital budget

(b) Non institute fund- collaborative research scheme (in relevant cases only).

(c) Other National / International fund

309. **Budget allocation.** Budget is allocated for the purchase of new equipment and maintenance (plan and non plan) under Budget Head 'F1'.

WARRANTY AND MAINTENANCE CONTRACT

310. Earlier no specific generalized terms & conditions have been framed for maintenance contract. Terms and conditions were usually accepted as per choice of vendor. Recently common terms and conditions have been made for most of the equipment under contract. The high tech equipment purchased recently (within last 5 years) have got the comprehensive maintenance contract & conditions are well defined.

AWARD OF MAINTENANCE CONTRACT

311. Contract for maintenance is awarded by following methods:-

(a) At the time of equipment purchase: many equipment, specially purchased after 2012 have the maintenance provision at the time of purchase. Radio diagnosis equipments, autoclave machine and other high cost equipment like laparoscopic sets etc forms part of this provision. The terms and conditions are incorporated in the tender floated for the purchase of equipment and finalized on the basis of specification and reasonable cost to be incurred in the maintenance. The maintenance contract is finalized on annual basis or at a stretch for more than one year. The renewal /extension is done subject to satisfactory work executed by contractor.

(b) After the equipment purchase: this is applicable where the maintenance provision for the equipment was not incorporated at the time of purchase. The contract is awarded to (1) manufacturer (2) authorized dealer of manufacturer or (3) third party. While awarding the contract, efforts are done that the maintenance is given to the manufacturer or authorized dealer of the equipment as a first choice but if not possible is given to third party, with expertise in the field.

Process of contract award

312. Contract of maintenance with manufacturer or authorized dealer is awarded on "proprietary basis". The maintenance charges quoted by the firm are negotiated to the tune to get cost effective results possibly. In case of "third part", the contract is awarded on the basis of specifications (terms & conditions) and reasonable cost offered by the contractor. The tender for the maintenance is floated in local / national nal newspaper depending upon sophistication of technology of the equipment or rate enquiry is made from the limited reputed firms. The equipment maintenance contract is awarded in two parts.

(a) **Comprehensive** – This includes contract of machine maintenance (service) and is applicable for preventive & breakdown maintenance both. A comprehensive maintenance management system coupled with knowledgeable and capable maintenance staff will yield longer asset life with fewer breakdowns; resulting in lower operating costs and a higher productivity. It will lead to reduction in administrative and maintenance costs, improving budgeting and control, ensuring continuity of supply of spare parts if required for repair, devotion of energies to other priorities and enabling benchmarking through setting of performance targets.

(b) **Non-Comprehensive** – This includes separate contract for the maintenance/service and spare parts or only for maintenance/service. This is also applicable for preventive and breakdown maintenance both.

313. Other than annual maintenance contract (AMC), "one time repair" practice is also existing in the institute. This is done in case of equipment breakdown. The maintenance cost thus finalized is on annual basis. Provision of cost escalation every year is considered at the time of finalization. Usually 10 % escalation of original maintenance cost is added annually or prorate rate annually which automatically cover the annual escalation, is fixed for the maintenance. The cost is fixed on the following basis:-

(a) Maintenance cost only

(b) Maintenance and spare parts cost separately.

(c) Maintenance and spare parts costs combined.

(d) Maintenance cost (breakdown) of one time repair is also finalized by the tender or rate enquiry form at least 3 vendors.

Payment Against Maintenance Work to Firm

314. Payment against work executed by the contractors is done on the basis of terms and conditions and verification of work and bill by the competent authority. The accounts section informed that sometimes there is a delay in payment due to incomplete verification of bills by the users and other financial formulates by the vendors.

FLOATING OF TENDERS

315. Procedures / Guidelines for Handling of Tenders, Open Tender Method shall normally be followed for all procurement worth more than Rupees One Lakh. Splitting of indents, in order to bring it outside the ambit of Open tender Method, is strictly prohibited.

(a) Notice inviting tenders (NIT) is given in at least two local dailies if the purchase is worth till Rupees Ten Lacs. NIT shall be given in at least two National dailies for procurement worth Rupees Ten Lacs. One complete set of NIT may be displayed on the Tender Notice Board.

(b) NIT should be short, clearly worded, and unambiguous and should mention the cost of tender document, the amount of EMD, last date of sale of tender documents, etc. It should give a brief description of specifications for the supplier, the last date of receipt of completed tenders, the date, time and venue of opening of tenders. Detailed technical specifications should be given only along with the tender papers.

(c) Global tender may be issued if it is felt that bidding from indigenous sources through open tendering shall not result in competitive prices. In such cases, in addition to the open tendering procedures, copies of the NIT may be sent to the Embassies of Countries where such manufactures are located by giving them sufficient time so that they can forward the notice to prospective bidders in their countries.

(d) Time Limit Allowed to Bidders :

(i) Open tender - 4-6 weeks

(ii) Global tender - 6-8 weeks

(iii) In case of urgency, time period can be reduced with proper justification and approval by competent authority.

316. The tender documents comprise detailed specifications, conditions of contract, the Performa in which the tender is to be submitted (two bid system) and such other material. Rates for open tender documents are (exclusive of postage/courier charges & sales tax) –

Value Cost

Rs 2 lacs – Rs 5 lacs	Rs 100
Rs 5 lacs – Rs 10 lacs	Rs 500
Rs 10 lacs –Rs 50 lacs	Rs 1000
Rs 50 lacs& above	Rs 2000

- The tender document must be accompanied by an Earnest Money Deposit/ Bid security by way of DD/BG @ 2-5% of the estimated value as decided. EMD is returned to unsuccessful bidders. Successful bidders shall furnish an unconditional Performance Guarantee in the form of a DD/BG for 10% or higher as decided till 60 days after the warranty period / at the time of release of the final payment.

Receipt of Tenders

317. Tenders are received through post/courier/hand. The tenders are dropped in the tender box whose keys are with the Purchase Officer. Tenders received late are returned to the bidders in original envelope without opening.

Opening of Tenders

318. The tenders shall be opened by a committee consisting of Rep. of FA, Stores Officer and the User Deparment, if required, in the presence of tenderers. If there is any discrepancy in the price quoted in figures and words, the higher of the two will be taken. The financial (Price) bid after the opening of the technical bids in case the two bid system is adopted will be kept in the

personal custody of the concerned purchase officer. The financial bids are opened only after short – listing of firms has been done on the basis of the technical evaluation. In case only one tender is received against an open tender, the case will be referred to the Specification Committee for consideration. After opening the tender , it becomes necessary to award the contract within the validity of the offers, clearly stipulating among others, the description of item, price , delivery and emphasis that time is essence of the contract. Then the supplier submit the bank guarantee and sign the memorandum of understanding with hospital.

Placement of supply order

319. Supply order for an item or a group items should be placed on the firm based on the approval given in the comparative statements. It should be ensured that the total cost of the individual item does not exceed the financial power laid down. After the sanction by the competent authority, required copies of supply orders are prepared by the purchase officer. The delivery period should be fixed at 4-6 weeks unless earlier delivery can be arranged with firms concerned in emergent cases. A clause to effect that liquidated damages/ penalty would be levied for late delivery/ non supply should be incorporated in the supply order.

EQUIPMENT STATUS

320. **Available Number and Type of Equipment**. CGH, Delhi Cantt has many types of medical equipments. Physical inspection of all departments was carried out to know number and types of equipment held by these departments. The exact number of equipment could not be included due to non-availability of the complete information on the same due to improper documentation. However , it was observed that CGH, Delhi Cantt have many types of equipment which are being classified as under:-

Table 5.1: Types of Equipment

	Type	Example
A	**On the basis of use**	
	1. Diagnostic	X Ray / Imaging machine, microscope
	2. Therapeutic	Ventilators , infusion pump

	3. Monitoring	Cardiac monitor , BG analyzer
	4. Supportive	Sterilizer, Autoclave, Dryer
	5. Administrative	Computer , Printer
	6. Research	Microscope
B	**On the basis of place of manufacturer**	
	1. Imported	Hysteroscope
	2. Indigenous	BP instrument , suction machine
C	**On the basis of technology**	
	1. Electrical	Suction machine, Diathermy machine
	2. mechanical	BP machine, weight machine
	3. biomedical	Ventilator , monitors
	4. electro magnetic	ECG Monitor, Diathermy Machine
	5. electronics	Defibrillator, ECG Machine
D	**On the basis of direct patient care**	
	1. routine care	BP instrument, suction apparatus
	2. intensive care	Ventilator , infusion pump
	3. Resuscitative	laryngoscope , defibrillator
E	**On the basis of indirect patient care**	
	1. Diagnostic	Endoscope , ultrasound machine
	2. Supportive	Sterilizer , Autoclave
	3. Monitoring	BG analyzer , Cardiac Monitor
F	**On the basis of requirement**	
	1. Vital	Defibrillator , laryngoscope
	2. Essential	Ventilator , Cardiac Monitor
	3. Desirable	Electronic BP Machine, Air curtains
G	**On the basis of cost**	
	1. Low cost	BP Instrument , Suction Apparatus
	2. Medium cost	Ventilator , cardiac monitor
	3. High cost	Laparoscopy set, High Definition Orthoscopic System

321. The custodian of these equipments are either head of the department or doctor / sister / technician in charge. CGH does not have a proper centralized method of information, therefore, no complete data regarding following is available:

(a) Number of equipment
(b) Types of equipment
(c) Value of equipment
(d) Maintenance cost of equipment
(e) Common maintenance procedure and terms & condition of the maintenance contract .
(f) Equipment audit.
(g) Details of Unserviceable / obsolescent equipment endorsed with other associated inputs.

EQUIPMENT MANAGEMENT PROGRAM IN CGH

322. CGH has a Central Stores Section for the tendering and purchase of equipment required by all departments of the Institute. However, the Departments does not have their own stores organizations headed by a Technical Officer. The system of purchase for equipment followed in CGH is a mix of centralized and decentralized methods. The Stores organization at CGH broadly comprises of the Stores Section of the Hospital which functions directly under the CMO and lays down the policies, procedures and practices in these stores are as per directives framed by the CGH based on Government rules, notably the DGS&D Manual and the General Financial Rules (GFR).

IN HOUSE MAINTENANCE FACILITIES

323. There does not exist any in-house workshop of CGH, hence, intimate and real time breakdown maintenance for various equipment of frequent use in the wards and laboratories is a problem and results in time delay. Though, most high cost equipment now have an Comprehensive Maintenance Contract incorporated in the initial tender for procurement for a period of 5 yrs., next 2 yrs, with spares & 3 yrs without spares and for High cost equipment which is more than 5 yrs old, CMC's are contracted by tendering local / national newspapers for breakdown maintenance. These CMC's are awarded and renewed annually on satisfactory completion of the period. Still, preventive maintenance gets adversely affected leading to

breakdowns due to absence of in – house workshop. Equipment wise maintenance record & expenditure was not maintained by respective Department or by Central Store Section at CGH. The maintenance schedule or history sheet of any equipment is neither maintained by centrally nor by the user. Therefore, cost effectiveness of the system could not be measured.

324. Broadly, at CGH, equipment maintenance is performed as follows:-

- **Low cost equipment** – Breakdown maintenance done by authorized dealers since no in-house workshop exists.
- **Medium cost equipment** – Manufacturer & Authorised dealers provide Preventive & Breakdown maintenance while third party is also at times involved in preventive & breakdown maintenance.
- **High cost equipment** – Preventive & Breakdown maintenance by Full Time Dedicated Engineers from manufacturer and/or authorized dealer for these high cost equipments.

325. Thus, CGH, till date does not have a comprehensive maintenance management program in place and most of the equipment do not have a log book and history sheets, which records the entire work history of the equipment from the time it is delivered to the hospital. Most high cost equipment now have an Annual Maintenance Contract incorporated in the initial tender for procurement for a period of 5 yrs., 2 yrs, with spares & 3 yrs without spares. For High cost equipment which is more than 5 yrs old, AMC's are contracted by tendering for preventive & breakdown maintenance. These AMC's are awarded and renewed annually on satisfactory completion of the period.

326. **<u>Problem Faced with respect to Equipment Maintenance.</u>**

(a) Unavailability of trained qualified technicians on strength of CGH for providing preventive & breakdown maintenance.

(b) Insufficient budget allocation

(c) Condemnation and disposal of some of the unserviceable & obsolescent equipments.

(d) Some equipment still to be operationalized even after lapse of an year due to problems related to documentation and delayed payment to vendor.

(e) Log books are not maintained by the user.

(f) Service manual or catalogue is not available for most of the equipments for maintenance / repair.

(g) Lack of 1st line maintenance (day to day maintenance practice) like dusting oiling, greasing of the equipments by the users.

(h) Framing of specification for equipment needs to be done in consonance with own workshop (which is not there in CGH) and technicians..

.

EQUIPMENT MAINTENANCEPROGRAMMEIN BLOOD BANK

327. Blood bank does not exist in CGH, hence, conduct of major surgery is problematic..

EQUIPMENT MANAGEMENT AT HOSPITAL DIETARY SERVICES

328. Absence of dietary services in CGH, hence, patient care gets adversely affected.

.

EQUIPMENT MAINTENANCE IN LAUNDRY

329. There is no laundry services in CGH, hence, there is a need to sensitize all concerned to take remedial measures against Hospital Acquired Infections.

EQUIPMENT MAINTENANCE IN MANIFOLD

330. Manifold system does not exist in CGH. This may be considered for implementation in future for improving patient care delivery.

EQUIPMENT MANAGEMENT IN CENTRAL STERILE SUPPLY DEPARTMENT

331. The building is located on the second floor, towards the back yard of the hospital. It is close to the patient care area and has easy accessibility through a wide corridor. The main equipment used in CSSD was autoclave, which consists of a chamber designed to withstand pressure, a vacuum pump to evacuate chamber gas, a jacket, a steam source to humidify chamber and a volatilizer to vaporize and inject sterilant. Other was Drying cabinet, Ultrasonic washer disinfector and Gauge cutting machine etc. In CSSD most of the high end equipment were covered under CMC. Some of the equipment was under AMC also. Repair were also carried out by Vendor on call basis.

332. **Equipment available in Central sterile supply department.**

(a) Steam Autoclave Automatic (Electrical) : 01

(b) Small Steam Autoclave High Speed Sterilizer Portable : 01

(c) Autoclave High Speed (Horizontal) :01

(d) Autoclave Steam Sterilizer (Square) :01

(e) Autoclave Portable Vertical Shape- Electric :05

(f) Gauge Cutting Machine :01

(g) Drying Cabinet :01

(g) Ultra sonic Cleaner 40 litres :01

(h) Washing Station Full Double Sink :01

Figure 5.1: Equipment used in CSSD

EQUIPMENT MANAGEMENT IN RADIO DIAGNOSIS

333. In Radio-diagnosis most of the high end equipment were covered under CMC. Some of the equipment were under AMC also. Minor repair were carried out by Vendor on call basis.

Figure 5.2: Equipment used in radiology

334. Equipment available in the department are as under :-

(a) X Ray Intensifier 500MA :01

(b) Mobile X Ray :01

(c) Ultra Sound Machine with Probes :01

(d) Automatic Film Processor :01

EQUIPMENT MAINTENANCE IN LABORATORY

335. In the service area, the laboratory department caters to CGH responding to patients from OPDs and Wards to perform The investigations range from routine biochemistry to haemogram. It is involved in Test selection (Pre-test counseling), Test performance and Test interpretation (Post-test counseling) in the area of clinical chemistry, clinical pathology, clinical hematology, and clinical microbiology having respective faculty member in charge of their specialized area. In Laboratory most of the high end equipment were covered under CMC. Some of the equipment were under AMC also. Minor repair were carried out by Vendors on call basis. The equipment present in laboratory department are various types as under :-

(a) Auto Bio Chemistry (Analyzer) 600 :01

(b) I Count :01

(c) Binocular Microscope :2

(d) Refrigerator :2

(e) UPS 10 KVA :1

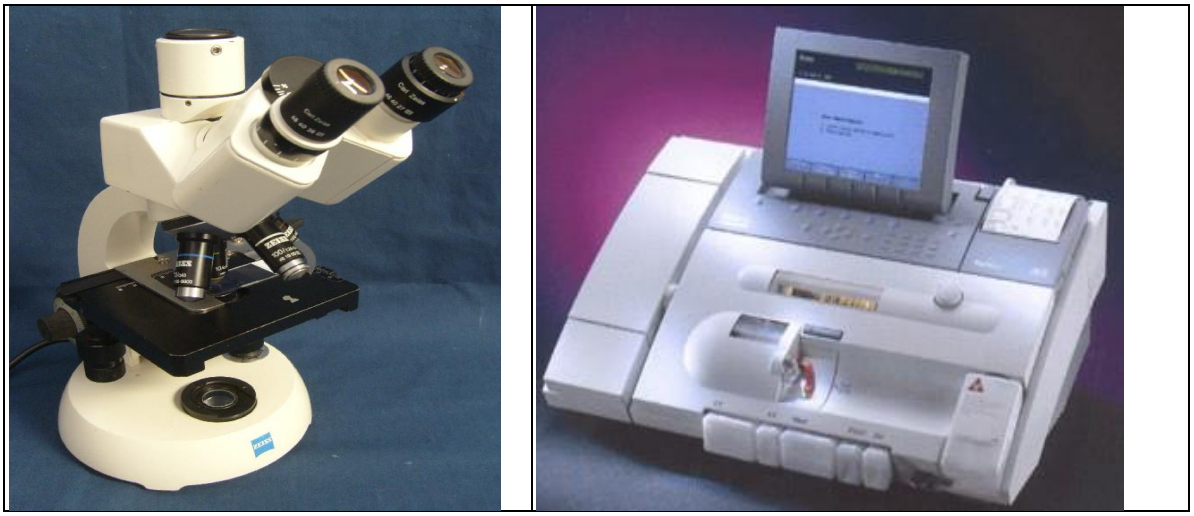


Figure 5.3 : Equipment used in laboratory

STATUS OF EQUIPMENT MAINTENANCE

Functional Status of Equipment

336. There is no central agency in the Hospital which has formalized details about all medical equipments including its maintenance, utilization, breakdown, downtime and repairs. As such effort was made with the help of the central store section to collect the information regarding number of equipment held, purchase cost and functional status of the equipments.

Functional status of Central Sterile Supply department

337. A study was conducted on functional and maintenance status of all equipment purchased during 2011 – 2016. Total equipment studied as under:-

Table.5.2. Functional status of CSSD Equipment

Sr.no	Name of equipment	Date of 1st inspection 22 Apr 2016 F / NF	Date of 2nd inspection 13 May 2016 F/NF	% Functional	% non- function
1.	Steam Autoclave Automatic Electrical Jan 2013	NF	NF	-	100%
2.	Small Steam Autoclave High Speed Sterilized Portable	NF	NF	-	100%
3.	Autoclave Steam Sterilizer(Square) Steel	F	F	100%	-
4.	Autoclave High Speed(Horizontal)	NF	NF	-	100%
5.	Drying Cabinet	NF	NF	-	100%
6.	Ultrasonic Cleaner 40 litres	NF	NF	-	100%
7.	Washing Station Full Double Sink	NF	NF	-	100%
8.	Autoclave Portable Vertical Shape (Electric)	NF	NF	-	100%
9.	Gauge Cutting Machine	F	F	100%	-
Total				22.22 %	77.77%

338. The general observations and discussions are as follows:

22.22 % equipment were in functional order.

339. Reason for equipment not in working condition (as given by Key Informants)

- Non availability of spare part
- Equipment yet to be installed.
- Delay in payment

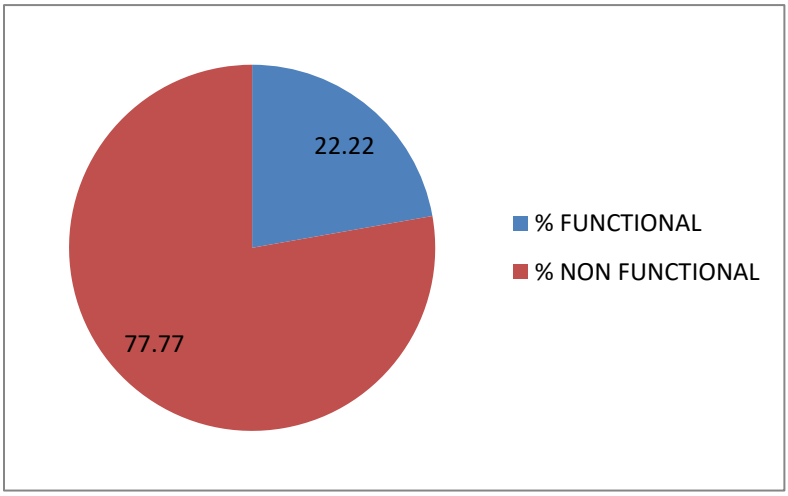


Figure5.4: Functional Status of CSSD

Table 5.3. Utilization index status of the equipment in CSSD, CGH hospital

Sr. no	Name of equipment	N = Average number of hours the equipment is actually used per day	M = Maximum number of hours the equipment can be used per day.	Utilization coefficient $\text{Use Coefficient (U.C)} = \frac{N}{M} \times 100$
1.	Steam Autoclave Automatic Electrical Jan 2013	08 Hrs	24 Hrs	8/24X100= 33.33%
2.	Small Steam Autoclave High Speed Sterilized Portable	08 Hrs	24 Hrs	8/24X100= 33.33%
3.	Autoclave Steam	08 Hrs	24 Hrs	8/24X100=

	Sterilizer(Square) Steel			33.33%
4.	Autoclave High Speed(Horizontal)	08 Hrs	24 Hrs	8/24X100= 33.33%
5.	Drying Cabinet	08 Hrs	24 Hrs	8/24X100= 33.33%
6.	Ultrasonic Cleaner 40 litres	08 Hrs	24 Hrs	8/24X100= 33.33%
7.	Washing Station Full Double Sink	08 Hrs	24 Hrs	8/24X100= 33.33%
8.	Autoclave Portable Vertical Shape (Electric)	08 Hrs	24 Hrs	8/24X100= 33.33%
9.	Gauge Cutting Machine	08 Hrs	24 Hrs	8/24X100= 33.33%
Total				8/24X100= 33.33%

Where N = Average number of hours the equipment is actually used per day. M = Maximum number of hours the equipment can be used per day.

Table 5.4: Downtime Status of the Steam Autoclave Automatic Electrical in CSSD, CGH

Steam Autoclave Automatic Electrical		
Date at Problem	**Rectified on Date**	**TOTAL DURATION in hrs**
5/1/15 11:30:00 AM	10/1/15 10:30 AM	119
18/3/15 10:00 AM	20/3/15 12:00:00 AM	50
16/7/15 11:30 AM	18/7/15 11:30 AM	48
27/7/15 9:00:00 AM	29/7/15 12:00 AM	51

TOTAL		268

Table 5.5: Down Time: Small Steam Autoclave High Speed Sterilized Portable in CSSD, CGH

Small Steam Autoclave High Speed Sterilized Portable				
Date at Problem		**Rectified on Date/ Still Off road or Not being Used**		**TOTAL DURATION hrs**
01/01/2015	9:00 AM	31/12/2015	6:00 PM	8745
		Downtime	Total	8745

Table 5.6: Down Time: Drying Cabinet in CSSD, CGH

Drying Cabinet				
Date at Problem		**Rectified on Date/ Still Off road or Not being Used**		**TOTAL DURATION hrs**
01/01/2015	9:00 AM	31/12/2015	6:00 PM	8745
		Downtime	Total	8745

Table 5.7: Down Time: Ultrasonic Cleaner 40 litres in CSSD, CGH

Ultrasonic Cleaner 40 litres				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
01/01/2015	9:00 AM	31/12/2015	6:00 PM	8745
		Downtime	Total	8745

Table 5.8: Down Time: Washing Station Full Double Sink in CSSD, CGH

Washing Station Full Double Sink				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
01/01/2015	9:00 AM	31/12/2015	6:00 PM	8745
		Downtime	Total	8745

Table 5.9: Down Time: Autoclave Portable Vertical Shape (Electric)in CSSD, CGH

Autoclave Portable Vertical Shape (Electric)				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
10/04/2015	9:00 AM	09/04/2016	6:00 PM	8745
		Downtime	Total	8745

Table 5.10: Down Time: Autoclave High Speed(Horizontal)in CSSD, CGH

Autoclave High Speed(Horizontal)				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
10/04/2015	9:00 AM	09/04/2016	6:00 PM	8745
		Downtime	Total	8745

Table 5.11: Down Time: Gauge Cutting Machine in CSSD, CGH

Gauge Cutting Machine				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
01/05/2015	9:00 AM	03/05/2015	11:00 AM	50
03/10/2015	10:00 AM	06/10/2015	11:00 AM	73
		Downtime	Total	123

Table 5.12: Down Time: Autoclave Steam Sterilizer(Square) Steel in CSSD, CGH

Autoclave Steam Sterilizer(Square) Steel				
Date at Problem		**Rectified on Date/ Still Off road**		**TOTAL DURATION hrs**
10/05/2015	9:00 AM	10/05/2015	4:00 PM	7
13/11/2015	10:00 AM	15/11/2015	1:00 PM	51
12/02/2016	9:00 AM	13/02/2016	11:00 AM	26

		Downtime	Total	84

Table 5.13: Downtime Index & Break down maintenance index of CSSD

Sr. no	Name of equipment	**Down time index** Downtime per week x100 / Available machine hour per week	**Break down maintenance index** Labour hour spent on breakdown maintenance x 100 / Labour hour spent on all maintenance (preventive + breakdown maintenance time in hrs).
1.	Steam Autoclave Automatic Electrical Jan 2013	5.15X100/168 =3.06%	2X4X100/.5X365+8=4.40%
2.	Small Steam Autoclave High Speed Sterilized Portable	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %
3.	Autoclave Steam Sterilizer(Square) Steel	1.62X100/168 =0.96%	2X3X100/.5X365+6=3.18%
4.	Autoclave High Speed(Horizontal)	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %
5.	Drying Cabinet	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %
6.	Ultrasonic Cleaner 40 litres	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %
7.	Washing Station Full Double Sink	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %

8.	Autoclave Portable Vertical Shape (Electric)	168.17X100/168=100.1%	2X1X100/.5X365+2=1.08 %
9.	Gauge Cutting Machine	2.36X100/168=1.41%	2X2X100/.5X365+4=2.14%
Total		67.34%	1.8%

Available machine hours = [(weekly working days) x (hours per day) x (number of machine)].

Downtime per week: total downtime in a year / number of week in one year

Each time labour hr spent on repair = 2 hrs

Preventative maintenance: 0.5 hrs each day

Weekly working days: 7 days

Hours per day: 24 hrs

Number of machine: calculated for single machine.

The term downtime is used to refer to periods when a system is unavailable. Downtime or outage duration refers to a period of time that a system fails to provide or perform its primary function.

340. **The observations were as follows**:-

(a) 22.22 % equipment were being used, that means 02 out of 09 equipments are being presently used..

(b) 77.77 % equipment, 7 out of 9 were not in use due to various reasons of pending finalization of documentation (including outstanding payment to vendor), equipment installation and inspection formalities and also due to a repair work.

(c) Utilisation coefficient of CSSD equipment were 33.33 %.

(d) Downtime index was **67.34 %**while breakdown maintenance index was only1.8 **%**. High downtime index and very low breakdown maintenance index was mainly due to non- utilization of a number of CSSD equipments on charge of CSSD,due to problems of installation, pending contract finalization etc.

Maintenance Practices in Laundry

341. Aspects regarding utilization and maintenance of Laundry equipment is not being considered here since, the Laundry Services are out-sourced.

Maintenance Practices in Manifold

342. Utilization and maintenance of Manifold equipments is not being considered since, CGH, does not have Manifold system and the supply of oxygen / gas cylinders are being undertaken physically on day to day basis since the quantity required is very less.

Maintenance Practices in Kitchen

343. Due to absence of the Dietary Services in the Hospital, there exists no dietary services equipment incharge of the CGH. The patients of IPD are only served bread, milk and eggs by the hospital. These patient have to cater for their own meals..

MAINTENANCE PRACTICES IN RADIO-DIAGNOSIS

344. Most of the equipment were dependent on CMC /AMC. Whenever equipment breakdown is there, they call the concern Company for repairs.

Table5.14. Functional / Non-functional status of the equipment in Radio-diagnosis, CGH

S.no	Equipment name	Date of 1st Inspection : 14 Mar 2016 F / NF	Date of 2nd Inspection : 14 May 2016 F/NF	% Functional	% non-functional
1.	Automatic Film Processor	NF	NF	-	100%
2.	Manual Film Processor	F	F	100%	-
3.	Mobile X-Ray	F	NF	50 %	50%
4.	X Ray Intensifier 500MA	F	F	100 %	-
5.	Ultra Sound Machine with Probes	F	F	100 %	-
	Total			70%	30%

345. The general observations and discussions are as follows:

70 % of equipment were in functional order.

346. Reason for equipment not in working condition (as given by Key Informants)

- Non availability of spare part
- Delay in payment

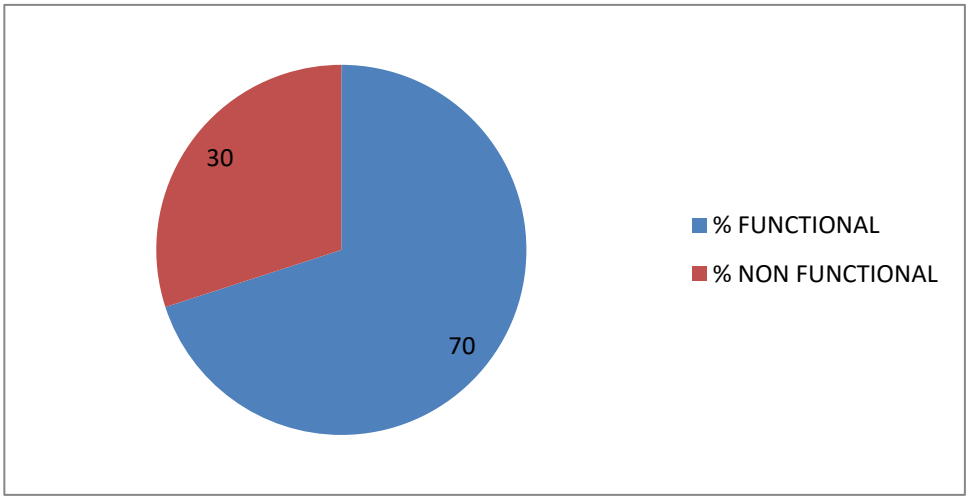


Figure 5.5: Functional Status of Radio-diagnosis

Table 5.15. Utilization index status of the equipment in Radio-diagnosis, CGH

Sr. No	Name of Equipment	N (Average number of hours the equipment is actually used per day)	M (Maximum number of hours the equipment can be used per day)	Utilization coefficient $\text{Use Coefficient (U.C)} = \frac{N}{M} \times 100$
1.	Automatic Film Processor	7 Hrs	9 Hrs	77 .77%
2.	Manual Film Processor	7 Hrs	9 Hrs	77 .77%
3.	Mobile X-Ray	7 Hrs	9 Hrs	77 .77%
4.	X Ray Intensifier 500MA	7 Hrs	9 Hrs	77 .77%
5.	Ultra Sound Machine with Probes	7 Hrs	9 Hrs	77 .77%

	Total			77 .77%

Where N = Average number of hours the equipment is actually used per day. M = Maximum number of hours the equipment can be used per day.

347. **Downtime Status of the Equipment in Radio Diagnosis , CGH**

Table 5.16: Downtime Status of the Automatic Film Processor, CGH

Automatic Film Processor		
Date at Problem	**Rectified on Date/Still not Rectified**	**TOTAL DURATION in hrs**
5/4/15 11:30:00 AM	10/4/15 11:30 AM	120
18/6/15 10:00 AM	20/6/15 12:00:00 AM	50
16/9/15 11:30 AM	18/9/15 11:30 AM	48
27/10/15 9:00:00 AM	29/10/15 12:00 AM	51
02/12/2015 9:30 AM	31/ 03/2016 4:30 PM	2863
TOTAL		3125

Table 5.17: Downtime Status of the Mobile X-Ray, CGH

Mobile X-Ray		
Date at Problem	**Rectified on Date/Still not Rectified**	**TOTAL DURATION in hrs**
5/5/15 11:30:00 AM	10/5/15 11:30 AM	120
15/6/15 10:00 AM	30/6/15 12:00:00 AM	362
16/11/15 11:30 AM	18/11/15 11:30 AM	48
27/01/16 9:00:00 AM	29/01/16 12:00 AM	51

16/03/2016 9:30 AM	31/ 03/2016 4:30 PM	367
TOTAL		948

Table 5.18: Downtime Status of the Ultra Sound Machine with Probes, CGH

Ultra Sound Machine with Probes		
Date at Problem	**Rectified on Date/Still not Rectified**	**TOTAL DURATION in hrs**
5/5/15 11:30:00 AM	09/5/15 11:30 AM	96
16/9/15 11:30 AM	18/9/15 11:30 AM	48
27/12/15 9:00:00 AM	29/12/15 12:00 AM	51
02/02/2016 9:30 AM	03/ 02/2016 4:30 PM	31
TOTAL		226

Table 5.19 : Downtime Index and Breakdown Maintenance Index of Radio Diagnosis equipment which was non functional during the year 2015-16

Sr.no	**Name Equipment**	**Down time index** Downtime per week x100 / Available machine hour per week	**Break down maintenance index** Labour hour spent on breakdown maintenance x 100 / Labour hour spent on all maintenance (preventive + breakdown maintenance time in hrs)
1.	Automatic Film Processor	60.10 x 100 / 54 = 111.3%	10 x 100 / 1x 365 +10 = 2.67 %
2.	Mobile X-Ray	18.23 x 100 / 54 = 33.75 %	10 x 100 / 1x 365 +10 = 2.67 %
3.	Ultra Sound Machine with Probes	1.42 x 100 / 54 = 4.35 %	8 x 100 / 1x 365 + 8 = 2,14 %
	Total	**49.8 %**	**2.49 %**

Available machine hours = [(weekly working days) x (hours per day) x (number of machine)].

Downtime per week: total downtime in a year / number of week in one year

Each time labour hr spent on repair = 2 hrs

Preventative maintenance: 1 hrs each day

Weekly working days: 7 days

Hours per day: 9 hrs

Number of machine: calculated for single machine.

348. The observations were as follows:

- 70 % equipment were in functional order.
- 30 % equipment were non-functional.
- Utilisation coefficient of Radio diagnosis equipment was 77.77 %.
- Downtime index is 49.8 % while breakdown maintenance index was 2.49 %. Downtime index is on the higher side since the Auto Film Processor has remained off road for long time and Breakdown maintenance index were in acceptable limit .

349. Reason for equipment not in working condition (as given by Key Informants)

- Spare part not available.
- There is a need to have a written SOP and checklist for preventative maintenance .

MAINTENANCE PRACTICES IN BLOOD BANK

350. Due to absence of Blood Bank in the Hospital, there exists no equipment related to the functioning of the Blood Bank in CGH. In case of requirement, the patients have to manage blood / component by themselves.

MAINTENANCE PRACTICES IN LABORATORY

351. Most of the equipment were dependent on CMC /AMC. Whenever equipment breakdown is there, store in charge call the concern Company for repairs.

Table 5.20. Functional / Non-functional status of the equipment in Laboratory ,CGH

S.no	Equipment name	Date of 1st inspection: 15 Mar 2016 F / NF	Date of 2nd inspection : 13 May 2016 F/NF	% Functional	% Non-function
1.	Automatic Bio Chemistry	F	F	100 %	
2.	I Count (Hematology)	F	F	100 %	
3.	Binocular Microscope 1	F	F	100 %	
4.	Binocular Microscope 2	F	F	100 %	
5.	Refrigerator No. 1	F	F	100 %	
6.	Refrigerator No. 2	F	F	100 %	
7.	UPS 10 KVA	F	F	100 %	
	Total			100%	

Though the equipments were found fully functional but there is a need for a written SOP on functioning of the Laboratory. Also, there is a need for preparing a checklist for preventative maintenance of Laboratory equipments.

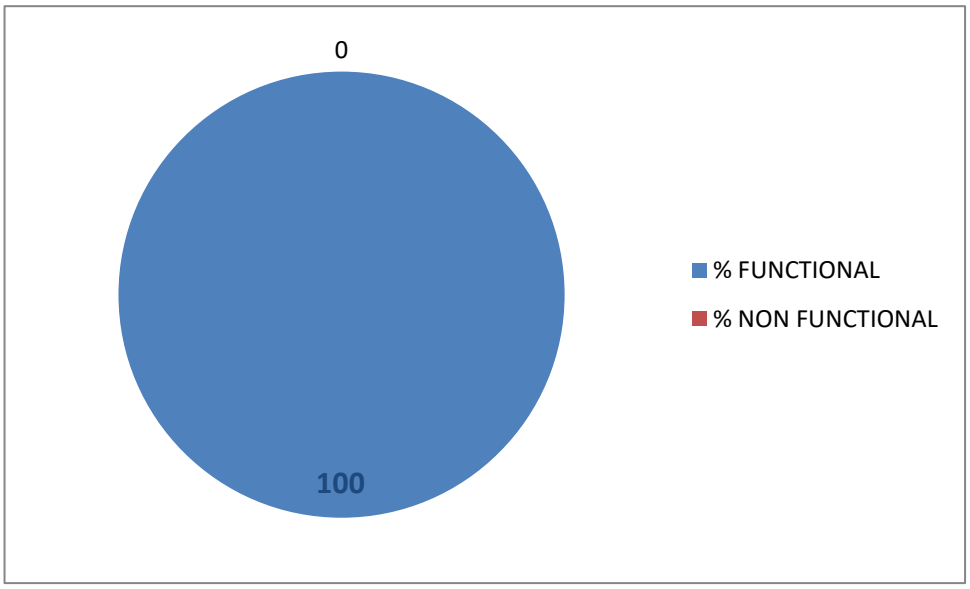


Figure 5.6: Functional Status of laboratory

Table 5.21. Utilization index status of the equipment in laboratory, Main hospital

Sr. No	Name of Equipment	N (Average number of hours the equipment is actually used per day)	M (Maximum number of hours the equipment can be used per day)	Utilization coefficient $\text{Use Coefficient (U.C)} = \frac{N}{M} \times 100$
1.	Automatic Bio Chemistry	7 Hrs	9 Hrs	77 .77%
2.	I Count (Hematology)	7 Hrs	9 Hrs	77 .77%
3.	Binocular Microscope 1	7 Hrs	9 Hrs	77 .77%
4.	Binocular Microscope 2	7 Hrs	9 Hrs	77 .77%
5.	Refrigerator No. 1	7 Hrs	9 Hrs	77 .77%
6.	Refrigerator No. 2	7 Hrs	9 Hrs	77 .77%
7.	UPS 10 KVA	7 Hrs	9 Hrs	77 .77%
8.	Total			77 .77%

Where N = Average number of hours the equipment is actually used per day. M = Maximum number of hours the equipment can be used per day.

352. **Downtime status of the equipment in Laboratory , CGH**

Table 5.22. Downtime status of the Automated coagulation analyzer in laboratory , CGH hospital

Name of equipment : Automatic Bio Chemistry		
Date at Problem occur	**Rectified on Date**	**TOTAL DURATION in hrs**
12/5/2015 11:30:00 AM	13/8/2015 4:30 PM	29
03/12/2015 9:00 AM	04/12/2015 4:00 PM	7
Total		36.00

Table 5.23. Downtime status of the I Count (Hematology), CGH

Name of equipment : I Count (Hematology)		
Date at Problem occur	**Rectified on Date**	**TOTAL DURATION in hrs**
12/05/2015 1:30 PM	12/05/2015 4:30 PM	3
03/12/2015 11:00 AM	03/12/2015 4:00 PM	5

Total		8

Table 5.24. Downtime Index and Breakdown Maintenance Index of equipment which was non functional during the year 2015-16

Sr.no	**Name Equipment**	**Down time index** Downtime per week x100 / Available machine hour per week	**Break down maintenance index** Labour hour spent on breakdown maintenance x 100 / Labour hour spent on all maintenance (preventive + breakdown maintenance time in hrs)
1.	Automatic Bio Chemistry	0.69x 100 / 54 = 1.27 %	4 x 100 / .15x 365 + 4 = 6.81 %
2.	I Count (Hematology)	0.15 x 100 / 168 = 0.089%	4 x 100 / .15x 365 + 4 = 6.81 %
	Total	**2.68 %**	**6.81%**

Available machine hours = [(weekly working days) x (hours per day) x (number of machine)].

Downtime per week: total downtime in a year / number of week in one year

Each time labour hr spent on repair = 2 hrs

Preventative maintenance: 0.15 hrs each day

Weekly working days: 6 days

Hours per day: 9 hrs(24hrs for freezer)

Number of machine: calculated for single machine.

353. The observations were as follows:

- 100 % equipment were in functional order.
- No single equipment was nonfunctional.

- Utilisation coefficient of Radio diagnosis equipment was 77.77 %.
- Downtime index is 2.68 % while breakdown maintenance index is 6.81%. Downtime index and breakdown maintenance index are in acceptable limits.

FINAL OBSERVATION OF SELECT SUPPORT SERVICE AREA OF CGH

Table 5.25. Functional / Non-functional status of the support service equipment in CGH hospital

Sr no	Department	Functional	Non functional
1.	**Blood bank**	Not Applicable	Not Applicable
2.	**CSSD**	22.22 %	77.77%
3.	**Manifold**	Not Applicable	Not Applicable
4.	**Kitchen**	Not Applicable	Not Applicable
5.	**Radio-diagnosis**	70 %	30%
6.	**Laundry**	Not Applicable	Not Applicable
7.	**Laboratory medicine**	100%	0 %
	TOTAL	64.07 %	35.93 %

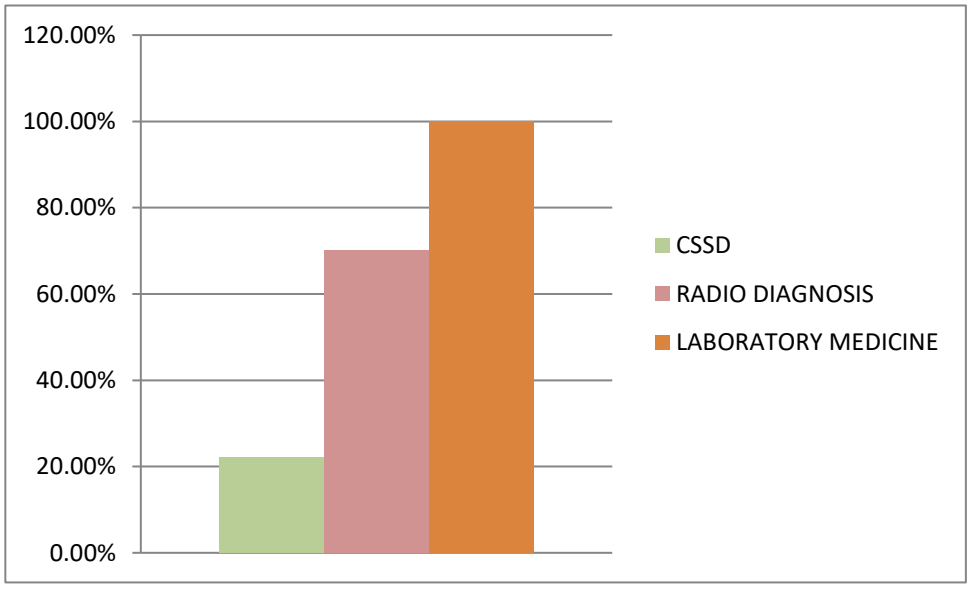


Figure 5.7: Functional Status of support service equipment

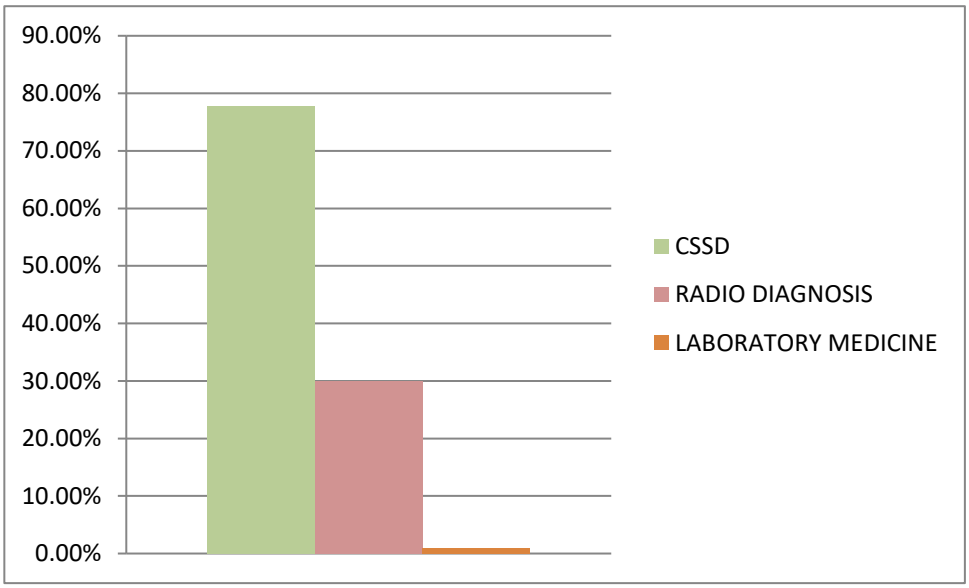


Figure5.8: Non Functional Status of support service equipment

354. Observation of functional status of select support service equipment :-

- Overall functional status of select equipment of support service area was 64.07 % and non-functional status is 35.93 %.

355. Reason of non- functional status of select support service equipment as given by key informants:-

- Spare part not available.
- Delay in financial sanction / payment.
- Intimate maintenance & repair cover not available due to absence of Technical Support Section / Central Workshop /elements of Bio- engineering Department in CGH.
- Need for proper maintenance of equipment documents like log book, history sheet and operating manuals for follow up actions.
- Need for streamlining the process of repair / maintenance by following SOPs and desired checklists of actions.

Table 5.26: Utilisation index of the support service equipment in CGH

Sr no	Department	Utilisation index
1.	CSSD	33.33%
2.	Radio-diagnosis	77.77 %
3.	Lab medicine	77.77 %

	TOTAL	62.96%

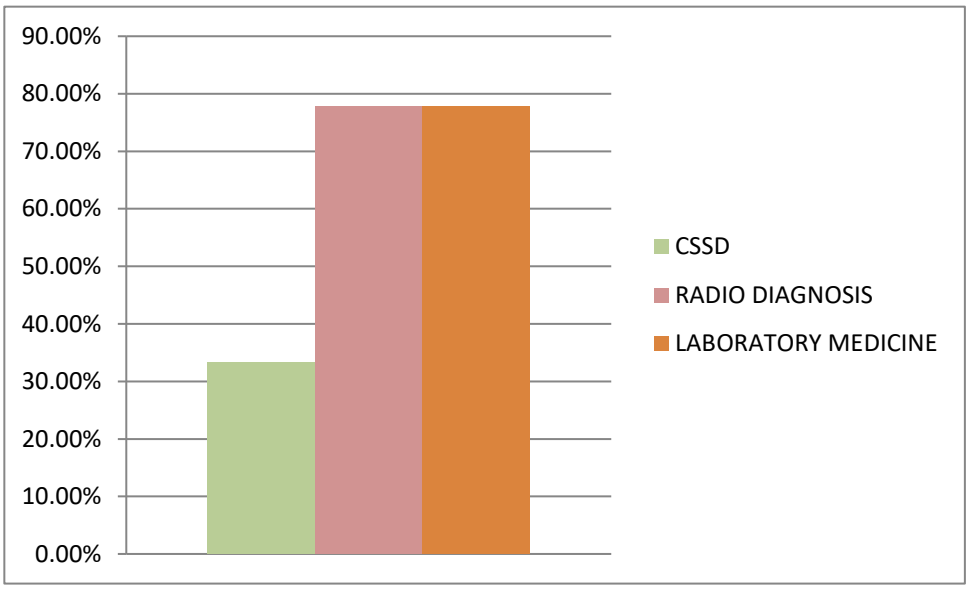


Figure 5.9: Utilization Status of support service equipment

356. Observation of utilisation index of select support service equipment :

- Overall utilisation index status of select equipment of support service area was 62.96 %.

357. Reason of low utilisation index of select support service equipment :

- The departments were having backup equipments which is used sparingly.
- Some equipments are still to be installed due pending documentation / installation site preparation.
- Some equipment are critical but their utilisation is very less.

Table5.27 : Downtime index of the support service equipment in CGH

Sr no	Department	Downtime index
1.	CSSD	67.34 %
2.	Radio-diagnosis	49.8 %
3.	Lab medicine	2.68 %
	TOTAL	39.94 %

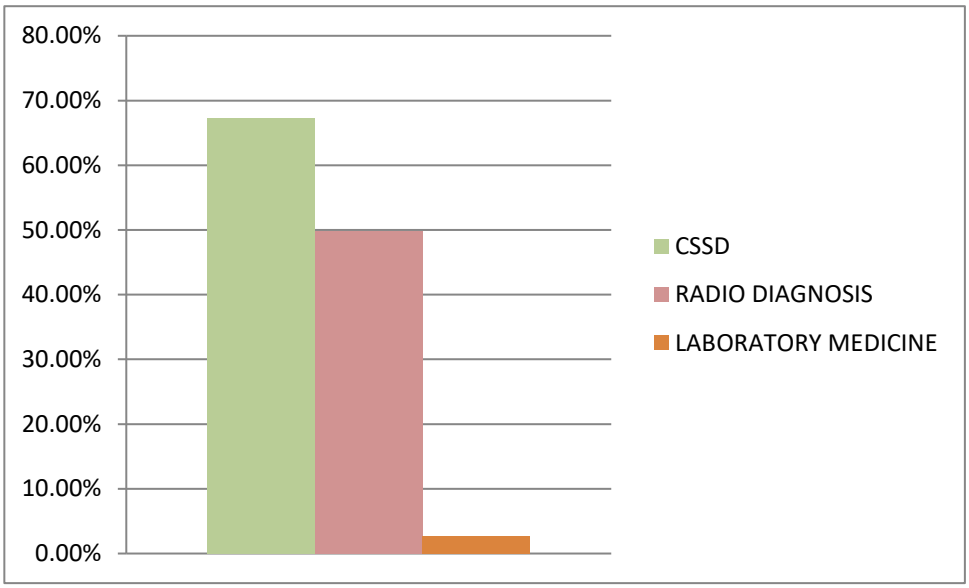


Figure 5.10: Downtime index status of support service equipment

358. Observation of Downtime index of select support service equipment :

- Overall downtime index status of select equipment of support service area was 39.94 %.

359. Reason of high downtime index of select support service equipment :

- Delay in repairs due to documentation / payment formalities.
- Few equipments non-functional due to non- availability of spare part.
- Departments were using backup equipment rather focusing on repair.
- Preventative maintenance was not effective due to absence of own Technical Support Section.
- SOPs , Checklist for maintenance were not available in any of the department.

Table 5.28: Breakdown maintenance index of the support service equipment in CGH

Sr no	Department	Breakdown maintenance index
1.	CSSD	1.8%
2.	Radio-diagnosis	2.49 %
3.	Lab medicine	6.81 %
	TOTAL	3.7%

359. Observation of Breakdown time maintenance index of select support service equipment :-

- Overall Breakdown time maintenance index status of select equipment of support service area was 3.7 %

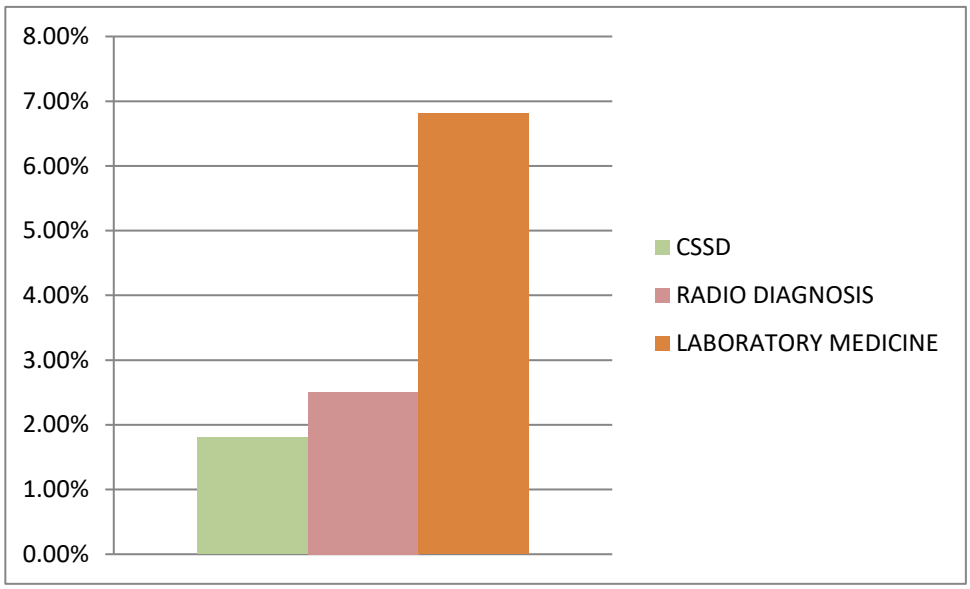


Figure 5.11: Breakdown Maintenance Status of support service equipment

360. Reason of high breakdown maintenance index of select support service equipment:

- Few equipment repairs getting delayed due to non- availability of spare parts.
- CSSD had equipments pending installation.
- Preventative maintenance was not effective.
- Equipment documents, operating SOPs and checklist for maintenance were not available in any of the department.

CHAPTER 6 : RECOMMENDATIONS

361. It is proposed that all equipment should have Comprehensive maintenance contract for proper utilisation and minimal downtime. It should be taken at the time of procurement which should cover a period of 5 years and wherever it is not possible equipment should be covered under Annual Maintenance Contract. Terms and conditions for the same should be embedded in tender document for the equipment. As most common reason for non functional status of equipment stated by key informant are non availability of spare parts, a comprehensive maintenance management system coupled with knowledgeable and capable maintenance staff, will yield longer asset life with fewer breakdowns; resulting in lower operating costs and a higher productivity. It will lead to reduction in administrative and maintenance costs, improving budgeting and control, ensuring continuity of supply of spare parts if required for repair, devotion of energies to other priorities and enabling benchmarking through setting of performance targets.

362. It was proposed to constitute a '**Hospital Equipment Utilisation Committee'** to assess the utilisation of equipment of different department. The Medical Equipment Utilisation Committee should comprise of the Chief Medical Officer or his Representative, Representative from Hospital Administration (after its applicability, this appointment is created, Head of proposed Technical Support Section / Maintenance Cell(Workshop), once created , Chief Nursing Officer or her Representative, Representative Medical Consultants and Representatives of Clinical Effectiveness and Store Officer / in-charge Store Section.

363. Its responsibilities would include the following:-

(a) Advising the Medical Equipment Utilisation Head on the development of Equipment Management Policy.

(b) Formulating, and monitoring the implementation of, procedures in support of the overall objectives of the medical equipment management policy.

(c) Monitoring the management of medical equipment within the hospital with consideration to clinical effectiveness, safety, efficiency, cost effectiveness and affordability.

(d) Developing and monitoring the implementation of purchasing policies for medical equipment which support the objectives of the equipment management policy.

(e) Establishing and managing the necessary working groups and sub-committees in support of these objectives, including those related to equipment assessment, safety selection, purchase, standardisation, use of equipment libraries and clinical user training.

(f) Liaising with the Hospital Drug and Therapeutics Committee and other appropriate committees and groups in support of the policy objectives.

(g) Reporting to the Hospital's Integrated Quality structure through the Clinical Effectiveness and Patient Safety Committee.

(h) For providing intimate maintenance and repair cover to CGH, Delhi Cantt, there is an urgent need for creation of a Technical Support Section / Central Workshop / Engineering Deparment integral to the Hospital. This would help in providing a proactive maintenance support to the user departments, thereby leading to optimum utilization of medical equipment in the Hospital. Once, conceived, created and operationalized they should be part of decision making process of equipment management system in CGH from beginning, so that they are aware their role in maintenance. The proposed workshop/ support section should be well equipped for smooth functioning. The following aspects needs cognizance on the subject:-

(i) The proposed central workshop / technical support establishment should be have qualified trained manpower, technology, tools, spare parts etc for smooth functioning.

(ii) Continuous training programme of the staff working, so as to familiarize the workers with advancement in the technology should be conceptualized and implemented.

(iii) Most of the low and medium cost equipment can be maintained / repaired in workshop provided that the proposed structure is adequately formatted.

(iv) Equipments to be procured from reputed, well established vendors, who have the capacity of maintaining the equipment, supplying the spare parts and carrying out technical capacity building of the staff (by conducting training programs on the new generation equipments being supplied).

(v) Service manual/ catalogue to be made available by the firm who supplies the equipment.

(vi) Equipment used in large quantity like suction machine, ECG machine, flow meter etc. to be procured from single source. This will facilitate the repair and maintenance of the equipment as technical specification and spares are easily available.

(vii) Users to be trained for proper handling and routine maintenance of the equipment. This will help in proper maintenance, preventing the frequent breakdown of the equipment and increasing the life of the machine.

364. Model Maintenance Program for CGH should be developed as under:-

Equipment Maintenance Model for CGH,Delhi Cantt

365. This model has been developed to ensure that medical equipment is acquired, stored, deployed, maintained and decommissioned in such a way that the risks inherent in its use are minimised and that its ownership represents good value for the hospital.

366. This must include the following:-

(a) Evaluation and selection of Equipment

(b) Tendering and purchasing

(c) Training of equipment users

(d) Provision of appropriate infrastructure and services

(e) Proper storage and disposition of equipment, including equipment libraries

(f) Appropriate prescribing of equipment to patients and end Users.

(g) Repair and maintenance

(h) Safe and legal disposal

367. All staffs are responsible for ensuring that equipment is used and stored properly.

368. The Chief Medical Officer has overall responsibility for the safe and effective use of medical equipments. He will ensure that all equipments are allocated appropriately, policies on medical equipment management, decontamination and incident reporting are regularly updated. There is also a need for these policies to be in line with latest safety norms and acknowledged best practice thereby ensuring that there are appropriate distribution, control arrangements and other safety alerts and guidance.

369. The Medical Equipment Utilisation Committee should comprise of the Chief Medical Officer or his representative, Representative from Hospital Administration (once this appointment is created), Head of Technical Support Section /Maintenance Cell /Central Workshop (once created), Chief Nursing Officer or her representative, Representative Medical Consultants and Representatives of Clinical Effectiveness, and Store Officer / In- charge.Its responsibilities include advising the medical equipment utilisation Head on the development of Equipment Management Policy. It would help in formulating, and monitoring the implementation of procedures in support of the overall objectives of the medical equipment management policy. It would also monitor the management of medical equipment within the hospital with consideration to clinical effectiveness, safety, efficiency, cost effectiveness and affordability. It would also develop and monitor the implementation of purchasing policies for medical equipment which intimately supports the objectives of the equipment management policy. This committee would also help in establishing and managing the necessary working groups and sub-committees in support of these objectives, including those related to equipment assessment, safety selection, purchase, standardisation, use of equipment libraries and clinical user training. It also would help to carry out liaison with the Hospital Drug and Therapeutics Committee and other appropriate Committees and Groups in support of the policy objectives. This committee should meet once in three months.

370. The proposed Workshop of the hospital would coordinate maintenance of all aspects of hospital equipment. Their particular responsibilities would be in Collaboration with clinical users and the Supplies Department to carry out pre-purchase evaluation of equipment, Checking and testing equipment on loan for demonstration or any other purpose, and recording indemnity, service history and other information. It would help in arranging for the safe disposal of

equipment according to appropriate hospital procedures. Correct disposal procedures must be followed, based on the value of the asset, to minimize the risk arising from the hospital's continuing product liability for discarded assets, and, in collaboration with the Facilities department, that waste disposal legislation is complied with. It would promote clinical user training, report incidents involving medical equipment; provide expert advice on health and safety issues relating to medical equipment, especially for devices using ionising radiation or where electrical safety is concerned. It would maintain a database of all equipment and its maintenance cycle. It would also manage and run medical equipment library (of Equipment Pools).

371. Overall, there should be recruitment of skilled manpower to enhance equipment management cover to the departments. Regular training programme be conducted on maintenance and repairs of equipment for the technicians and other concerned personnel. The Organisational structure of the proposed Workshop / Technical Support Section would be as follows:-

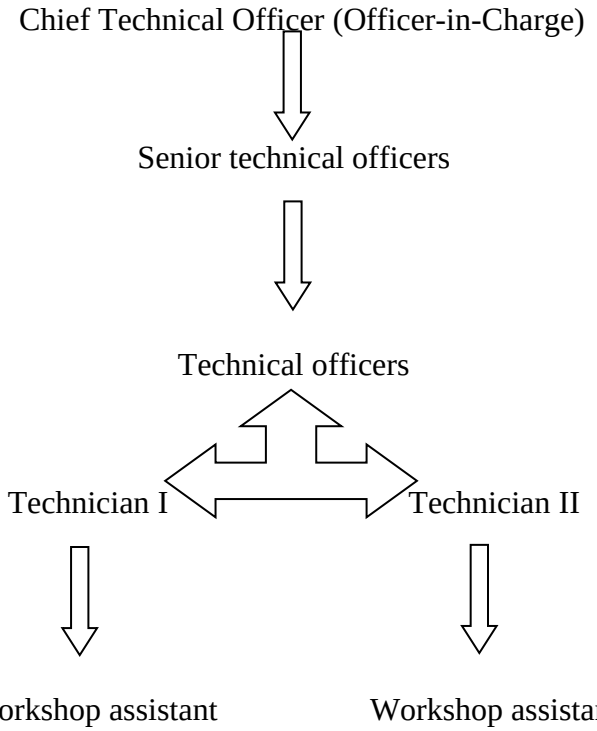


Figure 6.1: Flow of responsibility in proposed Technical Support Section

372. The recommended manpower required for the workshop would be as below :-

Table 6.1: Depicting manpower details of the proposed Technical Support Section

Appointment /Designation / Trade	**No. of Personnel**
Chief Technical Officer	1
Biomedical engineers	2
Sr. Technical Officer	1
Tech Officer	2
Technician Gr-I	4
Technician Gr-II	4
Workshop Assistant	5
UDC Clerk	1
Asst NS	1
Peon	1
Khalasi	1

373. Incoming equipment should be carefully checked for possible shipment damages; compliance with specifications in the purchase order; and delivery of accessories, spare parts and operating and service manuals.

374. **Installation of equipment :**Many common problems with medical equipment can be avoided if the equipment is properly installed. If the right equipment arrives in working order with the right parts and manuals then a long and useful life is more likely. Each person in the chain of equipment supply has a particular role and responsibility to fulfill. This applies right from when the need for new equipment is identified to the time when it is used. When equipment arrives, it would be necessary to record the fact and to check that everything has been supplied that was ordered ,this needs to be done by instituting an opening board on taking

over of the equipment. Here, it would also be necessary to check that the equipment is supplied in the right way. The following aspects also merit attention with respect to equipment management:-

(a) Installation should be done by the vendor and training should be provided at this stage to the user as well as to the maintenance technicians.

(b) **Whenever any equipment is** in out of order state, it needs to be sent to the proposed Central Workshop /Technical Support Section along with a **"job card"**. The job card bears the brief information about the equipment and brief about work to be done. Only breakdown maintenance needs to be done by the Workshop, for other repairs, authorized dealer / Vendor needs to be contacted.

(c) **For low cost equipment, the** breakdown maintenance needs to be done by the in-house Workshop .

(d) **For medium cost equipment, the** Manufacturer & Authorised dealers provide Preventive & Breakdown maintenance. In some cases third party is also at times involved in preventive & breakdown maintenance.

(e) **For high cost equipment, there is a need for** Preventive & Breakdown maintenance by Full Time Dedicated Engineers from manufacturer and/or authorized dealer for equipment such as Fess set, Laparoscopy set, Phaco-emulsification System, Image intensifiers etc.

375. **Corrective Maintenance (or Repair).** It is done to take corrective action in the event of a breakdown of the equipment. The equipment is returned repaired and calibrated. Repair procedure must emphasize on the following :-

(a) **Repairing and servicing** of sophisticated equipment under the guidance of a skilled person.

(b) Develop procedure for requisitioning repair services as and when a particular equipment breaks down or stops functioning.

(c) AMC of all sophisticated and costly equipment must be ensured.

(d) If **in-house facilities** are unable to repair a particular equipment, then the procedure for its repair from outside agencies should be worked out and planned.

(e) The technical personnel involved should be trained either by the established institution or by the company supplying those equipment.

(f) **Spare part** should be available within 24 hrs if equipment is of Indian make, while within 48 hrs if equipment is foreign manufactured.

(g) **Enquiry of breakdown** should be done to know the cause , especially in case of costly and sophisticated equipments.

376. **Planned (or Scheduled) Preventive Maintenance**. It is done in a planned way before repair is required and the schedule of the work is circulated well in advance. It involves cleaning, regular function / safety tests and makes sure that the problems are picked up while they are still at nascent stage. The choice of approach for Preventive and Corrective Maintenance depends on the complexity of equipment . It is the responsibility of all staff using medical equipment to ensure that they have received adequate training to ensure the safe and effective use of the equipment and single-use devices are not re-used and that equipment and devices are not modified.

377. The **maintenance tasks** will be placed in daily and weekly checklists. This will help in planning time for them to be carried out. In most cases, for daily tasks the beginning of the working day will be best, but any time will suit as long as the job is done. For weekly tasks, it may be easier to allocate a different day for each type of equipment, in order to spread the load through the week. A simple timetable with the person responsible can be used as a reminder.

378. The **maintenance checklists** will be designed to fit on a single page per Section. This makes it easy to print or copy them and display them near the equipment. The lists will only be useful if they are easy to see, so placing them on the equipment or on a wall nearby will be best. Each page could be covered with plastic laminate or taped inside a plastic wallet. The same could be done with the troubleshooting checklists, or these could be stored nearby for when needed.

379. **Operator Manuals**. These are essential and should be specified at time of purchase. It is often possible to obtain service or technical manuals in the language of the working staff, which should be held by the maintenance department.

380. **Schedule of Regular Visits**. Periodic visits by qualified maintenance personnel would be needed. This might be managed by the Maintenance Department or Senior Hospital Management. Whether the maintenance is in-house or outsourced, a system of reminders to prompt the work will be needed.

381. The user will need to be able to call on a repair team when things break. Smaller items of equipment will be serviceable by the hospital team, whereas large scanners etc will require specialist outside services.

382. The purchase contract should have details of what warranty services are available and contact details to call in these services. Either stores or administration should monitor performance against these contracts and plan for cover on expiry of any agreement.

383. The needs for consumables should have been specified during the procurement process, so that necessary supplies are available from the start of equipment use. A schedule of restocking will need to be developed, so that there is never a gap in services.

384. Technical advice will be required to decide which spares should be stocked on site and which should only be purchased when needed. As a general rule, it is recommended to keep spares likely to be needed for two years operation on site and to have these supplied with new equipment.

385. During procurement stage itself, it should be made mandatory for the vendors to provide the training to technicians and operators , providing user / operating manuals , service / maintenance manuals.

386. **Equipment Inventory**. All equipment in the hospital should be recorded on cards or in the computerized database. All relevant information about the equipment must be entered, including its location, records of repair and maintenance and manufacturer details. A reference number is written on each item. A proper entry should be made in the inventory register. The inventory record should contain the serial number and date of receipt as well as date of completed inspection.

387. **Establishing Intervals of Maintenance**. The frequency of these tasks must be decided. A heavily used item must be cleaned and checked more frequently than one which is used less often; however, minimum standards must be set. The frequency suggested in the manufacturer's manual can be used as a guide, but the amount of actual usage should determine the maintenance procedure required.

388. **Automation of Equipment Maintenance**. It is now essential for the operations of the hospital. There should be **central registry** of all equipments.

389. **Reminder System**. It wouldl be necessary to develop a reminder system, so that staff are prompted to carry out tasks when they are due. A card index / calendar system or a computer programme can be used.

390. **Technical Library**. A full technical library should be available and all concerned be sensitized to utilize it effectively.

391. Surveillance. After the maintenance programme has been set up, periodic surveillance must be carried out to ensure that records are legible and that all entries are being made. It is imperative that periodic evaluation of the quality of performance of equipment is done. An **effective equipment audit** is beneficial to the providers and seeker of healthcare. It assesses the present equipment status and ensures better equipment procurement in the future.

392. **Checklist for Implementation in the Proposed Maintenance Model of CGH,Delhi Cantt**

Table6.2: Acceptance Checks on Delivery

ACCEPTANCE CHECKS			
ON DELIVERY			
	Yes / done	No / not done	Corrected if applicable
Representative of supplier present?			
Correct number of boxes received?			

After unloading, are boxes intact?			
If damaged, has this been stated on the delivery note and senior management informed?			

TABLE 6.3: Acceptance Checks on Unpacking

ACCEPTANCE CHECKS			
ON UNPACKING (refer to invoices, shipping documents and original specification)			
	Yes / done	No / not done	Corrected if applicable
Is the equipment intact and undamaged?			
Equipment complete as ordered?			

User/operator manual as ordered?			
Service/technical manual as ordered?			
Spare parts as ordered?			
Accessories and consumables as ordered?			

Table6.4: Acceptance Checks on Installation

ACCEPTANCE CHECKS			
ON INSTALLATION (refer to manuals given by company)			
	Yes / done	No / not done	Corrected if applicable
Was installation carried out satisfactorily?			

Were all parts present and correctly fitted?			
Were technical staff present as learners?			
Was the equipment demonstrated as fully working?			
Were staffs trained in operation of the equipment?			

393. **Procedure for Maintenance**

(a) **When no Problem Found During Preventive Maintenance of a Medical Device.**

(i) Once the preventive maintenance procedure is performed, the technician will complete the preventive maintenance work order form.

(ii) The technician will affix an updated maintenance sticker, or other record of inspection, on the device. If the PM work request is completed in a month later than the scheduled month, the technician will date the sticker to correspond with the month the work request was completed.

(iii) The technician will return the device to service.

(b) **When Problem is Found During Preventive Maintenance of a Medical Device.**

(i) f a problem is determined to be minor, the preventive maintenance procedure can be completed and the device cannot be returned to service (e.g. a power cord has a cut in the covering), the technician should follow these steps:-

(aa) Perform the preventive maintenance procedure.

(ab) Complete the PM work order form.

(ac) Affix an updated sticker on the device.

(ii) If the PM work request is completed in a month after the scheduled month, the technician will date the sticker to correspond with the month the work request was completed. The due date should reflect the next due date based upon the last due month and the appropriate interval for the device. Initiate a corrective work order request, affix a label to the device indicating it is out of service and inform the user department of the delay in return to service of the device. If a problem is determined to be minor, the preventive maintenance procedure can be completed and the device can be returned to service (e.g. a hose bracket for an anesthesia machine is broken or a cosmetic label has fallen off).

394. There should be an equipment history record sheet to track the performance of the equipment. This sheet should note down the date of installation and commissioning, preventive as well as corrective maintenance records. Maintenance of history sheet and its subsequent write up is sine qua non for performance of equipment audit by the committee. Incorporating these in the computers of the stores will facilitates monitoring and follow up. The hospital will maintain

395. **Log book and history sheet of all equipment would be maintained as below**:-

LOG BOOK

1. Name of Equipment.
2. Warranty period.
3. Validity period of AMC
4. Periodic maintenance.

5. Details of Preventative maintenance
6. Date of breakdown.
7. Date and time of repair.
8. Cost incurred.

HISTORY SHEET OF EQUIPMENT

1. Name of Equipment.
2. Date of purchase.
3. Cost of equipment.
4. Name and address , contact number of supplier :
5. Name of manufacturer.
6. Date of installation.
7. Department where installed.
8. Environmental control.
9. Spare parts inventory.
10. Technical manual/circuit Diagram. Literature.
11. After sale service arrangements.
12. Guarantee/Warranty period.
13. Life of equipment.
14. Depreciation per year.
15. Charges of tests.(if any)
16. Use coefficient.

17. Down time/up date.

18. Cost of maintenance.

19. Date of condemnation.

20. Date of replacement.

21. Other Relevant Remarks

396. **Disposal of Equipment.**

CGH, Delhi Cantt must ensure that there are proper procedures in place for condemnation and disposal of equipment that is unserviceable or obsolete or which are no longer required. This would take old and potentially unsafe equipment out of service, make sure hazardous materials are properly treated and make storage space available. A systematically planned, scheduled condemnation process will greatly help in reducing holding cost of non-functional equipment and increasing the store capacity in stores. The life cycle of medical equipment will vary from 5-10 years. If the equipment is declared obsolete by the vendor it may not be possible to get spare parts. Even if the parts are available it can become too expensive to obtain them and the equipment is no longer economical to repair. Condemnation of equipment should be well planned and the necessary steps should be taken in advance to arrange replacement.

397. **Criteria for Declaration of Equipment as Surplus, Obsolete or Unserviceable.**

(a) **Surplus to Requirement.** Where a surplus piece of equipment remains serviceable, management should be informed. It may be decided to store the equipment, auction it or use it elsewhere.

(b) **Unserviceable or Unreliable.** If equipment cannot be repaired (either no parts available or not economical to repair) or it cannot be maintained properly it should be scrapped and replaced.

(c) **Obsolete.** When equipment is not usable because parts are out of date or the clinical technique is no longer recommended it should be scrapped.

(d) **Damaged through Negligence or Abuse.** Where abuse of equipment is suspected, this should be reported to management and the equipment taken out of use .

(e) **Beyond its Prescribed Life Period** : Such equipment should be reported to management and the condemnation committee. They should take into account any period of storage in addition to use, examine the condition of the equipment to see whether the item could be put to further use and if not they will declaring the item obsolete/surplus or unserviceable as appropriate.

CHAPTER 7 : SUMMARY& CONCLUSION

398. The equipment maintenance system of support system of CGH, Delhi Cantt was studied in general. Based on the Specific Objectives, a Cross sectional, Descriptive study was planned at Cantonment General Hospital, Delhi Cantt to assess the overall equipment maintenance programme of support services in the Hospital. The study was planned in two parts namely retrospective and prospective. Retrospective study was done by studying the documents and records pertaining to repair, maintenance and utilization of equipment. Prospective study was done by on the spot observation and interviews with key personnel of the respective areas of study. Equipment procured for support services during the period 2011-2016, with Year of Utilization of 2015-2016 were studied, but the outsourced equipment / facility and services not operational in CGH were excluded.

399. The overall functional status of select equipment of support service as per the study was 64.7 %. The most common reason of non- functional status of select support service equipment were inadequacy due to non availability of own integral Technical Support Section / Workshop, delay from the vendors in repair / maintenance action and infused delay imposed by vendors due to problems of documentation / timely payment. Overall utilisation index status of select equipment of support service area is 62.96 %. The most common reason of low utilisation was holding on of backup equipments in the department for intimate operational support, since there is no own integral technical support by means of workshop / trained technicians.

400. The recommendations of the study include proposal to constitute a Hospital Equipment Utilisation Committee for better utilisation of equipment. Also, for intimate maintenance and repair cover to CGH, creation of own integral Technical Support Section / Central Workshop with adequate trained man-power, equipment and spares is strongly recommended. This would provide a guaranteed technical support to the Hospital. Also,to maximise utilisation and optimise health care delivery, an Equipment Maintenance Model for CGH, Delhi Cantt has been developed to ensure that medical equipment is acquired, stored, deployed, maintained and

decommissioned in such a way that the risks inherent in its use are minimised and that its ownership represents great value to the Hospital.

References

1. Gupta SK, Kant S, Sahoo MC. Hospital Equipment Utilization: Increasing Operational Efficiency[Internet].[cited 2011 Sep 09];Available from:http://www.medicalbuyer.co.in/news/hospital-equipment-utilization-increasing-operational-efficiency-594-92.html.
2. Shakti Kumar Gupta, Sunil Kant, R. Chandrashekhar , Sidhartha Satpathy , modern trend in planning and designing of hospitals, principles & practice, 2009, p-82
3. Satish VL. Medical Equipment Management in Health Care Dec 1998, 252-264.
4. Bloom G (1989), 'The Right Equipment in Working Order', World Health Forum, 10 (1): 3-1
5. Medical Devices Agency: Health Equipment Information, Issue 98:28
6. World Health Organization ,Medical device regulations : global overview and guiding principles [Internet]. [cited 2011 Sep 09]; Available from: http://www.who.int/medical_devices/publications/en/MD_Regulations.pdf
7. Hospital & Medical Gases Management , by Dr Yash Pal Sharma , Dr Hem Chandra & Dr D K Sharma , Bharat Book Centre Lucknow 30-41.
8. Shakti Gupta, Sunil Kant , Hospital Store management an integrated approach ,2000 ed, p-127.
9. Halbwachs H. Health Care Equipment Management. Health Estate Journal Dec 1994; 16-19.
10. Shaffer MJ et al. A System Analysis Approach for Estimating the Costs of a Clinical Engineering Service. Proceedings of the 27th ACEMB, 1974.
11. Cooper Poole J (1979) WHO offset, No. 45. Approaches to planning and design of health care facilities in developing areas. Equipping Hospital and Health care facilities in developing countries.p32-36
12. Lenihan J. Technology in Health Care. International Hospital Federation 1991; 89-90.

13. Ridgway M. Classifying Medical Devices According to their Maintenance Sensitivity: A Practical, Risk-Based Approach to PM Program Management. Biomedical InstrumTechnol, p 167-176, May/June2001.

14. Bloom G (1989), 'The Right Equipment in Working Order', World Health Forum, 10(1): 3-10

15. McKie J (1987), 'The Management of Health Care Technology', in World Health Organization, Report on Interregional Meeting on the Maintenance and Repair of Health Care Equipment, held at Nicosia, Cyprus in 1986, pp37-84

16. Shakti Gupta, Sunil Kant , Hospital Store management an integrated approach ,2000 ed, p-131

17. Steele P A et al. (1983), 'Commissioning Health Care Facilities' in Approaches to Planning and Design of Health Care Facilities in Developing Areas, Vol.4, WHO Offset Publication No 72, WHO Geneva- 297

18. Mehta J. Engineering and Maintenance Services in Developing Countries. WHO offset Publication No. 72, 1983.p-151

19. Medical Devices Agency: Health Equipment Information, Issue 98:23.

20. McKie J (1990), 'Management of Medical Technology in Developing Countries', Journal Biomed. Engineering, 12(May):259-261

21. Indira V Ratnam. Procurement, Maintenance and administrative Problems of Hospital. Clinical proceedings of Nizam's Institute of Medical Sciences, Hyderabad. Jan 1997 Vol No. 12 No. 1; 13-27.

22. Pease-KA; Equipment Records for Modular Analytical: Quality Assurance, 1995 December; 4(4): 329-31.

23. Luke GM, Luckman J, Smith BW and Stringer J (1971): Patients Hospital and Operation Research, Tavistok Publication, London, p32-33.

24. Wagner Harvey M (1982). Principles of Operation Research with application to Managerial Decisions.353, 513, 785 and 888.

25. Whelpton-D, Cooke DK, Computer system for equipment management : Journal of Biomedical Engineering 1990 May; 12(3): 284-52.

26. Lenihan J. Technology in Health Care. International Hospital Federation 1991; 89-90.

27. Schwartz L (1979). Hospital Abstract Vol 19 No. 10, Para 14, 16: A Computer Assisted Preventive Maintenance system.

28. Gupta Ajay; A Study of the Specialized Hospital Equipment Utilization and Maintenance of AIIMS, New Delhi with Special Reference to the IRCH. Thesis for MHA 1990 January: 78.

29. Lambertic, Ursion M; Information System for Biomedical Equipment Management in Wide-area Environment: Medical-Biological Engineering – Computing 1990 July; 28(4): 350-4.

30. Carroll R (Ed). Risk Management Handbook for Health Care Organizations. Ed 4. Jossey Bass, 2003.p44-46

31. UrsGessner .The role of the medical Engineer in today's hospital. Hospimedica April 1992; 32-33.

32. Vijaya Kumar C; Quality Equipment Maintenance: A Tool for Total Quality Management; Journal of Hospital Administration 1994 September-December; Vol 31 No. 3, 4: 170.

33. Suffer-MJ; Biomedical Equipment: Maintenance Factors, Units of Measurement, and Standards; Medical Instrumentation 1985; November-December; 19(6): 268-72.

34. Jabatkin, Allen, D.J of clinical engineering, Bera, calif, 1980, vol -5, No.3,p-250.

35. M. P. Roitman, T. D. Ivanova and L. M. Tutina, Evaluation of the utilization of medical equipment in hospitals Semashko All-Union Research Institute of Social Hygiene and Health Organization, Moscow. Translated from MeditsinskayaTekhnika, No. 1, pp. 42–45, January–February, 1968

36. Satish VL. Medical Equipment Management in Health Care Dec 1998, 252-264.

37. Y. david ; technology Evaluation in a US hospital; the role of clinical engineering , medical and biological engineering computing; 1993 Jan HTA 28-31.

38. Cohen T; the Cost of Biomedical Equipment Repair and Maintenance: Results of a Survey; Medical Instrumentation; 1982 September-October; 16(5): 256-71

39. Sundaram B. Understanding cost of ownership: Asian Hospitals; 1997 December; 17-19.

40. R Hills Peter W; Vibration Based Predictive Maintenance Systems for Rotating Machinery Maintenance: British Council of Maintenance Association and European Federation of Rotational Maintenance Societies; UK 1989; Vol. 4, No. 1, 49-50

41. Strzelczyk J. Radiation Safety. In Dyro JF (ed). *The Clinical Engineering Handbook*. Burlington, MA, Elsevier, 2004 p -34-35

42. American College of Clinical Engineering. ACCE partners with telemetry manufacturers: AAMI, ASHE, and the AHA to recommend spectrum allocation to the FCC. ACCE News 8(6):11-12, 1998.

43. Murphy KG, Secunda JA, and Rockoff MA. Severe Burns from a Pulse oximeter.Anesthesiology 73(2):350-352, 1990

44. Bogner MS (Ed). Human Error in Medicine. Hillsdale, NJ, Lawrence Erlbaum Associates, 1994. P-76-77

45. Brennan TA et al. Incidence of Adverse Events and Negligence in Hospitalized Patients: Results of the Harvard Medical Practice Study I. N Engl J Med 324(6):370-376, 1991.

46. Bauld TJ. Productivity: Standard Terminology and Definitions. J ClinEng12(2), 139-145, 1987.

47. Gordon R. The Alarming History of Medicine, New York, St. Martin's Press, 1993.p-33-34

48. Joseph Dyro , The clinical engineering handbook, 2011, p-124-130

49. Gullikson ML, David Y, Blair CA. The Role of Quantifiable Risk Factors in a Medical Technology Management Program. JCAHO Environment of Care Series (3):11-26, 1996.

50. JCAHO.Comprehensive Accreditation Manual for Hospitals. Joint Commission on Accreditation of Health care Organizations. Chicago, 2000. P-46-48

51. Joseph Dyro , The clinical engineering handbook, 2011, p- 130-133

52. Barta, RA., A Computerized Maintenance Management System's Requirements for Standard Operating Procedures, Biomedical Instrumentation and Technology. 35, 2001

53. Stiefel R, ed. Medical Equipment Management Manual: How to Be in Complete and Continual Compliance with JCAHO Standards. AAMI, 2001 p-23.

54. [Internet]. [cited 2011 Sep 09]; Available from: http://www.healthpartners-int.co.uk/our_expertise/HCTGuide5.pdf

55. Fennigkoh L, Lagerman B. Medical Equipment Management. JCAHO Environment of Care Series (1):47-54, 1997.Risk Management in Health Care Institutions. Boston, Jones Bartlett Publishers, p 325-363, 2003.

56. Joseph Dyro , The clinical engineering handbook, 2011, p- 133

57. Joseph Dyro , The clinical engineering handbook, 2011, p-135

58. Joseph Dyro , The clinical engineering handbook, 2011, p-134

59. Joseph Dyro , The clinical engineering handbook, 2011, p-136

60. Dolan A. Risk Management and Medical Devices. *Biomed InstrumTechnol*33:331-333, 1999

61. Taylor K, Frize M, Iverson N, Paponnet-Cantat C. The need for the integration of clinical engineering and sociological perspectives in the management of medical equipment within developing countries; *JClinEng19* (4):291-296, 1994

62. Joseph Dyro , The clinical engineering handbook, 2011, p-147

63. Insurance in the NHS: Employers/Public Liability and Miscellaneous Risk Pooling, Health Service Circular HSC 1999:021, Department of Health, http://www.open.gov.uk/doh/coinh.htm, February 3,1999.

64. Silberberg JL. Performance Degradation of Electronic Medical Devices Due to Electromagnetic Interference. *Compliance Eng* 3:1-8, 1993.

65. Ridgeway M. Part II: Measuring the Performance of the Hospital's clinical or Biomedical Engineering Program. *J ClinEng*1980, Oct-Dec; 5(4): 287-298.

66. Clark JT and Forsell R. Clinical Equipment Replacement Planning. Biomedical Instrumentation and Technology, Hanley &Belfus, July-August 1990, pp. 271-276.

67. FAKT. Association for Appropriate Technology (FAKT), Germany, and Churches' Action for Health (CMC) of the World Council of Churches. Guidelines on Medical Equipment Donations. Technical Library, FAKT. In CMC Publication. World Council of Churches, Geneva, October, 1994. P64-65.

68. Wang B. The Facts on Used Equipment Export. *Biomedical Technology Management.*64, 1996.

69. ACCE. American College of Clinical Engineering. *Guidelines for Medical Equipment Donation*, Plymouth Meeting, PA, 14, 1995 P -31.

70. Shakti Kumar Gupta , Sunil Kant , Hospital Store management an integrated approach , 2007 reprint, P-141-42

71. Nagasawa Y. *District Hospitals: Guideline for Development.* Geneva, World Health Organization, 1992.p-34

72. Joseph Dyro , The clinical engineering handbook, 2011, p-665-661

Appendix'A'

LOG BOOK

1. Name of Equipment.
2. Warranty period.
3. Validity period of AMC
4. Periodic maintenance.
5. Details of Preventative maintenance
6. Date of breakdown.
7. Date and time of repair.
8. Cost incurred.

Appendix 'B'

HISTORY SHEET OF EQUIPMENT

1. Name of Equipment.
2. Date of purchase.
3. Cost of equipment.
4. Name and address , contact number of supplier.
5. Name of manufacturer.
6. Date of installation.
7. Department where installed.
8. Environmental control.
9. Spare parts inventory.
10. Technical manual/circuit Diagram. Literature.
11. After sale service arrangements.
12. Guarantee/Warranty period.
13. Life of equipment.
14. Depreciation per year.
15. Charges of tests. if any
16. Use coefficient.
17. Down time/up date.
18. Cost of maintenance.
19. Date of condemnation.
20. Date of replacement and Other Relevant Remarks.

GLOSSARY

Acceptance Quality Level (AQL) – A term used in inspection by the statistical sampling method to donate the highest acceptable ratio between the number of faulty parts and total parts in a batch of delivery.

Airway Bill – A formal document acknowledging the receipt of the goods on board an aircraft for carriage by air.The Airway Bill states the terms of carriage and constitutes title to the goods.

As is, where is – In current conditions and at their current location. The purchase is responsible for all handling, transport and insurance to remove goods from their current location.

Automatic data processing – The use of computers and other information- handling machines to store, organise and perform calculations on large quantities of numerical data with minimum **human intervention.**

Balanced score card-Is a set of measure that is directly linked to a Company's strategy on performance, knowledge and business processes with tangible goals and actions.

Bar coding – A technology which uses a variety of printing or imaging techniques to encode data in a pattern of bars and spaces. The bar code is attached to parts, containers or documents and then scanned to allow computers immediate access to information.

Bench Marketing – Defined as the continuous processof measuring products, services and practices against industry leaders.

Bench marking -Process of finding the best available processes, features, services and use them as a standard for improving the Company's operations

Bill of lading – Abbreviated B/L. A ship owner's contract and receipt of goods which he agrees to transport from one place to another and deliver to a designated person (or assigns)

Bin card– A record showing receipt, issue and physical balance of materials, and also showing maximum and minimum quantity to be held in stock and re-order level.

Budgeting – A process by which revenues and expenses are forecast for a specified period of time.

Buffer stock – A characteristic of inventory- divided into two parts, one working stock and the other buffer or safety in order to minimize the risk of storage and stock outs. It acts as a protective cushion when demands are high.

Bulk purchasing– The purchasing technique of buying in large quantities in the expectation of reducing the unit price of an item.

Centralized purchasing – A type of purchasing whereby the authority and responsibility for the procurement of all supplies and equipment is vested in one department or with one position.

Codification – A system of symbolizing stocks and stores for representing information for easier and correct identification.

Consignee – A person or Company to whom goods are to be delivered by the consignor. Generally, the buyer of goods is identified as a consignee on a Bill of Lading.

Cost Containment – Cost containment in health care institutions involves the utilisation of human resources and physical assets in a way that ensures economical delivery of high –quality health care.

Demurrage – A charge incurred when goods are not removed from a transport terminal within a specified time.

Deterioration – Product spoilage or damage which may occur over time in storage or due to environmental factors on storage or during transport.

Discrepancy – Any difference between the actual quantity, condition, identification or price of stores and the associated records.

Distribution – A materials management function whereby supplies and equipment are delivered to their point of utilisation by either manual or automated means.

Dunnage – Materials such as boards, planks, cushions, tarpaulins, straps, etc. used to support, secure, protect, or to facilitate storage of goods.

E.O.Q. (Economic Order Quantity) – Also known as economic lot-size, this involves selection of an order quantity which minimises the total variable costs of managing an inventory.

Earnest Money/Bid Security -Sum of money paid as deposit to show that the items promised will be delivered. Earnest money should be separate for different tenders, however, it should be clubbed for items in the same tender.

Ex-stock – Goods available immediately from suppliers.

FIFO – 'First In, First Out'. A technique used in issuance of materials that requires materials first acquired to be issued first. Materials to be used in the sequence of their receipts.

Forecasting – A material management function in which the quantities and supply usage patterns are fairly accurately predicted over a specified period of time.

Group purchasing – A type of purchasing whereby hospitals combine their volumes of certain categories of supplies to receive better prices or supply service or both.

Inventory – Typically, inventory implies a list of items held in stock. Stock implies the quantity of a particular item on hand.

Inventory Control – The technique for ensuring availability of materials while at the same time, holding in check, generally through a system, the tendency to hoard large amount of stock than is necessary.

Inventory Reduction – A planned process through which supply quantities are decreased to adequate quantities to more appropriately reflect the inventory turnover rate and usage patterns. It is an achievable cost containment objective.

Invoice – A bill sent to a buyer for payment. It shows quantity, price and nature of goods or service delivered.

Just In Time (JIT) – A concept developed by the Japanese in which required materials are delivered by the original supplier to the location where they are utilised and at the time they are needed.

Lead Time – The interval between the time when the need for the material is determined and the time the material is actually manufactured, delivered or received.

Lease – A contract by which the owner allows another person to use it for a specified time usually in return for rent.

Letter of Intent (LOI) – A letter issued in advance of a contract in which the signer declares his intention to buy, manufacture, or deliver a product or service.

Material Management – The management and control of supplies, equipment, and their related activities from acquisition to disposition. It represents a continuum along which many similar supply functions take place under the disciplined supervision of the materials manager. Among those functions are supply specification, purchasing, receiving, supply processing, distribution, inventory control, supply utilisation, standardisation, value analysis, cost analysis and forecasting.

Obsolescent – The status of an item, equipment or system which will be out of use within a period of time. It is no longer to be purchased although it may remain in use until worn out or declared obsolete.

OEE-Overall equipment effectiveness is the total availability and the reliability of the equipment resulting in higher productivity.

Order or Re-order Point – A number equal to the forecast of minimum reasonable demand during a lead time, when an order or re-order is placed to bring the available stock back to the order or re-order point. A replenishment order or re-order is released for one standard quality when stock reaches its point.

Pallet – A portable platform upon which goods are placed in unit loads to facilitate stacking and handling by mechanical equipment such as forklift trucks.

Pestilence – Any deadly infectious disease that spreads quickly through large number of people.

Productive assets- Productive assets are those capital assets like machineries and equipment which are directly responsible for producing the intended products to the require quantity.

Purchase Order – A document that represents a commitment to purchase goods and services under certain specified terms of quality, quantity and price.

Purchasing – A materials management function whereby all hospital supplies and equipment are bought and acquired using standardized specifications.

Quality – The totality of features and characteristics (both technical and economic) of a product that bear upon its ability to satisfy a given need.

Quality assurance – The pledge, guarantee, declaration or surety that the requirement for quality have been met.

Re-Engineering – Defined as fundamental rethinking, redesign of a process to achieve dramatic improvements in critical measures of performance (cost, quality, capital, services and speed).

Safety-Stock– Represents the difference between reorder point quantities and dependable lead time quantities which are based on variable supply use patterns. Also called Buffer Stock.

Salvage – Property that has some value in addition to its value as scrap, but which is no longer useful as a unit in its present condition and whose restoration to usefulness as a unit is economically not feasible.

Service level – A measure of the level of satisfaction provided by an inventory to users.

Shelf life – The maximum time an item can remain in storage without deterioration.

Specification – A concise statement of a set of requirements to be satisfied by a product, material, or process. A specification may be standard, a part of a standard, or independent of a standard.

Standardisation – The formulation and evaluation, at national and organisational levels, to define and prescribe the specified quality and/or performance characteristics of a material, product and/or operation and service.

Stockless Purchasing – This form of purchasing represents buying supplies for direct utilization by the respective departments without a duplication or accumulation in the central stores.

Stock-out – A situation when a normally available item requisitioned from the store is not available.

Storage cost – Costs directly related to the value of stock held.

Surplus stock – A term referring to inventory which is no longer useful or required. It is a general term normally encompassing excess, and obsolete stock.

Tender – Offer in writing to supply goods or to execute work.

TQM – A systematic managerial approach in an organisation based on continuous improvement of all operations, processes and functions.

Transit time – A standard allowance that is given on any particular order for the physical movement of items from one operation to the next.The time allowance for the transportation of goods.

Unofficial Inventory – Those supplies that have been expensed and dispensed to the various departments and units where they are temporarily stored until used.

Voucher – A written document showing that services have been performed, or goods purchased and authorising payment to be made to the vendor.

Warehousing – A form of inventory build up which is usually located off-side and in bulk quantities.