Improvement of Medical Imaging Equipment Management System of Bangladesh

by

(Md. Anwar Hossain)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering in the Department of Biomedical Engineering

Khulna University of Engineering & Technology
Khulna 9203, Bangladesh
June 2012

Declaration

This is to certify that the thesis work entitled "Improvement of Medical Imaging Equipment Management System of Bangladesh" has been carried out by Md. Anwar Hossain in the Department of Biomedical Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

Signature of Supervisor

Signature of Candidate

Dedicated

To

My parents Late Nazar Ali Mondol, Late Amena Khatun, eldest sister Late Joreyful Begum for their most prayer. In 1988, the author was the student of 3rd part of B.Sc Engineering at BIT, Khulna and that time Mrs. Joreyful Begum was physical attacked of heart diseases. Two valves of her heart were infected by early rheumatic fever. Author tried heart and soul to admit her at NICVD but failed. After all, Joreyful was died in September 1988 without treatment and author got severe mental shock for her death. All respectable readers of this thesis are requested to make a pray to architect (almighty Allah) for her departed soul. Before her death, author was advised by his eldest sister to join in NICVD to distribute health services through engineering profession. Hence, author completed his Engineering degree in 1990 and joined a simple medical equipment supplier company. Author ignored better job opportunities in the country and abroad and he joined at NICVD as an honorary Electro medical Engineer under the supervision of Japanese and French Biomedical Engineering team. He completed his post graduation training on Biomedical Engineering from 1992 to 1994 and joined at NEMEMW & TC as an Assistant Engineer and was depurated at NICVD by the authority. He served here more than 8 (eight) years and by the grace of Almighty Allah, he got admission in M.Sc in Biomedical Engineering under the Supervision of Dr. Engr. Professor Mohiuddin Ahmad, Head of the Department of Biomedical Engineering in 2010. He completed his courses in time. Meanwhile he obtained/awarded scholarship more than six developed countries.

Approval

This is to certify that the thesis work submitted by Md. Anwar Hossain entitled "Improvement of Medical Imaging Equipment Management System of Bangladesh" has been approved by the board of examiners for the partial fulfillment of the requirements for the degree of M. Sc. Engineering in the Department of Biomedical Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh in June 2012.

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List of contributors:

1. Professor Dr. Md. Abdur Rafiq, Head of the Dept., Electrical and Electronic Engineering, KUET, Khulna
2. Engr. A.B.M. Siddique, Chief Technical Manager, NEMEW & TC
3. Engr. Mr. Nazrul Islam, Former Chief Technical Manager, NEMEMW & TC
4. Dr. Shibli Russel, Former Senior Lecturer of Uni-TEN, Malaysia
5. Engr. Dr. M. A. Rashid, Senior Lecturer, University Malaysia Perlis, Malaysia
6. Engr. Forhadul Islam, Director, Ministry of Foreign Affairs.
7. Engr. Babul Mia, Senior Cold Chain Engineer, DGHS
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Abstract

This thesis deals with the development of a standard Medical Imaging Equipment Management System (MIEMS) in the public hospitals of Bangladesh. Medical imaging equipment management has become an important component of health services delivery in Bangladesh. One of the most serious issues of Hospitals, Medical Center, Clinics and the Health Systems is the threat in diagnosing diseases due to improper medical imaging equipment management system in Bangladesh. Presently a proper equipment management set-up does not exist in public hospitals and the overall diagnostic equipment condition in various departments is very poor. To find out the facts and reasons the author visited fifteen medical imaging equipment departments in public hospitals of Bangladesh. From the data it is seen that a big percentage of the required management steps were found to be lacking. Based on the findings of the studies and with a view to improving the existing MIEMS, it is proposed to improve the medical imaging equipment management system for public hospitals in Bangladesh.

The major findings are insufficient Biomedical Engineering Team, negligible in-house and central MIEMS, weak bridge between users and biomedical engineering team. The Ministry of Health and Family welfare of Bangladesh Govt., maintains a separate Medical Imaging Equipment Management System, which is not consistent with this plan. The MIEMS is designed to assure selection of appropriate medical imaging equipment to support the medical care processes of the nation and its ambulatory care facilities. The program is designed to assure effective preparation of staff responsible for the use or maintenance of the equipment. Finally, the program is designed to assure continuous availability of safe, effective equipment through a planned maintenance program, timely repair and evaluation of all events that could have an adverse impact on safety of patients or staff. The Clinical Biomedical Engineering Department staff has primary responsibility to maintain and repair all medical equipment including equipment under contract maintenance agreement by Vendors. All staff who uses medical equipment is required to learn and implement various general and specific procedures to ensure safe and reliable use of medical equipment. In addition, it will provide a proper guideline for all patient care staff, failures and user errors associated with the use of medical equipment. Regular maintenance and evaluation are necessary to assure that particular equipment delivers the expected performance within specified parameters.

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Nomenclature and Abbreviations/ Acronyms

MIEMS	Medical Imaging Equipment Management System
HSOB	Health Services of Bangladesh
JICA	Japan International Cooperation Agency
NEMEMW	National Electro-Medical Equipment Maintenance Workshop
TC	Training Center
DEMEWs	DEMEWs (District Electro-Medical Equipment Workshops
MIS	Medical Information System
MOH & FW	Ministry of Health & Family Welfare
MIE	Medical Imaging Equipment
ECG	Electro cardio gram
EEG	Electro encephalogram
MBET	biomedical equipment technician
NICVD	National Institute of Cardiovascular Diseases
SSH	Shahid Sohrawardy Hospital
DMCH	Dhaka Medical college Hospital
CT	Computed Tomography
MRI	Magnetic resonance imaging
US	Ultrasonography
DSA	Digital Subtraction Angiography
NMRI	Nuclear magnetic resonance imaging
CMSD	Central Medical Store Depot
WHO	World Health Organization
ISETMIE	In-service training and education of Medical Imaging Equipment
MIEMMS	Medical Imaging Equipment Maintenance Management System
DGHS	Directorate General of Health Services
TEC	Tender evaluation committee
IDMSMIE	Inventory and Documentation management system of medical imaging equipment
MCH	Medical College Hospital
SPH	Specialized Hospital
UHC	Upazila Health Complex
LINAC	Linear accelerator
MIEM	Medical Imagining Equipment Management
DGSH	Directorate General of Health Services
HED	Health Engineering Directorate
DGFP	Directorate General of Family Planning
CPP	consolidated procurement plan
CPTU	Central Procurement Training Unit
DGFP	Directorate General of Family Planning
DGHS	Directorate General of Health Services
EDCL	Essential Drugs Company Limited
EPI	Expanded Program on Immunization
GOB	Government of Bangladesh
ICT	information and communications technology

LD	Line Director
LMI	Logistics Management Institute
NEMEW	National Electro-Medical and Engineering Workshop
OP	Operational plan
PIP	program implementation plan
REMEW	Regional Electro-Medical and Engineering Workshop
SPS	Strengthening Pharmaceutical Systems
SWOT	strengths, weaknesses, opportunities, and threats

CHAPTER I

Introduction

1. 1 Background of the Study

Medical imagining equipment is an integration of medical devices by which a doctor can detect the normal and abnormal conditions of physiological organs of a human body in the form of medical images. It is a modern and advanced diagnosis technique, and it has become very much attractive for the diagnosis of complex diseases in recent years. The medical imaging equipments are technically sophiscated and highly expensive. To keep the imaging equipments funtional and hence to have reliable and faithful diagonosis results from the equipments, it is very much important to develop Medical Imaging Equipment Management System (MIEMS). The MIEMS is also required for the safety of patients, cost of imaging equipments as well as for the cost of treatments. At present people of Bangladesh are taking health services through imaging equipments from different private and public hospitals, medical centers, clinics etc. where imaging equipments are normally disfuntional or gives wrong results due to lack of knowledge about MIEMS or improper MIEMS. It is well established that the proper diagnosis of diseases is strongly associated with the development and implementation of MIEMS in health sector of Bangladesh.

In addition, the use of an efficient information system effectively increase the management performance. The MIEMS defines the mechanisms for interaction and oversight of the medical imaging equipment used in the diagnosis, treatment, and monitoring of patients. The related policies and procedures govern activities from selection and acquisition to incoming inspection and maintenance of medical equipments. The main goal of this study is to ensure that the equipment used in patient care must be safe, available, accurate, and affordable [1].

In this study an advanced MIEMS has been proposed concerning the existing MIEMS in the health sector of Bangladesh. It is well established that sound health services play an important role to ensure the development of a country. In modern medical science, no physician can provide actual treatment to the patient from complex deseases without digonosis by medical imaging equipments [2]. Therefore, development and implement of advanced MIEMS is an eargent need in the health sector of Bangladesh.

1.2 Present State-of-Art

Some developed countries have been using medical imaging equipments for diagnosis of diseases near about forty years ago and, they already built-up a qualified management team over the years [3, 4, 5]. In Bangladesh some (radiological) radiology equipments were introduced for the first time in the year 1972 at Dhaka Medical College Hospital and Shaheed Shurawardy Hospital for diagnosis of diseases [6, 7].

In 1982 Japan International Cooperation Agency (JICA) donated some X-ray equipments to National Institute of Cardiovascular Diseases for cardiac disease diagnosis and there was no medical equipment management system available in Bangladesh at that time. As a result, medical X-ray equipments management and maintenance were belongs to the equipment suppliers. Later on, Government of Bangladesh procured some conventional medical X-ray and Imaging equipments within 1983 and realized the necessity to establish a biomedical equipment management organization for maintaining and training issues on electro-medical equipments [8].

Accordingly, the National Electro-Medical Equipment Maintenance Workshop and Training Center (NEMEMW and TC) was established in 1983. With the addition of modern machineries and equipments to public hospitals, the government further strengthened the NEMEMW and established 18 DEMEWs (District Electro-Medical Workshops) in 18 previous greater districts in 1987 [2, 9]. Due to increase of Medical Imaging Equipments, later on, X- ray section was established in NEMEMW and TC in a small range.

Meanwhile 23 years have been passed, the number of modern medical imaging equipments have been increased by more than three folds in public and private hospitals. Unfortunately, no Biomedical Engineering work force in the form of MIEMS has been developed in this important sector [10, 11].

As a result, it becomes difficult to maintain properly and keep the equipment fully functional. Medical imaging equipments used in public hospitals are poorly managed; eventually the data taken from such machines are not reliable. As a result, patients suffer from the inferior medical imaging equipment management in the public and private hospitals [12, 13].

The following are key factors that are responsible for improper functioning of medical imaging equipments in Public and Hospitals of Bangladesh [14]:

- Much national currency is spent for procurement of new medical imaging equipment.
- Accurate result and optimum feedback would not be obtained from equipments.
- Equipments cannot be used to its full life expectancy.
- Radiation safety practices of medical imaging equipment is not monitored and followed properly.
- A good number of patients go abroad for treatment purpose due to unreliable results given from the machine used in poorly managed equipments.
- Huge amount of foreign exchange is drained from our country on account of public treatment in abroad, which affects our economy.

The purpose of this study is to outline an improvement of biomedical imaging equipment management in Health Services under the Ministry of Health and Welfare of Bangladesh Government that provides for the safe and reliable operation of medical imaging equipments used in the treatment of patients throughout the public Hospitals and Health Centers of the country. The improvement of Biomedical Equipment Management ensures that the equipment provides accurate, reliable information to the clinicians; the equipments are safe for the patients and operators, and also the equipment is utilized to its fullest capacity in order to optimize patient care. In order to deliver good treatment to the patients, the medical team in a hospital must be trained and educated for proper handling and operations of biomedical equipments.

The aim of this study is to recommend an imaging equipment management system. It is expected that when the proposed system is fully implemented, all equipments used in the health services will ensure not only its suitable performance, but also maintain a safe and reliable condition and also helps to buildup user confidence. The objective of this study is also to reduce the degree of procurement that leads to safe the government money.

It is expected that the proposed research will be helpful for understanding the importance of MIEMS to the non-technical policymakers who are and who will be engaged in the chain of health services. The outcome of the research will be applicable to improve the awareness of equipment users and develop a friendly relationship among the personnel associated with the health services. Further, the present study will give some suggestions to the Government of Bangladesh to produce technically skilled manpower by opening Biomedical Engineer Department in different polytechnics and technical universities. As a whole the people of Bangladesh will be benefited by the present research [12, 15].

1.3 Medical Equipment

Medical equipment is designed to aid in the diagnosis, monitoring or treatment of medical conditions. There are several basic types of medical equipments [18].

i) ***Diagnostic equipment***: includes medical imaging machines, used to aid in diagnosis. Examples are ultrasound and MRI machines, PET and CT scanners, and x-ray machines.
ii) ***Therapeutic equipment***: includes infusion pumps, medical lasers and LASIK surgical machines.
iii) ***Life support equipment***: is used to maintain a patient's bodily function. This includes medical ventilators, anaesthetic machines, heart-lung machines, ECMO, and dialysis machines.
iv) ***Medical monitors***: allow medical staff to measure a patient's medical state. Monitors may measure patient vital signs and other parameters including ECG, EEG, blood pressure, and dissolved gases in the blood.
v) ***Medical laboratory equipment***: automates or helps analyze blood, urine and genes.

Diagnostic Medical Equipment may also be used in home for certain purposes such as for the control of diabetes mellitus. A biomedical equipment technician (BMET) is a vital component of the healthcare delivery system. The people employed primarily by hospitals, BMETs are responsible for maintaining medical equipments.

1.4 Medical Imaging Equipments

Medical Imagining Equipment is defined as an integration of medical devices by which a doctor can detect the normal and abnormal condition of physiological organs of a human body in the form of medical Images. Radiology department of Bangladesh have been using different types of medical imaging equipments. They are mainly categories into two types, such as i) Radiology equipments, and ii) Ultrasound equipments. Figure 1.1 shows the list of some major medical imaging equipments.

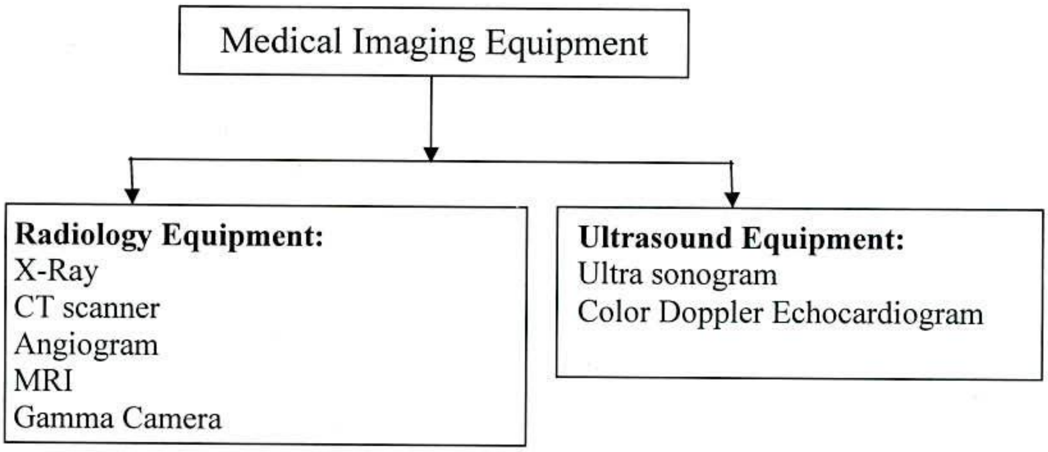


Figure 1.1: List of medical imaging equipments.

The list of medical imaging equipments and the location where the equipments are used given in **Table 1.1**. The main applications of medical imagining equipments are:

- Measuring the normal and abnormal condition of physiological organs of human
- Therapeutic purpose / treatment purpose
- Diseases pattern diagnosis purpose
- Research purpose

Table 1.1: List of medical imaging equipments used in different places of Bangladesh

Name of the equipments	**Year of operation**	**Purpose of use**	**Location**
Medical X-ray	1984	Diagnosis and therapeutic	NICVD, SSH, Dhaka
Coronary Angiogram	1990	Diagnosis and therapeutic	NICVD, Dhaka
CT scan	1990	Diagnosis	Dhaka Medical Collage Hospital
Ultra sonogram	1992	Diagnosis	NICVD, DMCH, Dhaka
MRI Machine	1996	Diagnosis	DMCH, Dhaka
Gamma camera	2002	Diagnosis	NICVD, Dhaka

A lot of modern sophisticated medical imaging equipments have been using in the health services globally since 20 years long. Their short descriptions are given below:

X-ray: X-ray signal is generated by X-ray tube and passes through the target of human organs and optical signal received by card film. Image is produced in the film. Radiologist prepares the report and physician evaluates the findings and takes decision. This system is called conventional X-ray image system. Presently their use is decreasing and developed digital X-Ray system. A digital X-Ray system is very convenient both of the patient and operator. Digital X-ray system means digital images and images could be store in computer and laser printer. A sample of digital X-ray equipment is shown in **Fig. 1.2**.

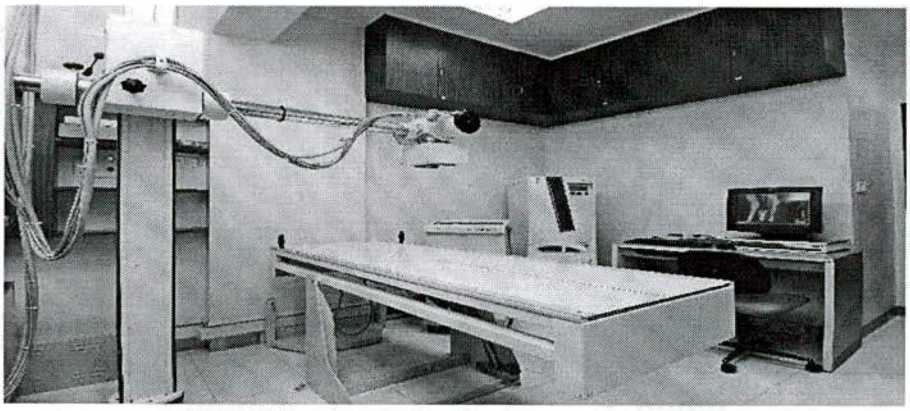


Fig. 1.2: A digital X-Ray.

CT scan: The CT scan equipment is worked as digital X-ray principle but gantry is rotated in a certain speed around the desired organ of human body and detector elements detect the object and then all signals receive as row images. All row images convert into analog or Syngo images. Syngo images are processed to produce digital images. A typical CT scan machine is shown in **Fig. 1.3.**

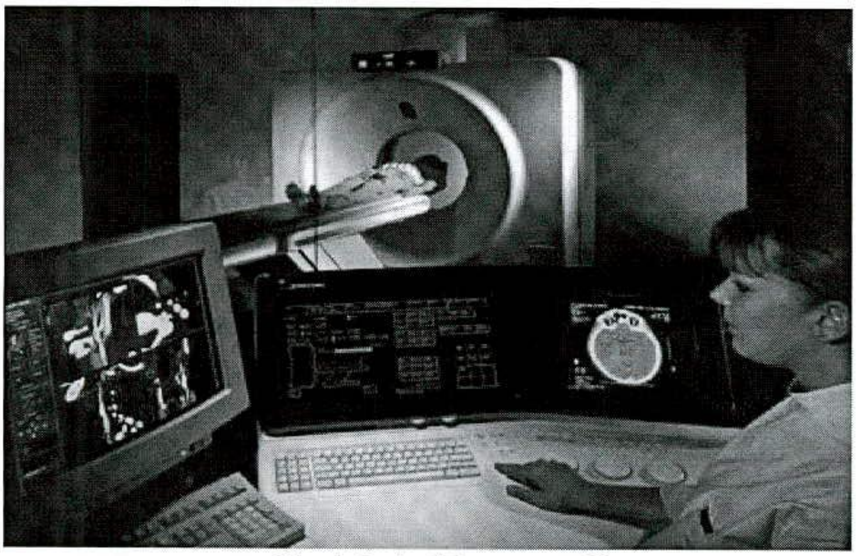


Fig. 1.3: A CT scan machine

Angiography or Arteriography /Coronary Angiogram: A coronary angiogram is a procedure that uses X-ray imaging to see the heart's blood vessels. Coronary angiograms are part of a general group of procedures known as cardiac catheterization. Heart catheterization procedures can diagnose and treat heart and also give information about blood vessel conditions. A coronary angiogram, which can help diagnose heart conditions, is the most common type of heart catheter procedure. During a coronary angiogram, a type of dye that's visible by X-ray machine is injected into the blood vessels of human heart. The X-ray machine rapidly takes a series of images (angiograms), offering a detailed look at the inside of the blood vessels. If necessary, the doctor can perform procedures such as angioplasty during coronary angiogram. It is a medical image technique used to visualize the inside of blood vessels and organs of the body with particular interest in the arteries, veins and the heart chambers. This is traditionally done by injecting a radio-opaque contrast agent into the blood. The X-ray images taken may either be still images, displayed on an image intensifier or film, or motion images. For all structures except the heart, the images are usually taken using a technique called digital subtraction angiography (DSA). Images in this case are usually taken at 2 - 3 frames per second, which allows the interventional radiologist to evaluate the flow of the blood through a vessel or vessels. This technique "subtracts" the bones and other organs so only the vessels filled with contrast agent can be seen. The heart images are taken at 15-30 frames per second, not using a subtraction technique. Since DSA requires the patient to remain motionless, it cannot be used on the heart. Both these techniques enable the interventional radiologist or cardiologist to see stenosis (blockages or narrowing) inside the vessel which may be inhibiting the flow of blood and causing pain [19]. A typical coronary angiogram machine and the corresponding examination of the heart image are shown in **Fig. 1.4**.

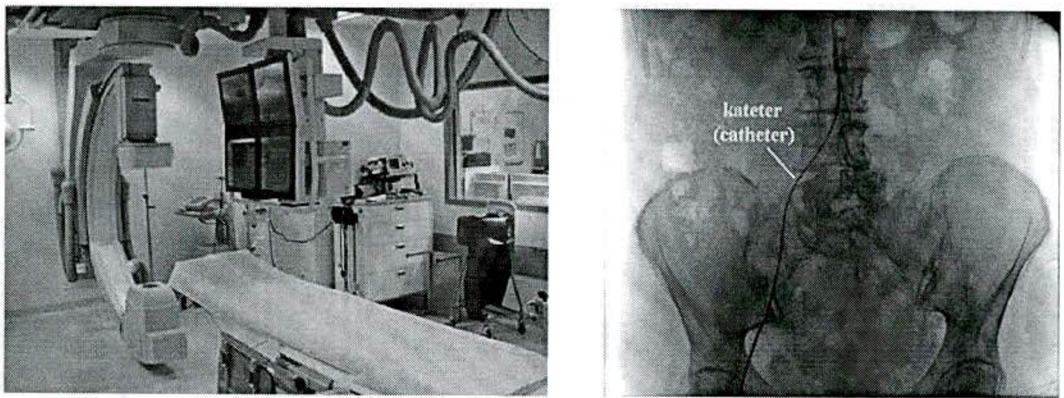


Figure 1.4: A coronary angiogram and a practical examination of patient

MRI Machine: Magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), or magnetic resonance tomography (MRT) is a medical imaging technique used in radiology to visualize detailed internal structures of a human body. MRI makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body. MRI machine uses a powerful magnetic field to align the magnetization of some atomic nuclei in the body, and radio frequency fields to systematically alter the alignment of this magnetization. This causes the nuclei to produce a rotating magnetic field detectable by the scanner and this information is recorded to construct an image of the scanned area of the body [20]. Magnetic field gradients cause nuclei at different locations to rotate at different speeds. By using gradients in different directions 2D images or 3D volumes can be obtained in any arbitrary orientation. MRI provides good contrast between the different soft tissues of the body, which makes it especially useful in imaging the brain, muscles, the heart, and cancers compared with other medical imaging techniques such as computed tomography (CT) or X-rays. Unlike CT scans or traditional X-rays, MRI does not use radiation. The human body is largely composed of water molecules. Each water molecule has two hydrogen nuclei or protons. When a patient is placed inside the powerful magnetic field of the scanner, the average magnetic moment of many protons becomes aligned with the direction of the field. A radio frequency transmitter is briefly turned on, producing a varying electromagnetic field. This electromagnetic field has just the right frequency, known as the resonance frequency and to be absorbed and flip the spin of the protons in the magnetic field. After the electromagnetic field is turned off, the spins of the protons return to thermodynamic equilibrium and the bulk magnetization becomes re-aligned with the static magnetic field. During this relaxation, a radio frequency signal is generated, which can be measured with receiver coils. Information about the origin of the signal in 3D space can be learned by applying additional magnetic fields during the scan. These fields, generated by passing electric currents through gradient coils, make the magnetic field strength vary depending on the position within the magnet. Because this makes the frequency of the released radio signal also dependent on its origin in a predictable manner, the distribution of protons in the body can be mathematically recovered from the signal, typically by the use of the inverse Fourier transform. Protons in different tissues return to their equilibrium state at different relaxation rates. Different tissue variables, including spin density, T_1 and T_2 relaxation times and flow and spectral shifts can be used to construct images [21]. By changing the settings on the scanner, this effect is used to create contrast between different types of body tissue. MRI contrast agents may be injected intravenously to enhance the appearance of blood vessels, tumors or inflammation. Contrast agents may also be directly injected into a joint in the case of arthrograms, MRI images of joints. Unlike CT, MRI uses no ionizing radiation and is generally a very safe procedure. Nonetheless the strong magnetic fields and radio pulses can affect metal implants, including cochlear implants and cardiac pacemakers. In the case of cochlear implants, the FDA has approved some implants for MRI compatibility. In the case of cardiac pacemakers, the results can sometimes be lethal, so patients with such implants are generally not eligible for MRI. Since the gradient coils are within the bore of the scanner, there are large forces between them and the main field coils, producing most of the noise that is heard during operation. Without efforts to damp this noise, it can approach 130 decibels (dB) with strong fields. MRI is used to image every part of the body, and is particularly useful for tissues with many hydrogen nuclei and little density contrast, such as the brain, muscle, connective tissue and most tumors. The body is largely composed of water molecules. Each water molecule has two hydrogen nuclei or protons. A typical MRI machine is shown in Fig. 1.5.

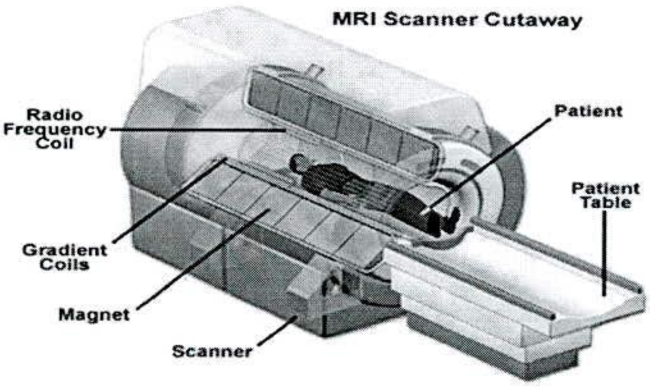


Figure 1.5: A MRI machine

The Ultrasound Machine: Diagnostic sonography (ultrasonography) is an ultrasound-based diagnostic imaging technique used for visualizing subcutaneous body structures including tendons, muscles, joints, vessels and internal organs for possible pathology or lesions. Obstetric sonography is commonly used during pregnancy and is widely recognized by the public. In physics, the term "ultrasound" applies to all sound waves with a frequency above the audible range of human hearing, about 20 kHz. The frequencies used in diagnostic ultrasound are typically between 2 and 18 MHz.

A basic ultrasound machine has the following parts (Fig. 1.6):

- **Transducer probe** - probe that sends and receives the sound waves
- **Central processing unit (CPU)** - computer that does all of the calculations and contains the electrical power supplies for itself and the transducer probe
- **Transducer pulse controls** - changes the amplitude, frequency and duration of the pulses emitted from the transducer probe
- **Display** - displays the image from the ultrasound data processed by the CPU
- **Keyboard/cursor** - inputs data and takes measurements from the display
- **Disk storage device** (hard, floppy, CD) - stores the acquired images
- **Printer** - prints the image from the displayed data

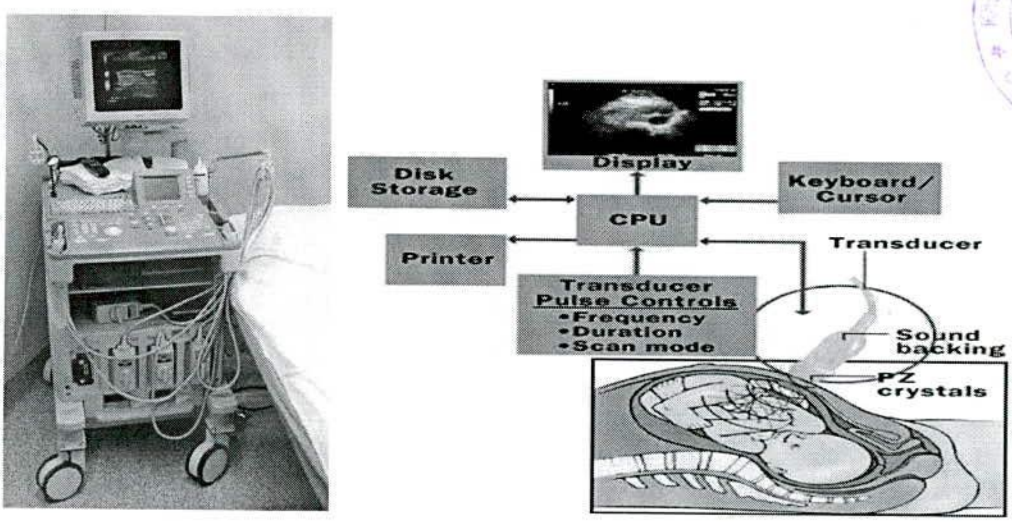


Figure 1.6: Different parts of an ultrasound machine

The CPU is the brain of the ultrasound machine. The CPU is basically a computer that contains the microprocessor, memory, amplifiers and power supplies for the microprocessor and transducer probe. The CPU sends electrical currents to the transducer probe to emit sound waves, and also receives the electrical pulses from the probes that were created from the returning echoes. The CPU does all of the calculations involved in processing the data. Once the raw data are processed, the CPU forms the image on the monitor. The CPU can also store the processed data and/or image on disk. The transducer pulse controls allow the operator, called the ultrasonographer, to set and change the frequency and duration of the ultrasound pulses, as well as the scan mode of the machine. The commands from the operator are translated into changing electric currents that are applied to the piezoelectric crystals in the transducer probe [24].

Gamma camera: A gamma camera, also called a **scintillation camera** or **anger camera**, is a device used to image gamma radiation emitting radioisotopes, a technique known as scintigraphy. The applications of scintigraphy include early drug development and nuclear medical imaging to view and analyze images of the human body or the distribution of medically injected, inhaled, or ingested radionuclides emitting gamma rays [25]. The schematic diagram of a gamma camera is shown in Fig. 1.7.

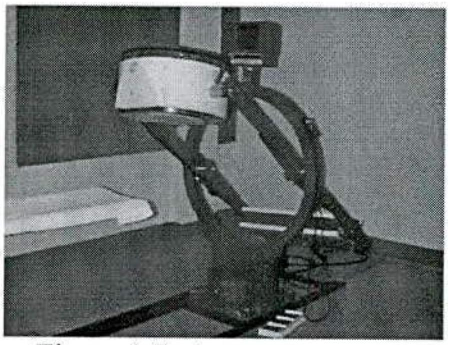


Figure 1.7: A gamma camera

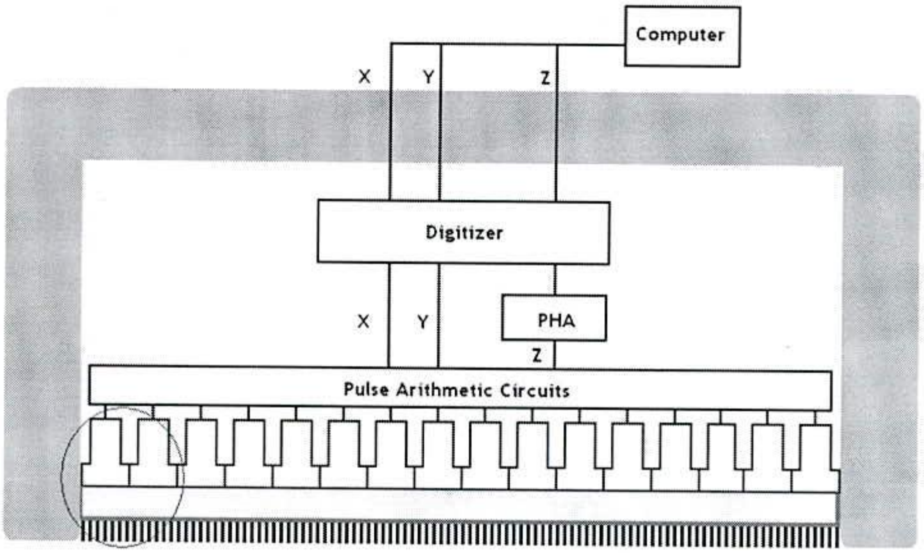


Figure 1.8: Diagrammatic cross section of a gamma camera detector

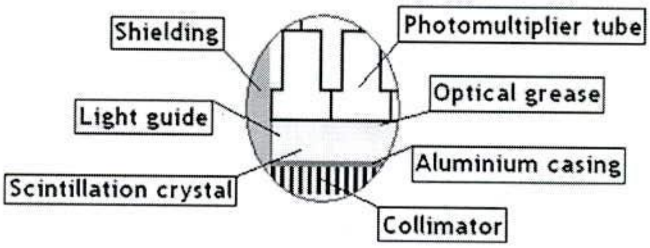


Figure 1.9: Details of the cross section of a gamma camera

A gamma camera consists of one or more flat crystal planes (or detectors) optically coupled to an array of photomultiplier tubes, the assembly is known as a "head", mounted on a gantry. The gantry is connected to a computer system that both controls the operation of the camera as well as acquisition and storage of acquired images. The system accumulates events, or counts, of gamma photons that are absorbed by the crystal in the camera. Usually a large flat crystal of sodium iodide with thallium doping in a light-sealed housing is used. The crystal scintillates in response to incident gamma radiation. When a gamma photon leaves the patient (who has been injected with a radioactive pharmaceutical), it knocks an electron loose from an iodine atom in the crystal, and a faint flash of light is produced when the dislocated electron again finds a minimal energy state. The initial phenomenon of the excited electron is similar to the photoelectric effect and (particularly with gamma rays) the Compton effect. After the flash of light is produced, it is detected. Photomultiplier tubes) behind the crystal detect the fluorescent flashes (events) and a computer sums the counts. The computer reconstructs and displays a two dimensional image of the relative spatial count density on a monitor. This reconstructed image reflects the distribution and relative concentration of radioactive tracer elements present in the organs and tissues imaged. The diagrammatic cross section of a gamma camera detector is shown in Fig. 1.8.

The location of the interaction between the gamma ray and the crystal can be determined by processing the voltage signals from the photomultipliers; in simple terms, the location can be found by weighting the position of each photomultiplier tube by the strength of its signal, and then calculating a mean position from the weighted positions. The total sum of the voltages from each photomultiplier is proportional to the energy of the gamma ray interaction, thus allowing discrimination between different isotopes or between scattered and direct photons. In order to obtain spatial information about the gamma emissions from an imaging subject (e.g. a person's heart muscle cells which have absorbed an intravenous injected radioactive, usually thallium-201 or technetium-99m, medicinal imaging agent) a method of correlating the detected photons with their point of origin is required [26, 27]. The detailed cross-section of a gamma camera is shown in Fig. 1.9.

1.5 Measuring System and Sources of Errors in the Measurements

1.5.1 Sample of Measuring System: Medical images produce from biomedical signals. Basic biomedical signals receive from human body by applying external energy to human body or signals receive through transducer. For ultrasound image, ultrasound frequency sends to the target region of human body and sound signal is converted into electrical signal and after signal processing, physician gets the information from images. In X-ray and CT images, a high energy radiation passed through the human body and receives signals. After processing of the images, information of physiological organs of human body is obtained. For MR images, patient is placed into the high magnetic field for excitation hydrogen molecules for alignment and same time radio signals near about 1Mz was applied through the transmitter and used amplifier. Amplified signals interact with charged hydrogen particles and receiver on the other end receives the signals. Finally, the information of defined organs processed as images. In Gamma radiation, patient was received isotope trough injector. After certain time, isotope excites the tissues and signals crates in the human body. These signals were received Gamma machine and hence converted it as images.

1.5.2 System Error (The sources of errors): Due to improper MIEMS (medical imaging equipment management system) in health services of Bangladesh, in most cases, accurate results could not be obtained from the MIEs (medical imaging equipments). The major errors are summaried in Table 1.2 [28, 29].

Table 1.2: (Sources of Errors) System Error of (from) Medical Imaging Equipments

Sl. No	System error (Errors)	Causes	(Result findings) Results	(Proven record) Impacts
1	Improper information	Environmental hazards	Cell phone, radio station were used by users and patient in hospitals premises	Practically found during ultra sonogram, some users and patient acknowledged
2	Image Processor	Unexpected temperature	Room air cooler and dehumidifier are installed without proper load calculation	Air cooler and humidifier are not been found functional due to lack of planned maintenance
3	Patient Management	Patient management is improper	Some patient become afraid due to awareness, incorrect positioning of patient	Physiological organs and circulatory system found improper
4	Power Management	Load shedding	On line UPS /Generator was used but due to fluctuation of line Voltage. image quality was not excellent	Inferior Image was found
5	Unskilled Operator	Insufficient academic qualification of operators and inadequate practical knowledge	Less ideas and inadequate basic training on equipments and lack of knowledge in computer software management	Due to unskilled handling, good image could not be obtained and machine could not be used for an expected longer time
6	Preventive Maintenance	MIEMS is not established	Improper maintenance	Machine demanding environments have not been complied resulting in errors from the equipment

1.6. Concept of Standard MIEMS

The MIEMS defines the mechanism for interaction and oversee the performance of imaging equipments used in the diagnosis, treatment and patient management. The relevant policies and procedures underlined in MIEMS govern activities from selection and acquisition to incoming inspection and maintenance of imaging equipments. The mission is to ensure that the equipments used for patient care is safe, available, accurate and affordable [1, 2]. MIEM is an important activity for the safety of patient and (treatment and equipment) cost management in modern hospital operations. In addition, the use of an efficient information system effectively promotes the management performance. The related policies and procedures govern activities such as the selection, planning, and acquisition of medical devices, through to the incoming inspection, acceptance, maintenance, and eventual retirement and disposal of medical equipments.

Medical equipment management is a recognized profession within the medical logistics domain. The purpose of healthcare technology management professionals is to ensure that equipment and systems used in patient care are operational, safe, and properly configured to meet the standard level of the healthcare. Also the equipment is used in an effective way consistent with the highest standards of care by educating the healthcare providers, equipment users, and patient. The equipment is designed to limit the potential for loss, harm, or damage to the patient, provider, visitor, and facilities through various means of analysis prior to and during acquisition, monitoring and foreseeing problems during the lifecycle of the equipment, and collaborating with the parties who manufacturer, design, regulate, or recommend safe medical devices and systems [30].

1.7 Relationship of MIEMS with Patient Treatment

There is an important relationship exists between MIEMS and treatment of patient (curative). It is observed that real diagnostic results could not be obtained without proper functioning of the equipment, and proper functional conditions must be ensured through MIEMS. It is therefore not possible for a physician to take actual decision about patient treatment without proper MIEMS. The existing and proposed treatment cycle of a patient are shown in Fig. 1.10 and Fig. 1.11 respectively [16].

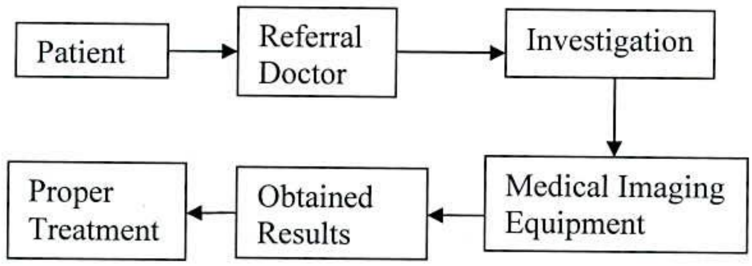


Figure 1.10: Existing treatment diagram of a patient

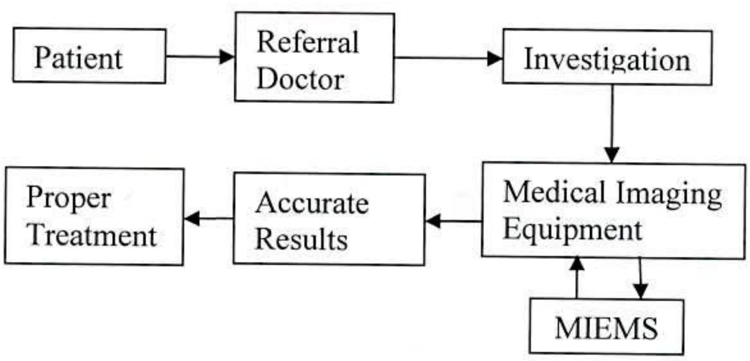
Results without MIEMS
Some Ultrasound images are received by improper maintenance management

Patient ID: Mrs Anjum
Age: 35
Date of Examination: 20-09-2011
Weight: 65 Kg
Patient category: problem of kidneys
Blood serum cretenin was: 3.5
Case study I: Unskilled user, machine was dirty, examination probe was not clean, and
Setting Probe Frequency: 3.5 MHz

Table 1.3: Data Table without MIEMS

Name Equipment	Examination name	Indicators of MIEMS not considered	Results I	Analysis by a doctor and Biomedical Engineer

Ultra sonogram	Image study of Kidneys	❖ Unskilled users ❖ Voltage fluctuation ❖ Applied contact gel was non homogeneously ❖ User and patent have cell phone ❖ Frequency setting was 3.5 MHz	❖ Stone was found in left kidney and size was 2mmx2mm ❖ Image quality was poor ❖ Border of the kidneys were not well defined	Doctor compared the result with clinical findings and advice him to review examination. He seems that result is not correct.
Ultra sonogram	Whole abdomen	Some spot was found in the probe	❖ Image quality is inferior ❖ Uterus found enlarged patient was attack allergy.	*Comments of Biomedical Engineer*: rechecked the machine and reexamine the patient



1.11: Proposed treatment diagram of a patient

Results with MIEMS:

Some Ultrasound images are received by improper maintenance management

Patient ID: Mrs Anjum
Age: 35
Date of Examination: 25-09-2011
Weight: 65 Kg
Patient category: problem of kidneys
Blood serum cretenin was: 3.5
Case study II: Skilled user, machine was clean, examination probe was clean and probe frequency setting was 5 MHz and proper operation and maintenance management was used.

Table 1.4: Data Table with MIEMS

Name Equipment	**Examination name**	**Indicators of MIEMS not considered**	**Results I**	**Analysis by a doctor and Biomedical Engineer**
Ultra sonogram	Image study of Kidneys	❖ Skilled users ❖ Use Regulated power supply ❖ contact gel homogeneously applied on the body surface ❖ User and patent had not cell phone ❖ Frequency setting was 5 MHz	❖ Stone was found in left kidney and size was 2.5mmx2.5mm ❖ Image quality found good ❖ Border of the kidneys were well defined	Doctor compared the result with clinical findings and found it correct and referred her to Kidney specialist
Ultra sonogram	Whole abdomen	❖ All parameters were setting by a biomedical Engineer and probe was changed	❖ Image quality found superior ❖ Uterus found enlarged but lees. Patient was not attack any allergy.	Comments of Biomedical Engineer: This examination was done by a Biomedical engineer and one sonologist rechecked the machine and reexamine the patient and found correct results

The mathematical relationship between patient treatment (curative may change in every where by treatment) and MIEMS is shown in Eq. (1)

$$y = \int x dx \qquad (1)$$

Where, y and x denote integrated performance of MIEMS components or phases and patient treatment, respectively. The x can be expressed by

$$x = (x_{epl} + x_{epr} + x_{eii} + x_{eid} + x_{eca} + x_{emp} + x_{emm} + x_{pm} + x_{iset} + x_{edd}) \qquad (2)$$

where equipment planning, equipment procurement, equipment incoming inspection, equipment inventory and documentation, equipment commissioning and acceptance, equipment monitoring and performance, equipment maintenance management, personnel management, in-service education and training, and equipment de-commissioning and disposal are represented by the variables x_{epl}, x_{epr}, x_{eii}, x_{eid}, x_{eca}, x_{enp}, x_{emm}, x_{pm}, x_{iset}, and x_{dd}, respectively. From the above functional diagram and equations, it is very clear that management of each the phases are correlated and has an impact on diagnosis and treatment of patients. It is concluded that only a standard MIEMS can deliver real information about patient evaluation to a physician.

1.8 Different Phases of MIEMS

To implement the proposed MIEMS, it is very requirement issue to understand different management phases clearly. The importances of different MIEMS phases are discussed in below [31, 32, 33].

(i) *Equipment Planning*:
In this phase, following conditions are vital Indicators for decision process:

- Demonstrate clinical needs. It means that actual requirement of equipment.
- Available qualified users mean the skill level of users
- Approved and reassured source of recurrent operating budget
- Confirmed maintenance services and support mean the skill Biomedical Engineering management
- Adequate environment support means the adequate room preparation, room shielding for radiation, air conditioning, arrangement of uninterruptible regulated power supply, patient preparation room

(ii) *Equipment Procurement*: For the procurement of equipment, a detailed and clear specification must be prepared as per requirements. All terms and condition along with manufacturer of equipment should be mentioned. Furthermore, required conditions need to include in the purchase order to specify that the supplier must supply operating and service manuals, operation and service training, and essential spare parts. Other special requirements can also be specified here. Withhold payment if specified conditions are not met.

(iii) *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.

(iv) *Commissioning and Acceptance*: Commissioning can be carried out by in-house technical staff if they are familiar with that item of equipment. If commissioning by the suppliers is needed, the process should be monitored by in-house technical staff so that any technical matters can be noted and recorded. It is particularly important to bear in mind that normally the supplier-warranty starts the day after equipment is delivered to the health facility. If equipment is not going to be used for some time after delivery, special arrangements must be made with the supplier to define the warranty period. Such an agreement should preferably be made in the purchase order. No payment to the supplier should be made before satisfactory performance has been confirmed by the in-house technical staff.

(v) *Inventory and Documentation System*: It provides information to support different aspects of medical equipment management. One important aspect is the consideration for standardization. Inventory entries should include accessories, spare parts and operating and service manuals. It is advisable to make copies of the manuals for distribution to the users, while the originals of the manuals should be kept in the technical document library for safekeeping.

(vi) ***Monitoring of the Use and Performance***: A common mistake is to think that the warranty period is covered by the supplier so that no in-house technical attention is necessary. It is important that in-house technical staff made a link between user and supplier and observe any supplier's technical services. Such warranty services should be recorded in the equipment service history. This will also provide a good learning opportunity for the in-house technical personnel and developed a centralized inventory system. Make departmental managers responsible for accounting for the assets under their control. Hospital administrators should have completed extensive studies of inventory control and loss management during their education and training. Inventories should contain detailed information about all equipments, such as, serial number, purchase price, date of acquisition, and its location within the hospital, its state of repair, its depreciation and its salvage. Any equipment shared between departments and divisions should be allocated a home-base from in which it is currently being used. Analyze equipment losses regularly to identify any obvious trends or patterns in losses. Closed circuit television monitoring may be necessary to try to identify causes of specific areas where losses are greatest.

(vii) ***Maintenance Management***: Proper maintenance of medical equipment is essential to obtain sustainable benefits and to preserve capital investment. Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy. This topic will be further discussed in the guideline.

(viii) ***In-Service Education and Training*****:** The In-service training and education of medical imaging equipment (ISETMIE) defines the mechanisms for interaction with the users and maintenance of equipment and should be trained to do routine simple maintenance on equipment. This will increase user care of equipment and cooperation with maintenance technicians to reduce equipment breakdowns. At the same time, this will promote the culture of equipment care and maintenance to improve the quality of health care [29, 35].

(ix) ***Personnel Management*****:** Technical management team means that the personnel involved in all the management phases. This area is crucial to the daily work activities. Biomedical managers must be able to correctly assign staff for the right job. Having a team leader/veteran is important for monitoring staff that might not have much experience. The monthly timesheet provides a method to record the time each person will be available for work during the month. The timesheet provides a gross breakout of how the time was spent, and provides a basis for productivity analysis reports. It also provides the monthly man-hour accounting data. This data can be used to process performance information about individual staff/team members. Each staff member should provide the following values of time, rounded to the nearest tenth of an hour, for monthly processing:

- Regular hours
- Overtime hours
- Non-duty absence
- Duty absence
- Administrative support hours
- Technician training hours
- Supervisory hours
- Travel hours

Personnel management can be calculated using the following example:

- Total hours = Regular hours + Overtime hours
- Hours available for work = Total hours - (Non-duty absence and Duty absence)
- Hours available for maintenance = Hours available for work- (Administrative support hours, Technical training hours, Supervisory hours, and Travel hours)

(x) ***De-commissioning and Disposal***: Most of the medical equipments in developing countries is old and spare parts are often in short supply, it may not be realistic to assume that the old equipments can be replaced within a short period of time. It would be wise to repare the existing old equipments to maintain continuity in health services. Some old units can be dismantled to provide spare parts for similar units. This process will also provide an opportunity for cultivating technical innovation using local resources. De-commissioned equipment must be shifted to the store by keeping the record [29, 34].

1.9 Typical MIEM Cycle

The typical life cycle of imaging equipment is illustrated in Fig. 1.12 [29, 34]. The stages in the life cycle of the medical device is shown in Fig. 1.13.

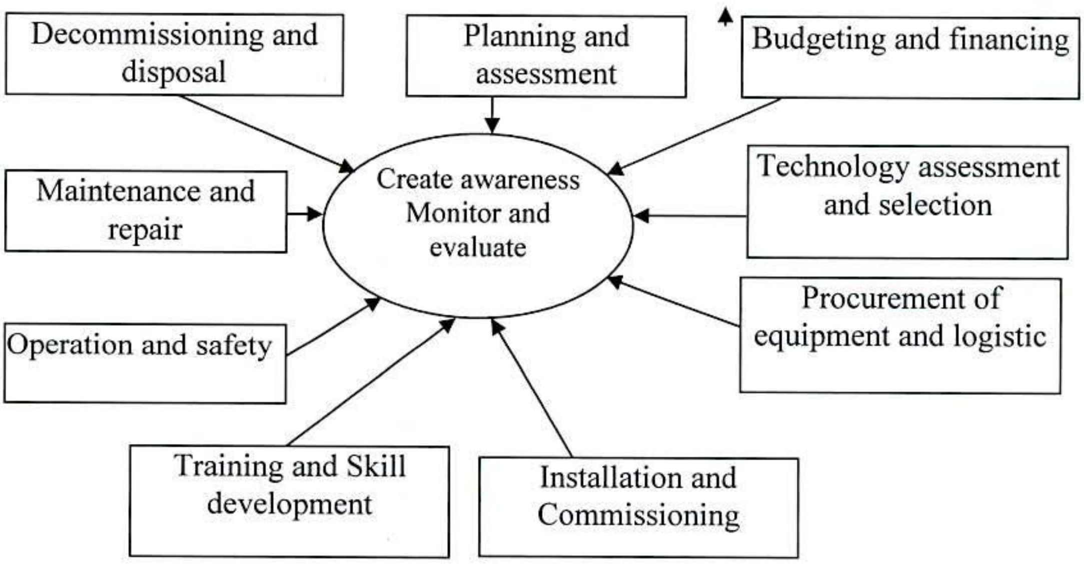


Figure 1.12: Cycle diagram of MIEMS

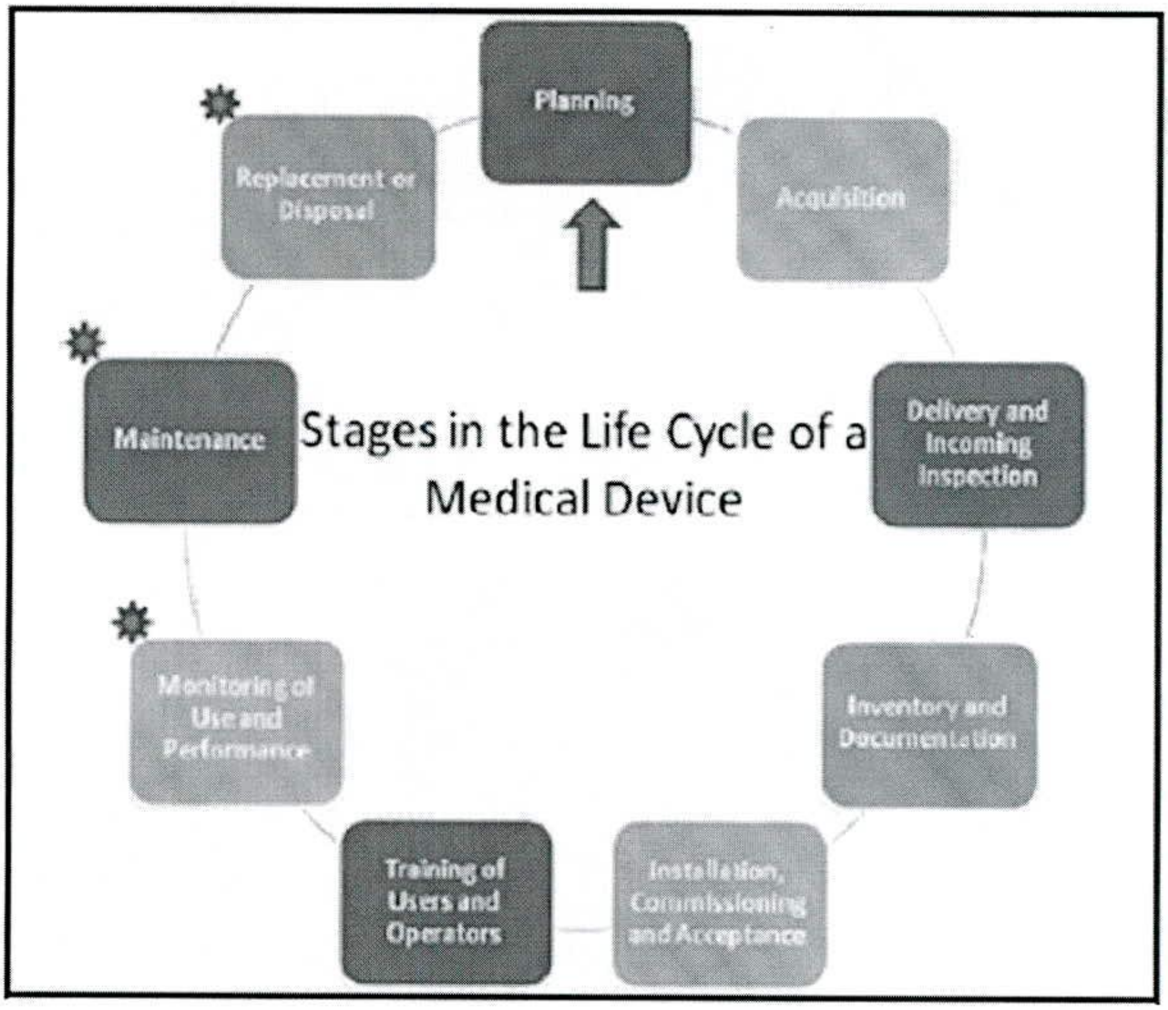


Figure 1.13: Stages of in the Life Cycle of a Medical Device

1.10 Objectives of the Study

The major objectives of MIEMS are given below:

- To develop MIEMS in the health services of Bangladesh (HSOB need to expand) for sustaining life cycle of medical imaging equipments as per standard of developed countries.
- To develop a management system which will be helpful for need based equipment selection, equipment inspection, proper installation, maintenance, and equipment decommissioning.
- To provide suggestions for better patient care using modern imaging equipment management.
- To develop training modules for national staffs, including technical managers, engineers, technicians, operators, and users.
- To strengthen the mechanism for exchange of information, experts, and training facilities at inter country sub-regional, regional and inter regional levels.
- To develop a system that will provide adequate facilities for safe and reliable operation of medical imaging equipment.

- To give education and training to hospitals medical team in proper handling and operation of Bio-Medical Equipments by the training module.
- To provide suggestions to the Government of Bangladesh for the recruitment of Biomedical Engineers and technicians in health sector.
- Establishment of information system capable of assimilating and disseminating technical information to health sectors.
- Suggestion for infrastructure development (Stretching) in national healthcare technical services.
- To develop a manual which will be helpful to make understand the non-technical policy makers easily understand the importance of biomedical imaging equipment management system.
- It will encourage to opening Biomedical Engineering Department in public and private Engineering Universities and polytechnics.

1.11 Outlines of the Thesis

Chapter I describes medical imaging equipment definition and description, pictorial diagram, picture, sample measuring error system, ideas of the standard medical equipment management, relation between management and patient, description of medical equipment phases and a typical life site of medical imaging equipment and objectives of the study.

Chapter II reflects the present scenario of medical imaging equipment phases in details as literature, data table picture, figure and the definite public hospitals of Bangladesh, their statistical data, functions of the different level of hospital and improvement strategies of MIMES.

Chapter III describes the comparison of MIMES with standard MIMES in the form of data table, analysis and recommendation.

Chapter IV describes improvement methodology of each phase of medical imaging equipment system of Bangladesh and improvement procedure of present MIE management units under the ministry of health and family welfare and proposal to establish two sub- zonal MIEMS unit of Dhaka metro poltroon area under the control of the management head quarter and sub-article (4.5 & 4.6) will be the summary of proposal for improvement, suggestions for government of Bangladesh.

Chapter V shows the research conclusion and suggestion future work. References of this research work will be found as an annexure. Appendices and abbreviations are enclosed in different pages.

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CHAPTER 2

Present Status of MIEMS in Public Hospitals of Bangladesh

2.1 Introduction

In Bangladesh near about 2500 numbers of different MIE have been using for the purpose of diagnosis diseases and for treatment. But MIEMS is not improved consequently. Not only that the existing MIEMS core personnel are going to be retired but no Biomedical Engineer and Biomedical Technician are not appointed. As a result, MIEMS is failed down below the datum level.

Since then 23 years have been passed meanwhile and with time, the number of modern Medical Imaging Equipments have also been increased by three folds in the public hospitals. Unfortunately, no Biomedical Engineering work force in the form of Medical imaging equipment management system has so far not been increased in this important sector [1]. As a result, it becomes difficult to maintain properly and keep the equipment fully functional. Medical imaging equipments used in public hospitals are poorly managed and in many casues the reading /data is taken from such machines are not reliable. As a result, patients suffer from the inferior medical imaging equipment management in the public hospitals [2, 3].

A national assessment is pre-requisite for the improvement of existing medical imaging equipment management system. Assessment results will be the base line data for the improvement of present MIEMS. Standard MIEEMS is consists of many phases and it will differ country to country. The World Health Organization (WHO) is leading and monitoring the health services internationally and according to WHO standard, it is found 10 phases of Biomedical Equipment Management System (BMEMS).The standard MIEMS is considered from WHO [2]. in this chapter, it is described statues of MIEMS of Bangladesh and at the same time it is compared with MIEMS of developed countries. The deviations MIEMS is summarized in the chapter III. Finally, improvement proposal of existing MIEMS is shown in chapter IV.

2.2 Status of Present MIEMS

Status of present MIEMS of Bangladesh is described in this chapter as phase wise. The standard MIEMS consists of ten phases and MIEMS phases is shown in the Table 2.1 [1, 2].

Table 2.1: Comparative statement between SMIEM and EMIEM

Sl. No.	Standard MIEM Phases	Existing MIEM Phases
1.	Equipment planning	Improper
2.	Equipment Procurement	Inferior
3.	Equipment incoming inspection	Improper
4.	Commissioning and acceptance	Inferior/improper
5.	Equipment inventory and documentation	Nil
6.	Equipment monitoring and performance	Nil
7.	Equipment maintenance	poor
8.	Equipment in-service education and training	Stop since 10 years
9.	Personal management	imperfect
10.	Equipment de-commissioning and disposal	inferior

The phase-wise status of existing MIEMS of Bangladesh is described below.

2.2.1 Medical Imaging Equipment Planning (MIEP)

The present planning of medical imaging equipment is not adequate due to following reasons:

- Planning has been prepared by users, doctors and non technical persons of health services of Bangladesh government. All the technical organizations like Bangladesh power development board, Bangladesh Telecommunication Limited, Heal Engineering Directorate, Rural Electrification Board have been planning their equipments by Engineering Management Team. On the other hand, in medical imaging equipment planning section, feedback from Biomedical Engineer has not been taken into consideration and thereby health services are affected due to improper equipment management [3, 4]. Figure 2.1 shows the organizational management planning of MIE. The difference between existing planning and proposed planning along with percentage of deviation in existing panning is presented in Table 2.2.

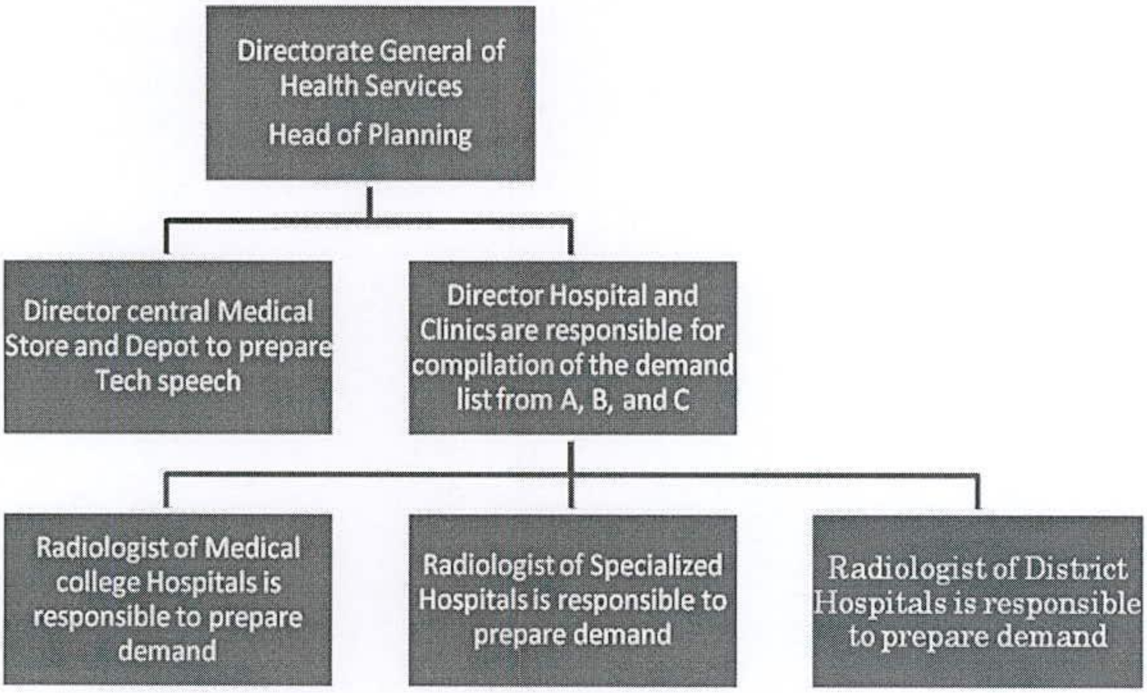

Figure 2.1: Existing planning chart of MIE

Table 2.2: Standard and Existing and planning of MIE

Standard Equipment Planning components	**Sub components**	**Devolved countries**	**Equipment Planning components in Bangladesh**
Demonstrated clinical needs	❖ Need assessment team ❖ Briefing Team ❖ Design Team	Proper	Improper
Available qualified users	❖ Trained Nurses ❖ Trained Radiologist ❖ Trained Radiographer	Proper and skilled	Unskilled and improper
Approved and reassured source of recurrent operating budget	❖ Approved revenue budget ❖ Regular operating budget	Adequate	Inadequate
Confirmed maintenance services and support	❖ Biomedical Engineers, Biomedical Technician ❖ PPM and CM	Available	Not available
Adequate environment support	❖ Room allocation ❖ Temperature ❖ Humidity ❖ Radiation protection ❖ Regulated power supply	Maintain ed properly	Unplanned and most of the X-ray rooms of Upazilla Health Centers are not radiation protection. Regulated power is not available
Total average result		**Proper**	**Improper**

The existing Equipment Planning result of Bangladesh with comparison of standard is shown and found a substandard MIEMS. Considering real situations of our country, a proposal is submitted in the chapter IV (4.1) for the improvement of present medical imaging equipment planning (MIEP).

2.2.2 Equipment Procurement Procedure (EPP)

Proper procedure is not being followed in the procurement of medical imagining equipments. The procurement chain of health services has not been improved with respect to other services. Most of the personnel involved in this sector are non technical and have insufficient know-how. Due to lack technical knowledge, procurement could not be completed in time. As a result, health development program is being hampered seriously. It is suggested that the technical personnel graduated in the field of Biomedical Engineers can be involved with the procurement of equipments. The procurement phases consist of different sub indicators, which are shown in Table 2.3 [5].

Table 2.3: A comparison between existing and standard procurement procedure

Factor is considered by standard MIEMS	Developed countries	Bangladesh
Need based equipment selection	Yes	No
Budget and financing	Yes	Improper due lack of skill
Preparing operational plan	Yes. Prepared by qualified technical manpower and in this team biomedical engineers is included	Prepared by non technical personnel only
Preprinting technical specification	Yes. Prepared by skilled users and Biomedical Engineers	Prepared by unskilled users and Non trained Engineer
Preparing tender documentation	Yes. Commercial personnel, skill procurement specialist and Biomedical Engineer were involved	General educated person , non trained engineers and unskilled users are doing
Tender invitation	Yes	Yes
Collection of tenders	Yes	Improper because nonqualified local agents submit tenders
Tender evaluation	Yes. Most of members are qualified Biomedical Engineers	Only one general Engineer with low level experience is involved
Work order and contract agreement	Yes	No biomedical Engineers assigned for the works, So improper agreement
LC opening	Yes	Delaying due to long procedure of procurement chain
Equipment incoming inspection	Yes. Checked by users and biomedical engineers	Diploma engineers , unskilled users and administrative doctor are involved
Distribution of equipment among users	Yes. Properly distributed according to pre-plan through specialized Management team	Not followed

A long procedure has been followed for the procurement of equipments. Due to less attention and lack of knowledge in the procurement procedure, proper management of MIE is not possible. Consequently, health services of Bangladesh are not up to the standard level and being interrupted seriously [6]. A comparison between developed countries and Bangladesh is shown in Table 2.3.

The mathematical relation between equipment planning and equipment procurement can be shown by Eq. (2.1).

$$y = \int x dx \qquad (2.\,1)$$

Where, y is the performance of procurement and x is the performance of equipment planning. If equipment planning is deviated from the standard and performance of procurement is interrupted. As a result any project could not be complete in time and foreign grants could not be utilized properly. Ultimately Health services of Bangladesh are suffering.

Typical tender evaluation committee (TEC) of MIE procurement:

Technical specification is most important for the technological selection and assessment for the smooth procurement. As the Biomedical Equipment Management System of Bangladesh is very inferior and its negative impacts are interrupting the procurement procedure. Therefore, the function of TEC is very much important to verify technical aspects of MIE. The structure of existing TEC committee for the procurement of MIE is as follows:

1. Additional Director General of Health Services
2. Director Central Medical Storage and Depot
3. Deputy Secretary Ministry of Health and Family Welfare
4. Director Hospitals and Clinics
5. Member from BG Press
6. Member from Education Ministry

Existing Technical subcommittee for selecting MIE:

1. Director hospitals and clinics
2. Two doctors form radiology and imagining departments
3. Deputy director procurement and clearance
4. Chief technical manger of NEMEW

Among the members, most of the members are doctors and others are nontechnical. No technical know-how (Biomedical Engineer) is incorporated in the existing TEC committee. Here a typical structure of TEC is proposed so that the problems of existing structure can be overcome. Proposed committees were given in the chapter 4.2.

2.2.3. Equipment Incoming Inspection

Equipment incoming inspection is done by a team having four members indicated in Table 2.4. This team is known as survey committee. The team data is shown in Table 2.4 [5].

Table 2.4: Existing team configuration

Standard	**Developed countries**	**Bangladesh**	**Remarks**
Chief Biomedical Managers	Yes	Director Hospital	Equipment could not be inspect properly due lack of knowledge and team configuration
Radiological Doctor (Radiologist	Yes	Radiological Doctor (Radiologist)	
Biomedical Engine	Yes	Unskilled Diploma Engineer	

To over come the problems a suitable committee is proposed in chapter IV.

2.2.4. Equipment Inventory and Documentation

It is one of the most important phases of MIEMS. The key parameters which associated with this phase are described below:

- A medical equipment inventory provides a technical assessment of the technology on hand, giving details of the type and quantity of equipment and the current operating status.
- The inventory provides the basics for effective asset management. It also facilitates scheduling of preventive maintenance and tracking of maintenance, repairs, alerts, and recalls.
- The inventory can provide financial information which is very much important for economical budget and assessments.
- The inventory is the foundation needed to organize an effective HTM department. Items such as equipment history files and logbooks, operating and service manuals, testing and quality assurance procedures, and indicators are created, managed and maintained under the umbrella of the equipment inventory. Furthermore, accessories, consumables and spare parts inventories are directly correlated with the main medical equipment inventory.

Table 2.5: A comparison of existing and standard inventory data and their deviation [7]

Sub constraint as per standard	Developed countries	Bangladesh
Data collection	Yes and correctly	No body is maintaining
Data recording	Yes. Executed through hard copy and soft copy	Improper
Audit and review	Yes. Qualified Biomedical Engineers are involved	Not available
Sequential number	Yes	Not Maintain
Coded	Yes	Nil
Barcodes	Yes	Nil

Table 2.5 shows a chart of inventory and documentation management system of medical imaging equipment (IDMSMIE) in health services of Bangladesh. From Table 2.5, it is found deviations of existing IDMSMIE. To improve the existing system a proposal is described in the Chapter 4.

2.2.5. Commissioning and Acceptance

Pre-installation work is the most important factor for commissioning and acceptance of MIE. Most of equipments are installed by supplier or Vendor Company. During planning, selection and room preparation for equipment and its environment have not been considered. Because, construction and electrical power supply in the equipment's room are implemented by other government organization named Health Engineering Directorate and Power works department. Due to inadequate knowledge of MIE appropriate design is not possible, as a result, commissioning and acceptance procedure could not be finished in time. From the data Table 2.6, the average deviation of this phase can be detected [7, 8] and a proposal is submitted in chapter IV.

Table 2.6: Commissioning and acceptance (CA) indicator between Bangladesh and developed countries

CA indicators as per standard	Developed countries	Bangladesh
Installation	Yes. Vendor's engineers are qualified and trained from factory. On the other hand hospital in house MIEMS executed the whole works	Most of the equipment could not be installed properly due unskilled local agents and in house MIEMS is not available.
Functioning	Yes. Engaged skill users doctors, nurses and biomedical technicians and medical technologists	Most of the equipment is not optimum functioning due to lack of knowledge of users
Commissioning	Yes	Improper

2.2.6. Skill development through in-service education and training

Problems in operation and maintenance of an instrument can be overcome through in-service training and education. Technological development is a continuous process and continuing in-service education and training can fulfill the requirement of the service personnel. The existing and standard status of in-service education and training are shown in the Table 2.7 [8].

Table 2.7: Existing and standard in-service education and training (ISET)

ISET pointer	Existing
National Trainer	1
Library	0
Activity of training center	1
Local Training	1
Foreign training	0
Research center	0
Biomedical department in Public University	4
Training fund	2

All information has been collected from existing MIEM. Standard data is considered as reference value. According to definition of any management all sub phases are considered as equal as one are equally linked to each other.

2.2.7 Personnel management

Long time has been passed; no initiative is taken in government and nongovernment levels to develop skilled man power in health sectors. Only two posts of Biomedical Engineers and a post for diploma technician have been created since 1987 [1].the total number of equipment is 2500. The existing and standard personnel management (PM) with respect to equipment number is shown in Table 2.8.

Table 2.8: Existing and standard PM and their deviation with different indicators

Standard PM	**Developed countries**	**Bangladesh**
Medical Equipment Commission (MEC)	Yes	No
Biomedical Engineer Managers	5	0
Senior Biomedical Engineer	10	0
Assistant Biomedical Engineer	20	1
Diploma Biomedical Technician	30	1
Biomedical Technician	40	0
Total management personnel	**105**	**02**

2.2.8. Monitoring of use and Performance (MUP)

Monitoring of use and Performance of MIE is the most important sub phase of MIEMS. Technology assessment, selection of new equipment, cost effective maintenance plan are evaluated by MUP. Monitoring of use and Performance of MIE was not developed. Actually Inventory and documentation exercise was not developed in Bangladesh due to lack of MIEMS.

Table 2.9: Present status of MUP of Bangladesh

Standard MUP Display	**Developed countries**	**Bangladesh**
Date of installation	Recorded correctly	Partially recorded
Date of fault	Recorded in time	Not recorded
Date of repair	Recorded in time	No log book and not maintained properly
Total repairing cost	Recorded in time	No record
Analysis of Performance	Analysis properly	No man power and have no system
Date of disposal	Correctly maintain	Not done

2.2.9 Maintenance of medical imaging equipment (MMIE)

The performance and lifetime of MIE depends on the maintenance. Due to lack of technical manpower maintenance of MIE is seriously interrupting and which is affected our economy and every year the procurement rate of new equipment is increasing. The maintenance scenario in Bangladesh is getting worse and requires special attention. Maintenance capabilities must be building up by developing and recruiting technically skilled persons during purchasing the equipment to solve the maintenance problems [9]. The present status of maintenance of MIE is shown in Table 2.10.

Table 2.10: Present status of Equipment maintenance management

Standard Maintenance Components	Developed countries	Existing
Planned Preventive Maintenance	Proper	Nil
Repair / breakdown Maintenance	Less	More
Hospital in-house Maintenance	Established	No
National Level Maintenance	75%	Maximum 5% possible by existing manpower
Contract Maintenance	Yes. It is a frame work contract	Only for sophisticated Equipment (MRI,CT)
Safety and Calibration Test	Regular exercise	Not done properly
Stock spare parts and consumables	Yes. It is ensured during procurement of equipment and price was determinate during agreement	No.

2.2.10 Equipment decommissioning and disposal (EDD)

Medical imagining equipment decommissioning and disposal procedure has not been developed in the public hospitals of Bangladesh. It is well known that the equipment decommissioning and disposal (EDD) is connected with the medical equipment management system, which is not being well established in health services of Bangladesh. Consequently, the existing management has not sufficient knowledge about EDD and most of the important places of hospital are occupied by condemn equipments. EDD is directly related to new equipment procurement. The present status EDD data indicators are shown in Table 2.11 [10, 11].

Table 2.11: Present status of EDD

Standard MIEDD components	Developed countries	Bangladesh
Inspection	Yes	Nil
Examined	Yes	Nil
Discard	Yes	Not done properly
Yearly evaluation	Yes	No

2.3. Public Hospitals in Bangladesh

Most people of Bangladesh is getting treatment from different public hospitals of Bangladesh. Public hospitals in Bangladesh are different categories and different sizes based on location, management systems, etc.. These are divided into two broad groups like General and Special Hospitals. Classification of Public Hospital is shown in Fig. 2.2. Map of Bangladesh is presented in Fig. 2.3 for locating the hospitals and health network easily

[9].The list of Specialist and other hospitals are shown in Table 2.12 & Table 2.13 respetively.

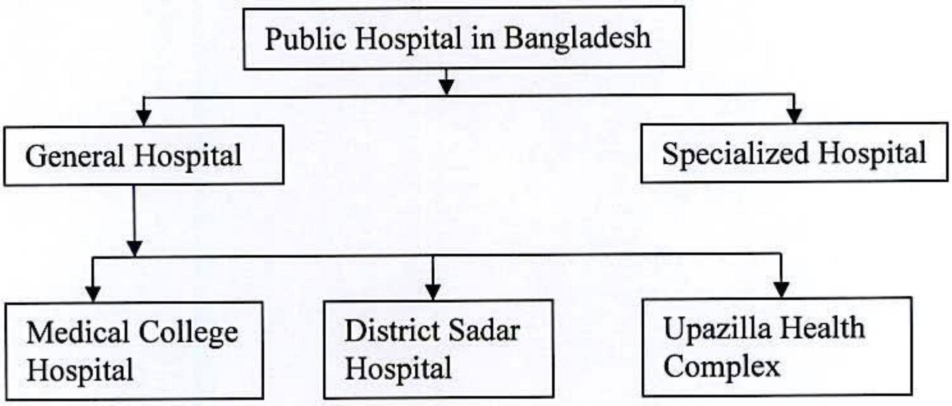

Figure 2.2: Tree of public hospitals in Bangladesh

Figure 2.3: Map of Bangladesh and the location of hospitals

2.3.1. Specialized Hospitals

Specialized hospital means a special type of hospital in which specialized physician have to provide the treatment for one particular physiological organ of patient. In this hospital all types of diagnosis facilities are available. Some of the specialized hospitals are listed in the Table 2.12.

Table 2.12: List of some specialized public hospitals in Bangladesh

Sl #	Name of Hospitals	Abbreviated Term	Location	Medical Imaging equipment status
1	National Institute of Cardiovascular diseases	NICVD	Dhaka	Good
2	National Institute of Kidney and Urology Diseases	NIKDU	Dhaka	Good
3	National Institute of Mental Health Diseases	NIMHD	Dhaka	Excellent
4	National Institute of Trauma and orthopedics rehabilitation	NITOR	Dhaka	Fair
5	National Institute of ophthalmoscope & Hospital	NIOH	Dhaka	Excellent
6	National Institute of Cancer Hospital	NICH	Dhaka	Excellent
7	National Institute of Chest Diseases and Hospital	NICDH	Dhaka	Good
8	TV Clinic and Laparoscopy Hospital	TVLH	Dhaka	Fair
9	Infection Diseases Hospital	IDH	Dhaka	Fair
10	National institute of heart Disease Control Center	NIHDC	Dhaka	Fair

2.3.2. District Hospitals and medical collage hospitals

District hospitals are divided into two broad groups. Such as medical college hospital and District Sadder hospitals. But medical college hospital is not available in every district. Sixty four (64) districts Sadder hospitals provide mid level common treatment. There are 25 numbers of medical collage hospitals in Bangladesh. List of medical collage hospitals is given in Table 2.13 [9].

Table 2.13: Government medical college hospitals and medical imaging equipment

Sl.	Name of MCH	Location	Medical Imaging Equipment
1	Dhaka MCH	Dhaka	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
2	Sir Salimullah MCH	Dhaka	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
3	Mymensingh MCH	Dhaka	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
4	Chittagong MCH	Chittagong	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
5	Rajshahi MCH	Rajshahi	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
6	MAG Osmani MCH	Sylhet	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
7	Sher-E-Bangla MCH	Barisal	X-ray, CT, Ultrasonograph,
8	Dinajpur MCH	Rajshahi	X-ray, CT, Ultrasonograph,
9	Rangpur MCH	Rajshahi	X-ray, CT, Ultrasonograph,
10	Comilla MCH	Chittagong	X-ray, CT, Ultrasonograph,
11	Khulna MCH	Khulna	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
12	Shaheed Ziaur Rahman MCH	Rajshahi	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
13	Faridpur MCH	Dhaka	X-ray, CT, Ultrasonograph, gram
14	Shaheed Suhrawardy MCH	Dhaka	X-ray, CT, Ultrasonograph, Angiocardiogram
15	Pabna MCH	Rajshahi	X-ray, CT, Ultrasonograph
16	Noakhali MCH	Chittagong	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
17	Cox's Bazar MCH	Chittagong	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
18	Jessore MCH	Khulna	X-ray, CT, MRI, Ultrasonograph, Angiocardiogram
19	Shaheed Nazrul Islam MCH		X-ray, CT, Ultrasonograph
20	Kushtia MCH	Rajshahi	X-ray, CT, Ultrasonograph,
21	Satkhira MCH		X-ray, Ultrasonograph,
22	Sheikh Sayera Khatun MCH, Gopalganj	Khulna	X-ray, CT, Ultrasonograph,
23	Govt. Unani and Ayurvedic Medical College & Hospital	Dhaka	X-ray,
24	Govt. Homeopathic MCH	Dhaka	X-ray, Ultrasonograph,
25	Sheik Abu Nasher Specialized Hospital	Khulna	X-ray, CT, MRI, Ultrasonograph,

2.3.3. Upazila Hospitals

There are 470 Upazilla in 64 districts of Bangladesh. Every Upazilla has health service center named as Upazila Health Complex (UHC). Most of Upazillas have X-ray machine for basic diagnosis of small part of physiological organs of patient.

2.4. Improvement Approaches of MIEMS: The improvement approaches of MIEMS are divided into two broad categories:

a) Improvement of MIEMS phases
b) Organizational improvement of Existing MIEM organizations

(a) Improvement of MIEMS Phases

Following methodology can be adopted for the improvement of MIEMS phases in health sector of Bangladesh

- Standard MIEMS already been established in developed countries is taken as a reference management system in the present study.
- Complete a base survey regarding existing MIEMS of Bangladesh.
- Compare the existing MIEMS of Bangladesh with the standard MIEMS of developed countries.
- The difference between the standard and the existing MIEMS will be the proposed improvement of the MIEMS in Health sector of Bangladesh.

The complete methodology of improvement strategy is illustrated in the flow diagram of Fig. 2.4.

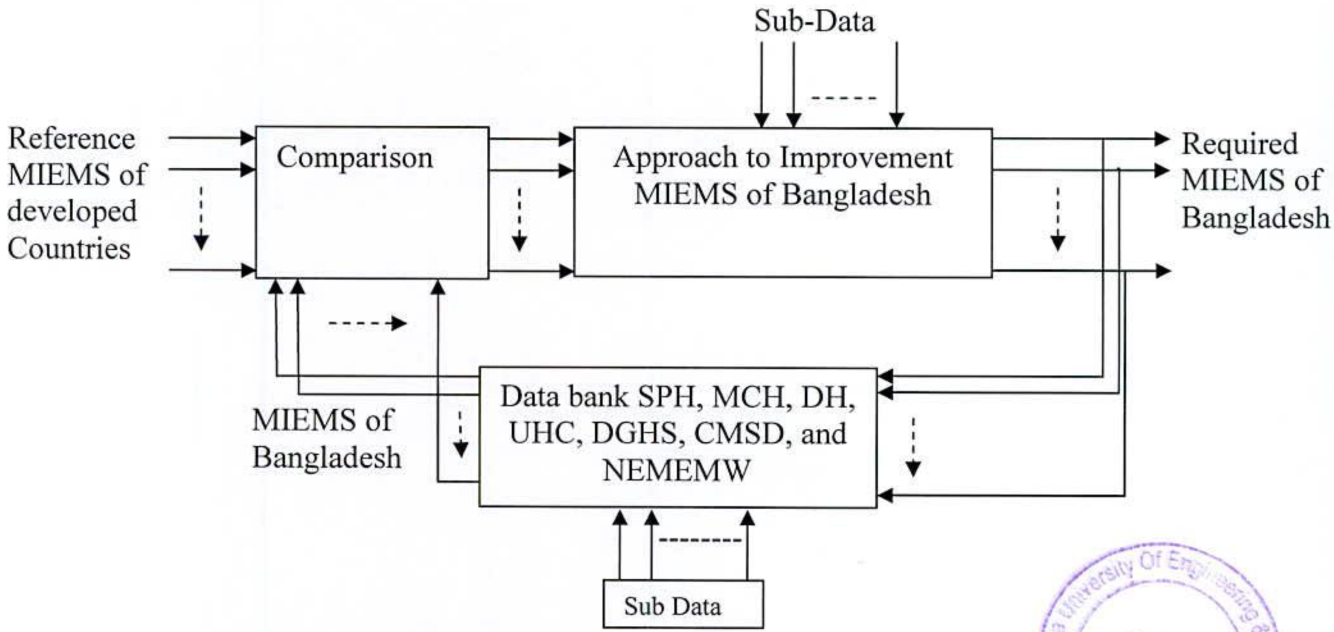

Figure 2.4: Improvement methodology of MIEMS Phases

Standard 10 (ten) phases are used in medical equipment management system. All the data are grouped as Data Bank. The MIEMS consists of the following phases as per standard of **WHO and some developed countries**.

1. Equipment Planning
2. Equipment Procurement
3. Equipment Incoming Inspection
4. Equipment Inventory and Documentation
5. Equipment Commissioning and Acceptance
6. Equipment Monitoring of use and Performance
7. Equipment Maintenance management
8. Personnel Management
9. In-Service Education and Training
10. Equipment De-commissioning and disposal

All data has collected from 20 different organizations: The list of organizations is stated below:

i. Six Specialized Hospitals (SPH) in Dhaka City.
ii. Seven Medical colleges Hospitals (MCH) in Bangladesh.
iii. Four District Hospitals (DH) in Bangladesh.
iv. Directorate General of Health services (DGHS), Dhaka
v. Central Medical Store Depot, Dhaka.
vi. NEMEMW and TC, Dhaka.

(b) Improvement of MIEM in existing organizations: The strategy is described in Figure 2.6.

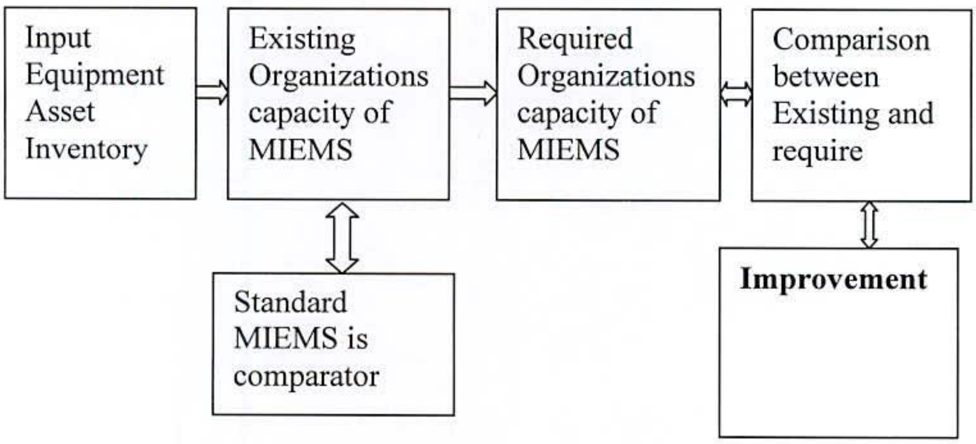

Figure 2.5: Improvement of MIEM in existing organizations

2.5 References

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CHAPTER III

MIEMS of Bangladesh with Standard MIEMS of Developed Countries

3.1. Introduction

Study of present MIEMS of different developed countries is pre-requisite to compare the existing medical imaging equipment management system (MIEMS) in the public Hospitals of Bangladesh. It will reflect the deviation, errors and base line data. Study results and findings, will be the guideline MIEMS phases and summarization of all phases will be the total improvement of medical imaging equipment management system of Bangladesh [1]. The Major objectives of the study are as follows [2]:

- To compare with the standard MIEMS of developed countries
- To find out the deviation of present MIEMS of Bangladesh
- A standard MIEMS will be developed.

Medical imagining equipment Management System of developed countries were established with the development of global new technology. All develop countries have sufficient research fund, manufacturing plant of Medical imaging equipment and public and private Universities were conducting Biomedical Engineering degree but in Bangladesh Health services could not develop a proper MIEMS due some limitations. Health services of Bangladesh have been using a lot of sophisticated modernized medical imaging equipment but due to lack of knowledge of the management person in this sector MIEMS falls down in substandard. Day by day, it is gowning down and patients suffering are increasing [3]. Table 3.1 gives the complete inventory data of the present status in the public hospitals of Bangladesh.

The major objectives of the comparison study are as follows:

- Comparison results will be one of most tools to improve MIEMS of Bangladesh
- From the comparison, it can be easy to understand the deviation of present MIEMS of Bangladesh

Table 3.1: Inventory data

Level of Hospital	Location	Numbers	Category of Medical Imaging Equipment in Public Hospitals of Bangladesh with quantity										
Level-Station-Number of stations			X-ray	CT Scan	MRI	Angiogram	LINAC	Mammography	Gamma camera	C-ARM X-ray	Ultrasound	Color Doppler	Lithotripsy
Level 1 UHC	Thana	470	475	X	X	X	X	X	X	X	X	X	X
Level 2 DSH	District	64	75										
Level 3 MCH	9 oldest districts and 7 divisions	16	48	8	6	6	6	12	5	12	32	26	2
Level 4 SPH	Dhaka	12	30	10	8	6	4	0	2	4	36	12	X
Level 5 TV Clinics	Districts	64	64	X	X	X	X	X	X	X	X	X	X

3.2. MIEMS Data Comparison

In chapter 2, it has been discussed and reflected all medical imaging equipment management sub data. The existing status of MIEM has been reflected clearly in different sub-chapters of chapter 2. From the study, it was found a big percentage deviation of MIEM Bangladesh. The summery of existing MIEMS of Bangladesh is compared with MIMS of developed countries in the Table 3.2.

Table 3.2 MIEMS data comparison

Sl #	**Standard Data Phases of MIEMS**	**MIEM Phase of Develop countries**	**Existing MIEM Bangladesh**
01	Equipment Planning (decision to acquire)	It was done properly through Biomedical engineering management	With respect of quantity/number of equipment a negligible MIEM personnel are involved and EP is going to inferior
02	Equipment Procurement	Most of the committee members are skilled Biomedical Engineers and skilled Radiologists and their ratio is 4.1	Most of the committee members are unskilled Radiologist and normal Diploma Electrometrical Engineers and their ratio is 1.4

03	Equipment Incoming Inspection	Most of the inspectors are skilled Biomedical Engineers and skilled Radiologists and their ratio is 4.1	Most of the inspectors are unskilled and Normal Electromechanical Diploma level Engineers and their ratio is 4.1
04	Equipment Inventory and Documentation	Computerized and executed by a information technical personnel and Biomedical Engineers	Done by normal Store keeper
05	Commissioning and Acceptance	Users Skill doctors and Biomedical Engineers	Unskilled users doctor., Medical technologist and Electro medical diploma technician
06	Monitoring of use and Performance	Performed by monitoring cell including skilled Biomedical engineers and IT Professionals	This exercise is not existed and no body knows the condition of equipment.
07	Maintenance Management	Hospital In house Maintenance Engineering Team, contract Maintenance with Manufactures / Skill local agents and Central level	Hospital in-house engineering maintenance Team is nil and in some case contract Maintenance agreement have with local agents but local agents have low-level Technician and normal Diploma engineers. In central level only one biomedical engineers has been working
08	Equipment decommissionin g & disposal	Regular practice	Different model and make. Negligible Biomedical Engineers and practice did not start
09	In-Service Education & Training	Continuing and according to new technology through training center and university	Training Center Is not functioning due to vacant post of technical Manager Training, Lack of trainers and found.
10	Personnel Management	Executed by medical equipment commission (MEC)	MEC is not available and personnel management is negligible

The global standard medical imaging equipment management system phases were mentioned in chapter 2. At the same time medical equipment management phases of Bangladesh has been described in the same chapter. All sub data of each phase were show individually as sub-chapter from 2.1.1 to 2.1.11. in Table 3.2, existing MIEMS ten phases were described and compared with standared MIEM of developed countries. From the summery of Table 3.2, it was found a major differences between the existing MIEMS and proposed MIEMS.

3.3. Conclusion: The finding deviation of MIEMS in Public Hospitals of Bangladesh will need to be improved immediately. The improvement methodology is proposed in Chapter IV of the thesis in detail.

3.4 References

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CHAPTER IV

Improvement Methodology of Medical Imaging Equipment Management System in Public Hospitals of Bangladesh

4.1. Introduction

In subchapter 3.2, it is found big percentages of deviation of existing medical imaging equipment management system (MIEMS) of Bangladesh with respect to MIEMS of developed countries. As a result, physician could not get appropriate results from the medical imaging equipment and most of the cases patient has been getting wrong medication. So, improvement of the existing MIEMS in the public Hospitals of Bangladesh is a national claim. Results of present MIEMS is considered as the base line data. The major objectives of the study are as follows [1]:

- To compare the present MIEMS with the standard MIEMS of developed countries
- To find out the deviation of present MIEMS of Bangladesh
- To develop a standard MIEMS for Bangladesh.

4.2. Improvement approaches

The improvement approaches can be divided into two broad categories:

(i) MIEMS phases improvement
(ii) Organizational improvement of existing MIEMS organizations

The above mentioned two methodologies are described below separately. The main steps of the methodology can be divided into the following steps, such as

Step1: Consider the standard medical imaging equipment management system of developed countries.

Step2: Complete a base survey of existing medical imaging equipment management system of Bangladesh.

Step3: Compare the existing medical imaging equipment management system of Bangladesh with the standard biomedical equipment management system of developed countries.

Step4: The differentiated result between (ii) and (i) will be "approach to improvement of medical imaging equipment management system of Bangladesh".

The complete methodology of the proposed approach is illustrated in the flow diagram of Fig. 4.1.

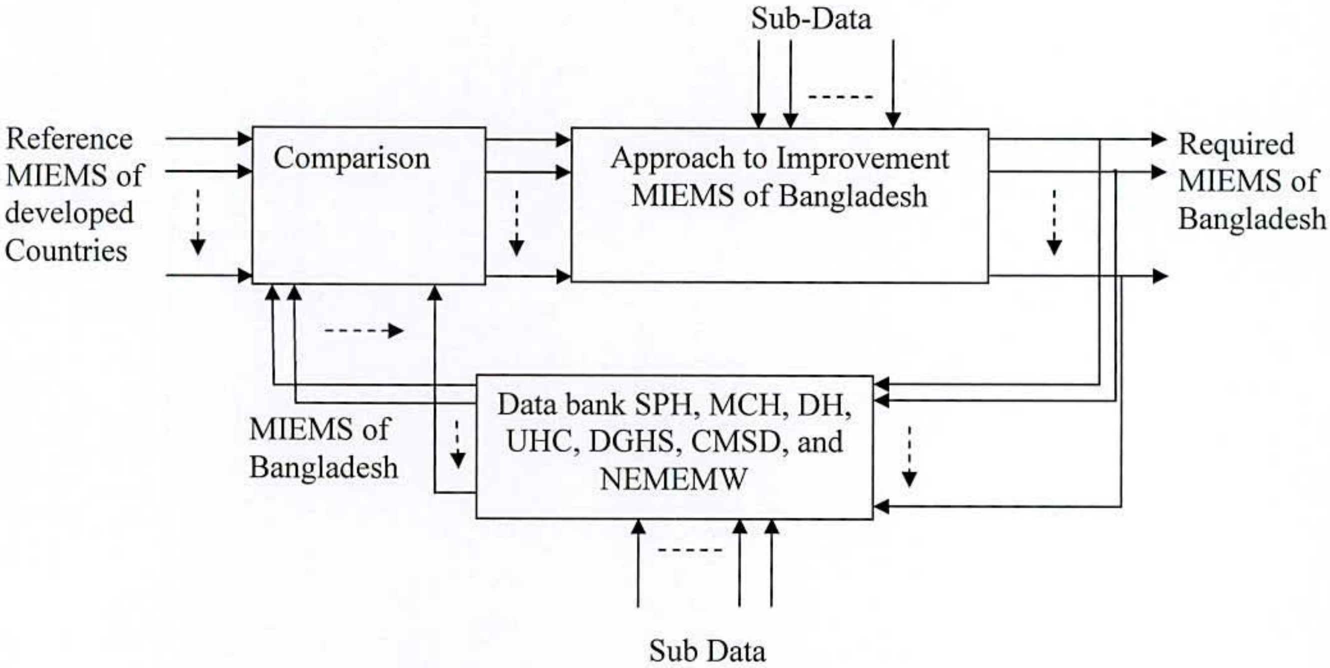

Figure 4.1: MIEMS Phases improvement methodology

About 10 data phases are used in medical equipment management system. All the data are grouped as Data Bank. The data bank consists of the following items [2].

1. Equipment planning
2. Equipment procurement
3. Equipment incoming inspection
4. Equipment inventory and documentation
5. Commissioning and acceptance
6. Monitoring of use and performance
7. Maintenance management
8. Personnel management
9. In-Service education and training
10. Equipment de-commissioning and disposal

All data has collected from 20 different organizations: The list of organizations is stated below:

(i) Six specialized hospitals (SPH) in Dhaka city.
(ii) Seven medical college hospitals (MCH) in Bangladesh.
(iii)Four district hospitals (DH) in Bangladesh.
(iv)Directorate general of health services (DGHS), Dhaka
(v) Central medical store depot, Dhaka.
(vi)NEMEMW and TC, Dhaka.

4.3. Improvement Methodology of Each Phase: The improvement methodology of each phase is described below.

4.3.1. Medical Imaging Equipment Planning (MIUP)

In chapter 2 it is discussed that medical imaging equipment planning is prepared by users only. As a result, equipment planning deviation was found. Proposed medical imaging equipment planning in the public hospitals of Bangladesh is stated in Table 4.1. In general, the people involved in this process are health planners, functional planners, financial planners and physical planners, architects, engineers (such as civil, mechanical and biomedical), quantity surveyor, finance managers, staff responsible for procurement of supplies, staff members such as doctors/nurses, clients/end users [**3**].

Methods of improvement of equipment planning:

The complex process of planning is a multidisciplinary endeavor. In general, the people involved in this process are:

- Health planers, functional planers, financial planners and physical planners.
- Architects
- Engineers (Biomedical, Civil, and Mechanical)
- Quantity surveyors
- Finance manager
- Staff responsible for Procurement of supplies
- Staff members such as biomedical engineers, doctors/nurses, clients/end users

For equipment planning, the following planning team and the process is discussed *(outlined)* below:

Needs assessment team: For efficient equipment planning an interaction among various stake holders of the hospital management; i.e. administrative staff, hospital planners, financial managers, doctors, nurses and technical staff is essential. They should sit together for a need assessment and plan ahead considering range of service to be provided, target patient in a catchments area, cost benefit analysis, availability of fund & expertise.

Briefing Team: Having determined the need assessment and the size of a hospital, the planning team sit together to prepare a document considering functions of the planned hospital, activities, space requirement & its distribution and any other information required to transform the plan into reality. Such a planning document may be named as "the design brief" of the hospital in consideration.

Design Team:
The proposed team consists of personnel from all walks of hospital operation; hospital planners, administrative staff, doctors, nurses, engineers, technician, and financial staff. This team will act as an instrument for implementation of the plan into design, cost estimation, construction, procurement of equipment, installation of services & facilities, recruitment of operating staff, etc.

Construction team: This team consists of engineers, architects, and builders.

Table 4.1: Stages of equipment planning

Stage	Task	Input	Output	Working team consultative	
First	Establish demand for new equipment for hospital expansion	Information Indicators Projection	Decision to construct Renovate, expand	User/Client/Planners	
Second	Prepare design brief	Services to be delivered Function requirement	Design brief	User/client	Architect/ Engineers
Third	Design	Design brief Additional data from consultants	Design of hospital Working documents	Architect /Engineers	User/ Client
Fourth	Construction	Design of hospital Working drawings	Hospital in Physical form	Architect/ Builder/ Engineers	User/ Client
Fifth	Commissioning	List of staff List of furniture List of equipment List of supplies	Appointment and training of staff Procurement of furniture, equipment, supplies	User/ client/ Procurement/ Staff/ Personnel staff	Biomedical Engineers

Present MIEMS in public hospitals of Bangladesh is not considered the mentioned articles during planning of equipment but it is very important part and parcel of MIEMS. Comparing the existing planning with equipment planning of developed countries, a practical MIE planning improvement is proposed in Fig. 4.2.

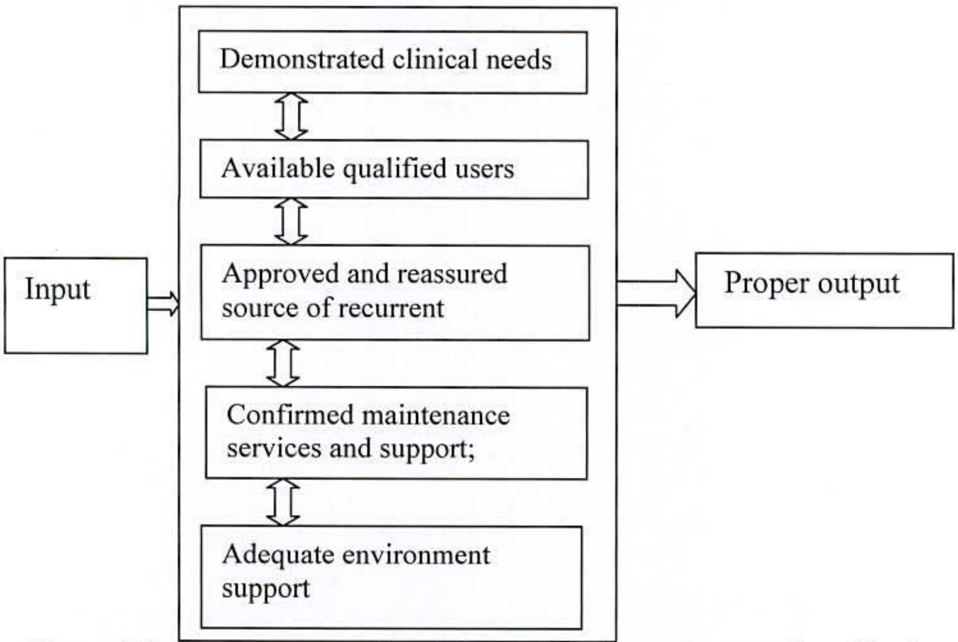

Figure 4.2: Improvement of equipment planning to be considered by hospital management

Proper equipment planning depends on various inputs from different specialized. In the Figure 4.3, it is clear that five inputs from five professional are taken into account. It is an integrated part of equipment planning. One indicator is interrelated with other. If any input is unskilled then MIEP will be improper and next phases of MIEMS will be affect seriously. Ultimately, its negative impact will be hampered real vision of health services. So, every professional is very important to each other to prepare a proper MIEP.

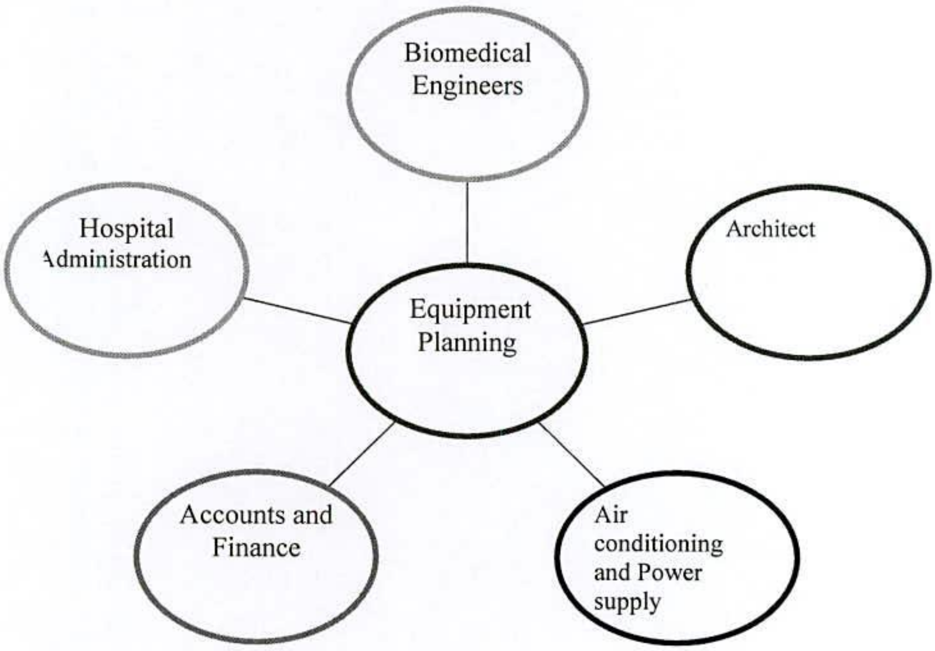

Figure 4.3: Input diagram from personnel on" Improvement of Equipment Planning

4.3.2 Equipment Procurement Procedure: Procurement procedure includes the following factors. The procurement chain is shown in Fig. 4.4. The configuration of the procurement committee is shown in Table 4.2.

- Need based equipment selection.
- Preparing operational plan
- Preprinting technical specification
- Preparing tender documentation
- Tender invitation
- Collection of tenders
- Tender evaluation
- Work order and contract agreement
- LC opening

The present management has been procuring medical imagining equipment in two manners:

1) Central procurement through central medical store depot.
2) Medical college hospitals and specialized hospitals are procured by their procurement committee

Conclusion: But both of the cases, it is found that the input from Biomedical Engineering Management is negligible. As a result some important factors are missed and which is hampered next MIEMS Phases. Ultimately proper diseases diagnosis could not be achieve.

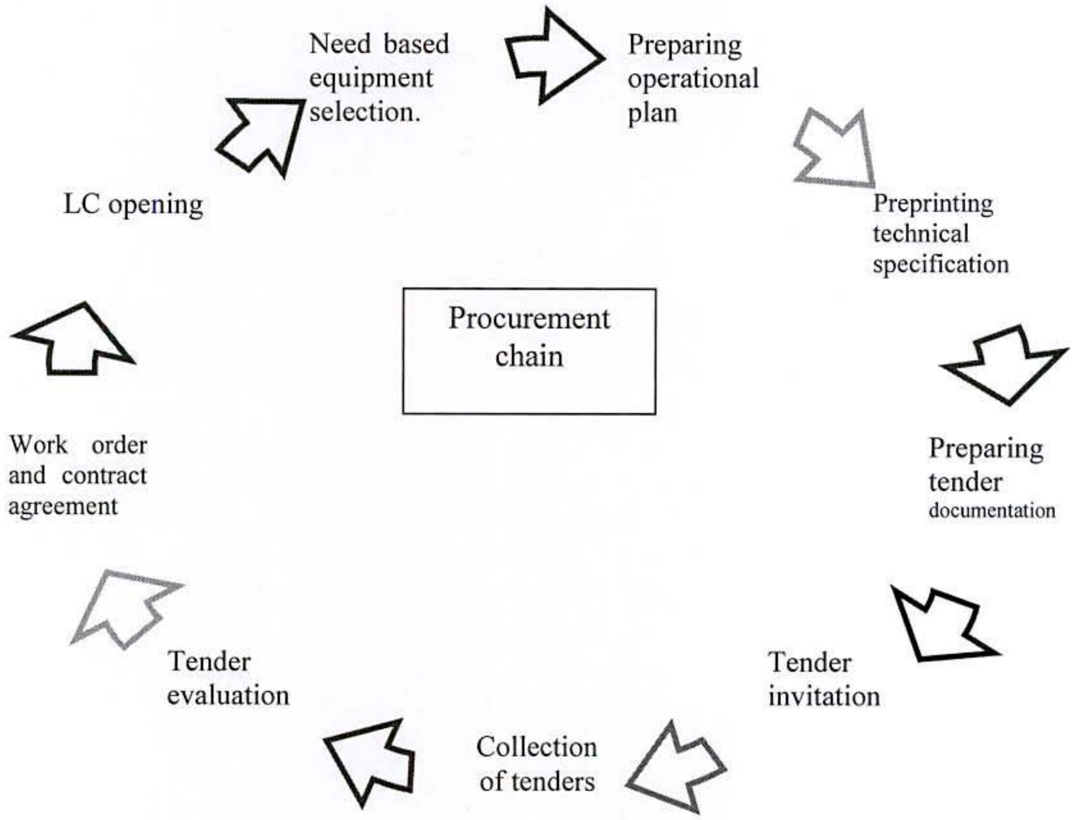

Figure 4.4: Improvement proposal cycle procurement procedure

Table 4.2: Proposed Procurement Committee

Present Tender evaluation committee (TEC)	**Proposed Improvement TEC**	**Technical Sub-committee (TSC)**	**Proposed Improvement TSC**
1. Additional Director General of Health Services 2. Director Central Medical Storage & Depot 3. Deputy Secretary Ministry of Health and Family Welfare 4. Director Hospitals and Clinics 5. Member from BG Press 6. Member from Education Ministry	1. Additional Director General of Health Services 2. Chief Biomedical Engineer 3. Director Central Medical Storage & Depot 4. Biomedical Engineering Manager 5. Users Expert 6. Radiation officer (AECB) 7. Deputy Secretary, MOH & FW 8. Member of Finance Ministry	1. Director Hospitals and Clinics 2. Two doctors of Radiology and Imagining 3. Deputy Director procurement and Clearance 4. Chief Technical Manger of NEMEW	1. Director Hospitals and Clinics 2. Biomedical Engineering Manger 3. .Biomedical Engineers Radiology Imagining 4. one specialist doctor of Radiology & Imaging

The advantages of proposed improvement committee are described. The proposed Tender Evaluation Committee (TEC) and Technical Sub-committee (TSC) are integrated with more Biomedical Engineering Engineers. So, it is obviously a knowledgeable committee for evaluation of MIE procurement. On the other hand these committees can take prompt action without interruption. Practically it has been found that actually most of the works and decisions were being under taken by Biomedical Engineers. But due to lack of knowledge or positional interest, role of Biomedical Engineers are hidden. Chief Biomedical Engineer is the core personnel of Medical Equipment Management. His idea and knowledge with regard to imaging equipment is more important than a medical doctor. The existing procurement committees consist of medical doctor. Repeatedly, it has been found that for any decision on procurement they refer to Biomedical Engineering Management. As a result, procurement of medical equipment and hospital projects could not be complete in time, thereby national health services could not ensure. The proposed improvement committee will be able to deliver the desired objective. A special proposal on technical terms and conditions of procurement is shown in ***Appendix I***.

4.3.3 Equipment Incoming Inspection (EII)

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. The proposed equipment incoming inspection improvement procedure is shown in Table 4.3.

Table 4.3: Equipment Incoming Inspection improvement procedure check list

Inspection Indicators	Present system	Proposed system	Analysis	Recommendation
Shipment damages	Checked by clearing & Forwarding Agent & insurance company	Biomedical Engineer expert need to be incorporated in the shipment committee	Some times shipment damage can not be detected by the committee due lack of technical knowledge	Shipment committee needs an orientation training on equipment before shipment of equipment
Compliance with specifications in the purchase order	Physically checked by Users and General Electro medical Engineer	Well trained Biomedical Engineer and Expert Users	Committee members did wrong due lack of technical knowledge	More Biomedical need to be appointed
Delivery of accessories	Physically Checked by users and Normal Engineer	Well trained Biomedical Engineer and Expert Users	Some times Committee members could not understand	Expert biomedical engineer and operator need to be involved
Spare parts	Physically Checked by users and	Well trained Biomedical Engineer and	Committee members have not enough	Expert biomedical engineer and biomedical

	Normal Engineer	Expert Users	knowledge	technician are required to recruit and involved in this committee
Operating and service manuals	Physically Checked by users and Normal Engineer	Physically Checked by users and Normal Engineer	Checked but less importance was given	A general government audit on this issue need to be established

4.3.4 Equipment Inventory and Documentation (EID)

It is one of most important phase of medical imaging equipment management system. The following important parameters of this phase are described below:

- A medical equipment inventory provides a technical assessment of the technology on hand, giving details of the type and quantity of equipment and the current operating status.
- The inventory provides the basics for effective asset management, including facilitating scheduling of preventive maintenance and tracking of maintenance, repairs, alerts and recalls.
- The inventory can provide financial information to support economically and for budget assessments.
- The inventory is the foundation needed to organize an effective HTM department. Items such as equipment history files and logbooks, operating and service manuals, testing and quality assurance procedures and indicators are created, managed and maintained under the umbrella of the equipment inventory. Furthermore, accessories, consumables and spare parts inventories are directly correlated with the main medical equipment inventory.

More than 2500 number of different types of medical imaging equipment have been using in the public hospitals of Bangladesh but till to date a suitable inventory and documentation system has not been developed due to improper medical imaging equipment management system [1, 4]. The terms and conditions of repairing of MIE for Hospital & Company is shown in *Annexure I.* The proposed inventories of medical imaging equipment may be maintained at different levels within a country's health-care structure based on present system, and which is discussed below. The ***improvement approach*** is described below.

(1) Level: National level
***Supervisor/Executor*:** NEMEEW & TC (Proposed rename as NIBMEM), Ministry of Health and family welfare
***Category of equipment inventory and documentation*:** The category is (i) highly sophisticated regulated equipment devices used in nuclear medicine (ii) devices that emit ionizing radiation.

Causes and justification: To ensure the proper service is implemented to protect large investments of highly technical equipment and to monitor potential hazards, including radioactive and nuclear exposure.

(2) *Level*: Specialized Hospitals

Supervisor/Executor: Hospital In-house Biomedical Equipment Management department
Category of equipment inventory and documentation: MRI, CT Scan, Ultrasound, color Doppler, Linear accelerator, cobalt therapy, medical digital X-ray, Mammography, Coronary Angiography, and Gamma camera
Causes and justification: Meanwhile, high-level specialized hospitals may have thousands of items listed in the inventory, with continual updates. Every inventory is unique to reflect the facility's assets; the size and complexity of the inventory will depend on its type and purpose and the scale of the operation. Many types of medical imaging equipment require consumables and accessories.

Therefore, in conjunction with the medical imaging equipment inventory, the healthcare facility should maintain a separate inventory of consumables necessary to operate medical equipment. These include items such as ultrasound probe conductive gel, helium gas of MRI. The inventory includes a stock-control system to track details such as quantities and expiration dates so that items remain in stock and are used before they expire. Effective stock control of consumables inventory prevents stock-outs and allows budget estimates to cover the cost of consumables.

For each medical imaging device, it is important to have a stock of the items that wear over time or need to be replaced regularly recommended by the manufacturer. In addition, general maintenance materials, such as fuses, screws and electrical wires must be kept in supply through the use of the inventory.

(3) *Level*: Medical Collage Hospitals

Supervisor/Executor: In house Biomedical Equipment Management Department
Category of equipment inventory and documentation: MRI, CT Scan, Ultrasound, color Doppler, cobalt therapy, medical digital X-ray, conventional X-ray machine Mammography, Coronary Angiography, Gamma camera.
Causes and justification: The inventory includes a stock-control system to track details such as quantities and expiration dates so that items remain in stock and are used before they expire. Effective stock control of consumables inventory prevents stock-outs and allows budget estimates to cover the cost of consumables.

For each imaging medical device, it is important to have a stock of the items that wear over time or need to be replaced regularly recommended by the manufacturer. In addition, general maintenance materials, Such as fuses, screws and electrical wires must be kept in supply through the use of the inventory.

(4) *Level*: Regional/provincial

Supervisor/Executor: DEMWE (Renamed as RBMEMU)
***Category of equipment inventory and documentation*:** Medical X-ray machine and medium class ultrasound machines.

***Causes and justification*:** Most medical imaging equipment inventories, however, are held at the health-care facility level. For smaller organizations, such as a local clinic, the inventory may consist of a few simple items and may be updated very infrequently.

Conclusion: All level /all organizations said in above should keep the following tools and documents with very carefully.

- Workshop tools and test equipment
- Radioactive and hazardous materials and waste
- Equipment History
- Operating and Service Manuals CDs, DVDs and all other soft copy
- Spare parts Accessories
- Consumables
- Disposable

***Causes and justification*:**

(1) Assist in estimating the annual maintenance costs of the medical equipment stock.

(2) Other inventories that could be implemented in support of or related to health-care technology include the following:

(i) *Workshop tools and test equipment inventory*: Assists the medical equipment maintenance team in keeping tools and test equipment organized, in good working order and in calibration. for calibration and patient safety radiation a measuring tools named as does meter are very important to calibrate the medical X-ray imaging equipment and in some cases an ECG simulator is essential to calibrate the patient monitor because during neuro surgery biplane angiography was used and with ECG recorder.

(ii) *Radioactive, hazardous materials and waste*: Maintaining an inventory of such materials helps to ensure proper regulation, disposal and prevent unnecessary contamination. .

The ***focal personnel or responsibility*** of these levels are as follows:

(i) Record can be kept in national level and in hospitals.
(ii) To prepare an inventory and documentation and preserve a copy in machine room and a copy in central library under the supervision of biomedical engineer and users.
(iii) Put labeling on each part as code and preserved in store with a desired environment under supervision of technical personnel.
(iv) Put labeling on each part as code and preserved in store with a desired environment under supervision of technical personnel and users.
(v) Put labeling on each part as code and preserved in store with a desired environment under supervision of technical personnel and users.

The proposed data insertion in MIE Inventory and documentation is shown in Table 4.4. A sample Medical imaging equipment inventory Form is shown in ***Appendix II***.

Table 4.4: Proposed data insertion in MIE Inventory and documentation

Item	**Brief description**	**Types of Inventory**
Data collection	Purchase history	MIE
Equipment Identification number	Unique identifier for each piece of equipment	MIE

Brief description of equipment/item	Describe the items including its function/purpose	MIE
Model/Part	Unique identifier of the product line(assigned by manufacturer)	MIE
Serial number	Unique identifier of the product line(assigned by manufacturer)	MIE
Physical location within health care facility	Includes room number or department; allows medical equipment to be located when preventive maintenance is due ; may include storeroom information for consumables and spare parts	MIE
Condition /operating status	Identifies equipment as "in service" or "out of service; includes reason for being out of service, such as calibration due, preventive maintenance due, under repair, awaiting spare parts or damaged beyond repair	MIE and testing equipment
Power requirements	Clarifies the required power to run the equipment, such as 110V, 220V, 380V or three-phase; may be useful for identifying equipment that requires transformers or other special attention	MIE & Testing equipment
Operation and service requirements	Identifies any special requirements needed in operation or service of equipment	MIE & Testing equipment
Data inventory performed /updated	Date the equipment was entered into the inventory and the last date the information was updated	All
Maintenance service provider	Lists details of provider including name, contact details and contract details when medical equipment is maintained by an outside service organization (including when under warranty by manufacturer) or peripheral workshop; information on maintenance performed	All
Purchase supplier	Used as a point of contact regarding purchase, reorders, warranty replacements, etc.	All

4.3.5 Equipment Commissioning and Acceptance (ECA)

Commissioning can be carried out by in-house technical staff if they are familiar with that item of equipment. If commissioning by the suppliers is needed, the process should be monitored by in-house technical staff so that any technical matters can be noted and recorded on the **Equipment Service History.** The occasion also provides an excellent opportunity for in-house technical staff to gain familiarity with the new item. Ideally, in-house technical staff should also attend the operator's training session. It is particularly important to bear in mind that normally the supplier-warranty starts the day after equipment is delivered to the health facility. If equipment is not going to be used for some time after delivery, special arrangements must be made with the supplier to define the warranty period. Such an agreement should preferably be made in the purchase order. No payment to the supplier should be made before satisfactory performance has been confirmed by the in-house technical staff. The proposed improvement methodology is shown in Table 4.5.

Table 4.5: Proposed improvement methodology

Sl no.	**Commissioner for Commissioning**	**Qualification**	**Benefit /advantages**	**Alert and warming**
1	In-house Biomedical Technical staff	Must be familiar with that equipment	Government staff and always available in hospital and prompt service can be obtained	No risk and case to case training and technical guide line should be obtained from national level. As result, commissioning will never be occurred
2	Biomedical technical Personnel of Suppliers	Must have training on that equipment from manufacturers	The process should be monitored by in-house technical staff so that any technical matters can be noted and recorded on the **Equipment Service History.** The occasion also provides an excellent opportunity for in-house technical staff to gain familiarity with the new item. Ideally, in-house technical staff should also attend the operator's training session.	It is particularly important to bear in mind that normally the supplier-warranty starts the day after equipment is delivered to the health facility. If equipment is not going to be used for some time after delivery, special arrangements must be made with the supplier to define the warranty period. Such an agreement should preferably be made in the purchase order. No payment to the supplier should be made before satisfactory performance has been confirmed by the in-house technical staff.
3	National Biomedical Equipment Management of Government	Must have excellent knowledge and updated training on that equipment	Faithful service and must have accountability to the government and acts as trained arm force in this field. A good chain of commands will be maintained from national level to in-house level. Dependency on the suppliers engineers will be reduced	It will be accelerated service for Bangladesh and a lot of technical manpower will be built. A linkage to be made between users and Biomedical Equipment Management department and which will be able to sustain Medical imaging equipment management system properly

4.3.6 Monitoring of use and Performance

Monitoring of the use and performance is defined as continues checking of functional condition of the equipment and performance means that the cost effective equipment. A common mistake is that the warranty period is covered by the supplier so that no in-house technical attention is necessary. It is important that in-house technical staff become the link between user and supplier and observe any supplier's technical services. Such warranty services should be recorded in the Equipment Service History is known as monitoring of use and performance. Cost effective equipment selection can be realize by monitoring of the use and performance. World globally is maintaining this tools but in Bangladesh Health services was not maintaining this tools to insufficient technical knowledge. The improvement methodology of Monitoring of the use and Performance are illustrated in **Fig. 4.5.** Leakage current of Medical imaging equipment is shown in ***Annexure V***. List of tools for Medical imaging equipment maintenance is shown in ***Annexure VI***. Regulated AC Power Supply for Medical imaging equipment is shown in ***Annexure VII***.

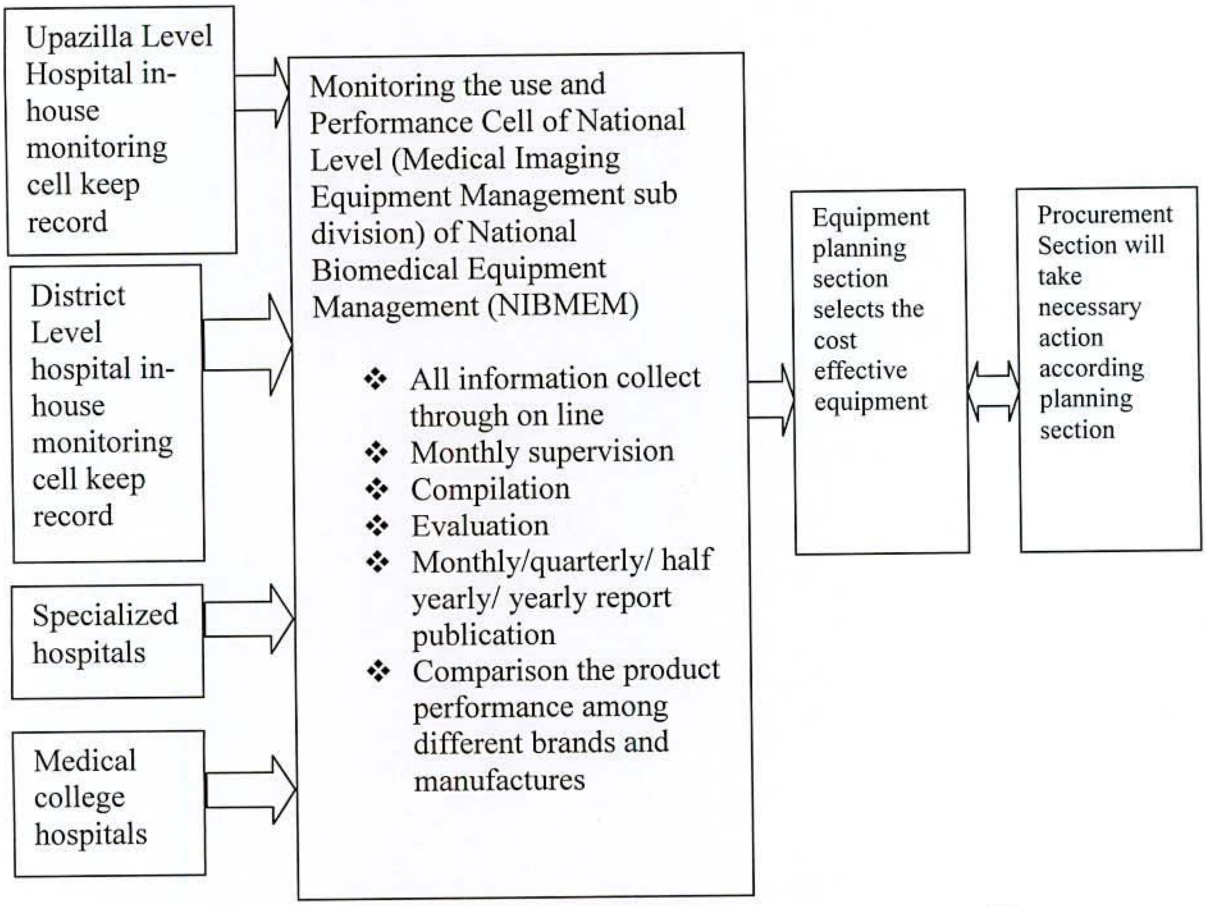

Figure 4.5: MIE monitoring the use and performance improvement diagram

4.3.7 Maintenance Management

The Medical Equipment Maintenance Management can be defined as different activities undertaken/executed right from the very first stage of equipment planning, selection, preparation of specification, standardization, procurement through tendering process, installation, periodic calibration, maintenance and finally condemnation & decommissioning /disposal of equipment. Proper maintenance of medical equipment is essential to keep the instrument/device functional for a long time to provide reliable diagnosis and to save capital investment. This will enhance user care of equipment, reduce equipment breakdowns and develop an attitude of cooperation between users and maintenance personnel. Thus a culture of equipment care and maintenance will be developed among users and engineer, which will result in better health care services in public sector. Various obstacles in expanding medical equipment maintenance capabilities in Bangladesh have been discussed. Maintenance Management problems are complicated by the ever-increasing use of medical imaging equipment along with the modernization of health care services. To date, the maintenance situation in Bangladesh is getting worse and requires special attention. To minimize maintenance problems maintenance capabilities are required to be evaluated during the initial stage of equipment acquisition. The mission is to ensure that equipment used for patient care is safe, available, accurate and affordable. Lack of standardization is a major problem in medical equipment management in Bangladesh because of the use of great variety of make & models from different manufacturer. This greatly complicates the use and maintenance of equipment. The Equipment Inventory List (EIL) and equipment service history (ESH) can provide important information. Models which show frequent breakdowns or which have high maintenance cost should be avoided.

The factors described below affect implementation of a proper MIEMM system in Bangladesh:

- Equipment cannot be used accurately.
- Frequently fault condition interrupts the health delivery services.
- Spare parts and consumables are not found during repair.
- Break down maintenance increases cost.
- Equipment de-commissioning and disposal are not being done regularly.
- More funds is required and spent for procurement of new medical imaging equipment which affects our economy.
- Equipment cannot be used to its full expected life.
- Radiation safety in cases of some imaging equipment is not followed. Medical imaging equipment Radiation safety Alarm and precaution is shown in Annexure II.
- An ill managed equipment maintenance interrupts the overall health service.

The main contributions of the proposed work are as follows: (i) to propose an approach to improve MIEMM system in the HSOB for sustaining life cycle of MIE as per standard of developed countries. (ii) to propose a management system which will be helpful in need based spare parts selection, preventive maintenance, supervision and monitoring functional status, installation, calibration, in house maintenance, central level maintenance and equipment decommissioning.

A more practical approach is recommended here to combine in-house maintenance system with external services. The reasons are in general; for a given piece of equipment maintenance problems of different level of complexity arises. The majority of the problems is relatively simple and can be corrected by a technician trained in front-line maintenance by specialist engineer. Everyone in our country knows that present day medical service is both expensive and improper. With regard to equipment maintenance, it is experienced that simple first line repairs would be less costly if performed by in-house maintenance personnel. Complex repairs requiring high-level expertise and non-available spares/consumables can be left to company trained specialists. There is a need for a workshop in case of in-house medical imaging equipment maintenance in large hospitals and district hospitals [5].

***Proposed methodology to improve the existing maintenance system*:**

The probable method of solving the problem of bio-medical equipment management system (BMEM) is to develop or establish an organization under the Health Ministry named as National Institute of Biomedical Equipment Management (NIBMEM). This institute will act as the central management wing of Ministry of Health & Family Welfare (MOH&FW) of Government of Bangladesh (GOB). It also acts as government regulatory body regarding medical equipment management and In-service Education & Training Center. The basic organizational chart of BEMS of Bangladesh is shown in Fig. 4.6. This is represented by dashed line. The proposed MIEMMS is also shown in Fig. 4.6 which is the subsection of NIBMEM. One subdivision of NIBMEM is to be named as Medical Imaging Equipment Management (MIEM).

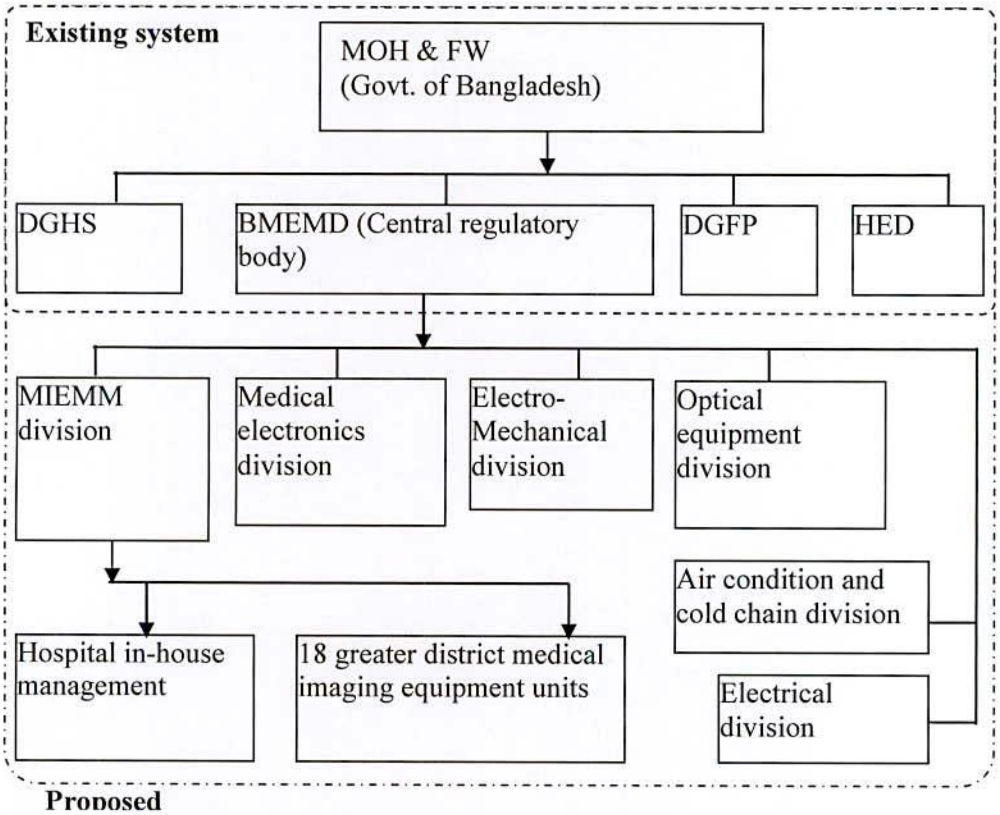

Figure 4.6: Proposed organization chart of Medical Imaging Equipment Management System of Bangladesh

MIEMM Sub-division:

The detailed proposed medical imaging equipment maintenance management (MIEMM) sub-divisional system is shown in Fig. 4.7. For standardizing management, the MIE division is sub-divided into two parts- (i) Hospitals in-house management and (ii) Greater Districts medical equipment units as mentioned in Fig. 4.6.

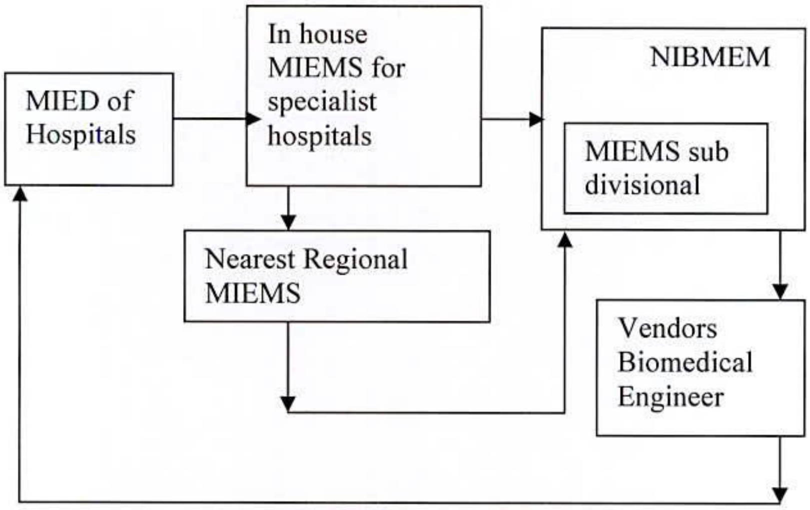

Figure 4.7: Proposed MIEMM sub-divisional system

Work Methodology of MIEMM:

Finally the work methodology of the medical imaging equipment maintenance management (MIEMM) system is shown in Fig. 4.8.

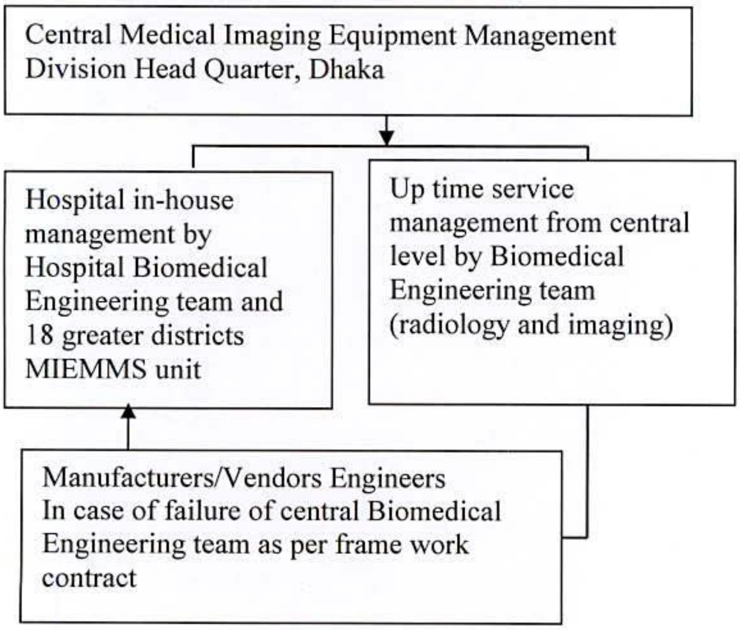

Figure 4.8: Proposed work methodology of MIEMM.

Radiation safety/ Radiation protection of Patients and Operators: Most of the districts and Upazillas Hospitals X-ray rooms have no proper sheilding and the windows are opended. Radiation hazerds is exaggerated to the patients and operators. It is very harmful for the nation. Ration controling officer (RCO) are not avilable in the hospitals and also NWMEW and TC. Occsaionaly Atomic Energy Commission monitored some of the places. To overcome the serous issue a propsal, which is described in ***Annexture II***.

Summarization of Maintenance: A clear-cut national policy on maintenance of MIEMM system needs to be established. This will greatly help to reduce any future problems arising out of contracts, spare parts and maintenance of equipment acquired locally, internationally or provided by partner agencies. Therefore, MIEMMS is essential to ensure proper health delivery and patient evaluation. A sample form (Form-A2) for assessment of repairing of medical imagining equipment in the public hospitals of Bangladesh is shown in ***Appendix III***. Medical imaging equipment planed preventive maintenance form (Form-A4) is shown in ***Appendix IV***.

4.3.8. Personnel Management: Individual persons who are qualified and available to do Medical Imagining Equipment Management must be identified. A list should be drawn up of personnel who are readily available. Once the personnel have been listed, specific responsibilities should be assigned, perhaps in the form of a work order, giving clear instructions for the task. Each person should have a clear knowledge of his or her responsibilities. Job assignments must correspond to the level of engineering education, training, experience and aptitude of the individual. Training is discussed in the next sub-subsection. If the hospital staff includes a large number of well trained experienced individuals who are familiar with medical equipment, in-service training can be effectively organized. A practical approach is shown in Fig. 4.9. Medical imaging equipment Radiation safety Alarm and Precautions are shown in ***annexure I***. Moreover, medical imaging equipment radiation safety Alarm and Precaution is shown in ***annexure II***.

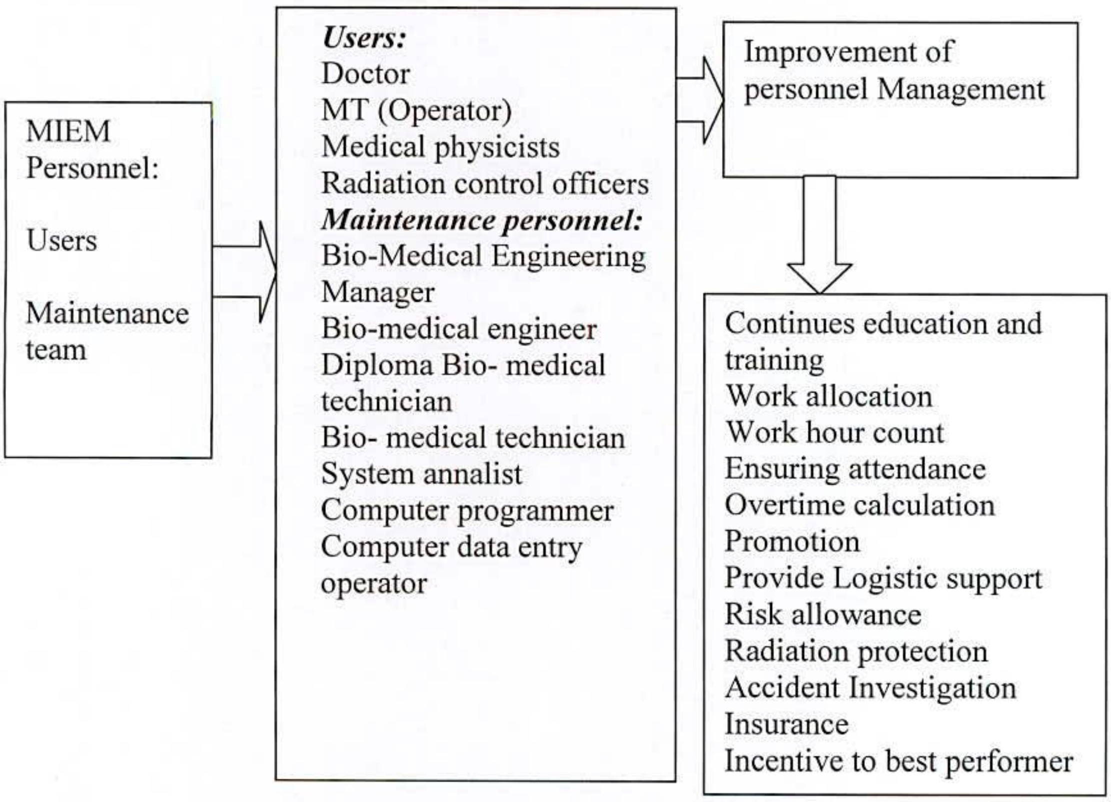

Figure 4.9: Proposed personnel management improvement

4.3.9 Skill developed through In-service Education and Training

Proper use and maintenance problems can be minimized through in-service training and education. Since technological development is a continuous process, in-service education of service personnel should be continued and a training center can fulfill this requirement. The present status of MIEM is not found effective and as a result patient suffering are increasing day by day in both public and private sector hospitals. On the other hand, huge money is drained out every year for procurement of new equipment which is a direct outcome of unplanned and improper equipment maintenance system in practice. To overcome the problem a proper "In-service Education and Training Center" need to be established immediately. A practical approach for the improvement of existing ISET is proposed in Fig. 4.10 [6].

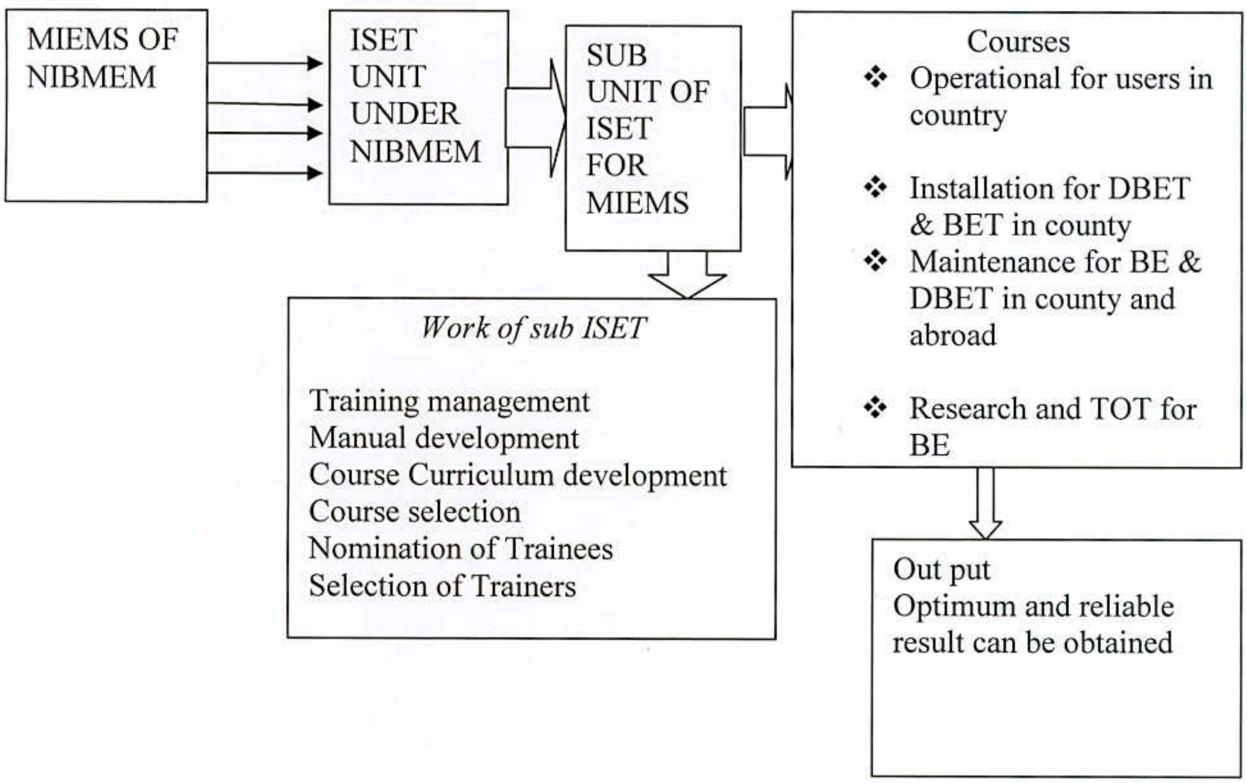

Figure 4.10: Proposed practical approach for the improvement of existing ISET.

4.3.10 Equipment decommissioning and disposal

Equipment decommissioning and disposal system is the most important part in selection of new equipment with capital investment. Given that the majority of medical equipment in developing countries is old and spare parts are often in short supply, it might not be realistic to assume that such equipment can be replaced within a short period. Therefore, as much as practicable, existing old equipment should be repaired. Old unserviceable units can be dismantled to provide some spare parts for repair of similar units. Such system of maintenance is known as "Cannibalization" where functioning components/parts from old unserviceable equipment is extracted and preserved in the inventory to be used later in maintenance of similar model machine. Such working/serviceable parts are to be removed from condemned equipment before their disposal and stored centrally under NIBMEM. This process will also provide an opportunity for cultivating technical innovation using local resources. De-commissioned equipment must be disposed off/deleted from inventory to keep it current. Good management practice should include all these aspects. Nearly all major hospitals in industrialized countries and some developing countries have in-house clinical engineering departments which take up this management responsibility. Smaller health facilities often share such services with major hospitals. In many industrialized countries, proper management of medical equipment is a mandatory component for health facilities to be accredited. District health facilities in developing countries should build up such comprehensive management in gradual steps. All national and provincial (or state) hospitals should have in-house technical staff to carry out comprehensive medical equipment maintenance. These services can provide guidance and support for the district facilities and help the districts eventually to build up their own comprehensive management programs. An improvement methodology is proposed in the Fig. 4.11.

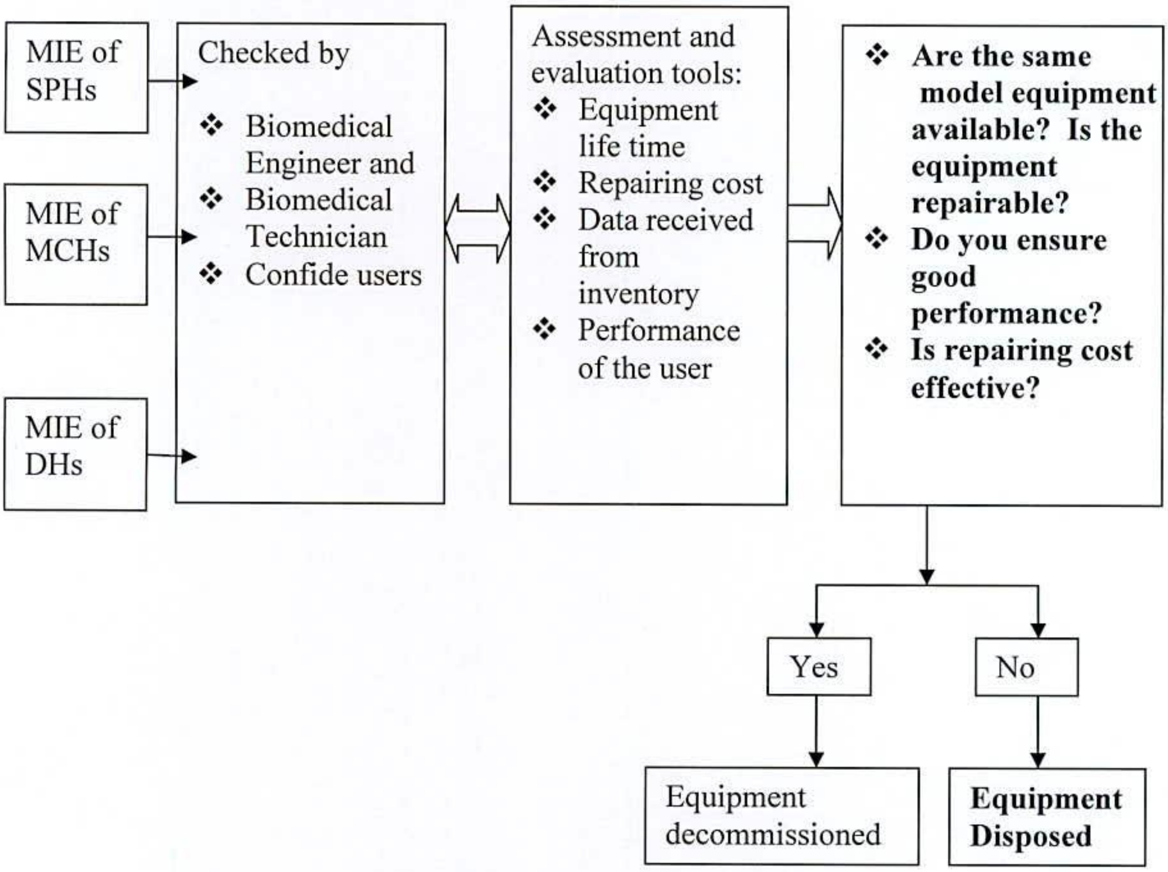

Figure 4.11: Proposed Improvement Methodologies

Organizational improvement of Existing MIEM: The Existing MIEM organizations are stated in Table 4.6.

Table 4.6: Existing MIEMS organizational manpower of Ministry of HSOB

Name	Location	Administrative controller	Existing man power 21			Education level and experiences		
X-ray Section of NEME MW & TC	Mohakhali, Dhaka	Ministry of Health & Family Welfare	Assistant Engineer X-ray	Sub- Assistant Engineer Electrical	Senior Technician	Bsc. Engineering in EEE and trained from abroad, 20 years experience	Diploma Engineering with 12 years experience	Class SSC with trade course
X- ray sections DEME M	18 greater districts of Bangladesh	Directorate General of Health services	Chief Technician Electrical	Chief Technician Mechanical	Chief Technician	Diploma Engineering in Electrical and Mechanical but they have no basic training on this field		

To improve the existing MIEM organizations, some important factor must be included as reference to the number of medical imaging equipment. A standard MIEM organizational improvement methodology is proposed in the Fig. 4.12.

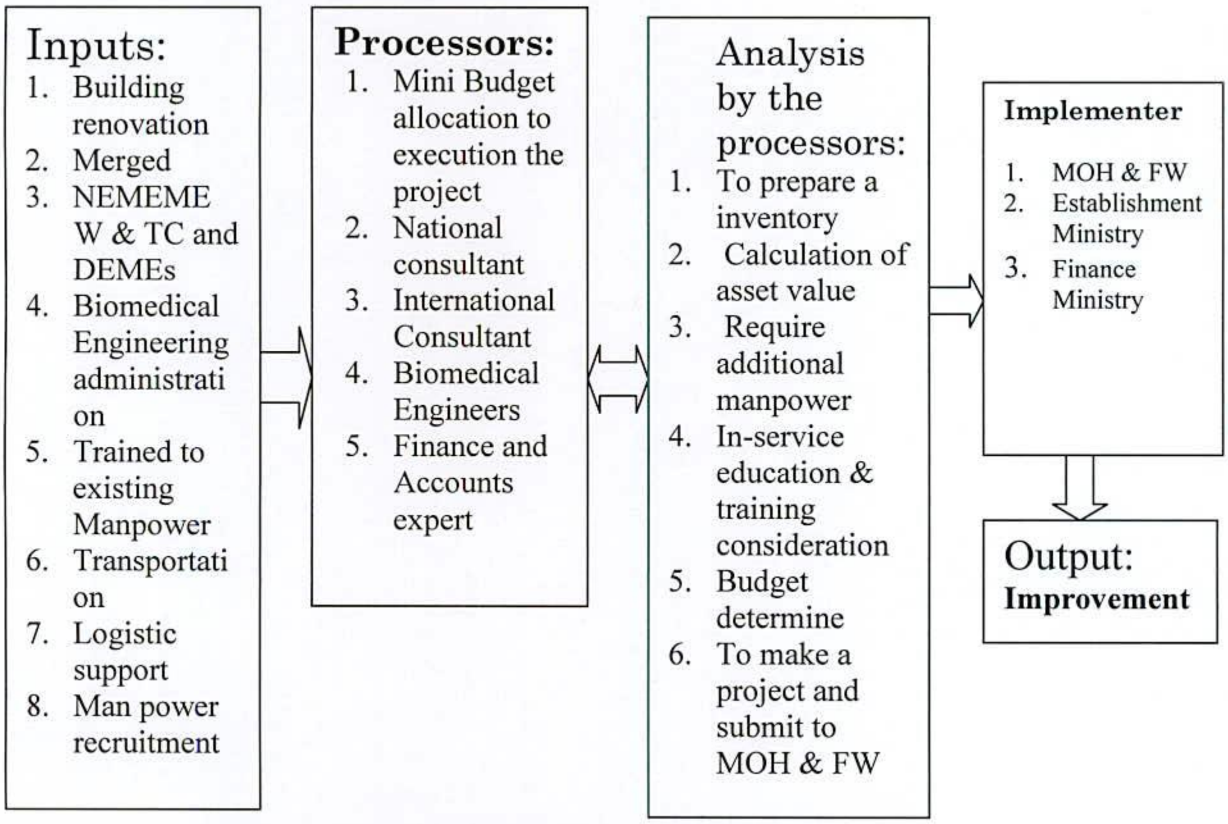

Figure 4.12: Organizational Improvement of existing MIEM

4.4 Improvement methodology of present Electro Medical Organizations under the Health Ministry of Bangladesh Government

Under the Ministry of Health and Family Welfare three Directorates and NEMEW& TC were shown in Figure 4.13. NEMEW is not well reputed organization nationally and internationally like three Directorates under the Ministry of Health and Family Welfare. As a result, most government hospitals do not know which organization is responsible for medical equipment management. Moreover globally Biomedical Engineering Management is the core management for Medical Equipment. Therefore, lot of critical questions arises about the meaning of NEMEMW (an un-reputed organization) by overseas stake holders. As a result, foreign grants and scholarships are missed out. Radiation protection guideline is shown in ***Annexure III***. In this situation, it has been discussed and proposed as BMEMD instead of NEMEMW. Presently four organizations are in charge of Maintenance Management of all sorts of medical equipment in the public Hospitals of Bangladesh. An improvement structure is shown in Fig. 4.14.

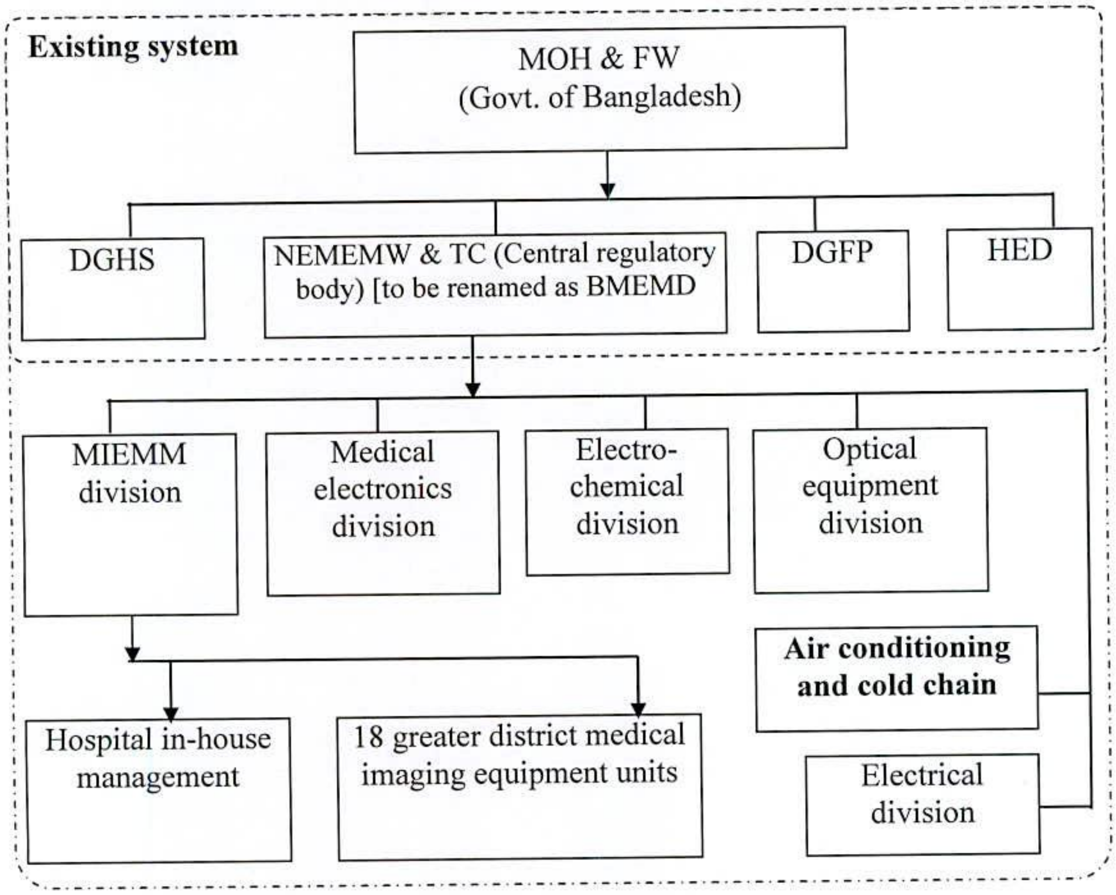

Figure 4.13: A practical approach for the improvement of NEMEMW& TC

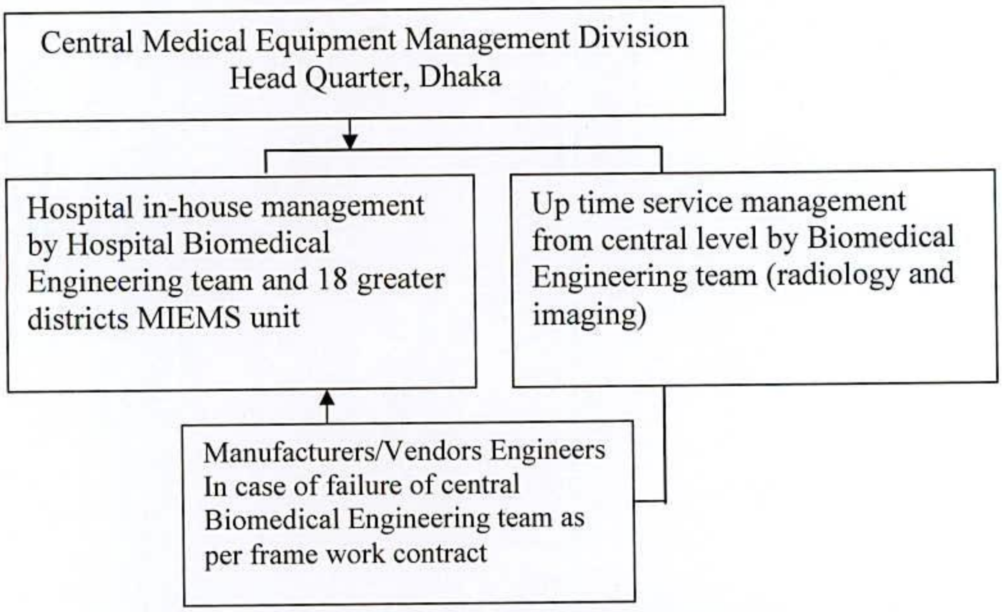

Figure 4.14: A practical approach- working diagram of BMEMD

4.4.1 MIEM Unit of National Electro medical Maintenance Workshop and Training Center in Dhaka

A small subunit named Medical X-Ray section was founded in 1982 under the control of NEMEMW & TC. There is four technical staff in this section and this section is presently treated as MIEM of Dhaka Head quarter. Among them only one Biomedical Engineer (Radiology and Imaging) has been working in the Dhaka MIEM Unit. Based on the quantity and global MIEM standard, a practical MIEM has been proposed for the improvement of existing MIEM subunit for Dhaka Head Quarter and also proposed work methodology, which is shown in Fig. 4.15.

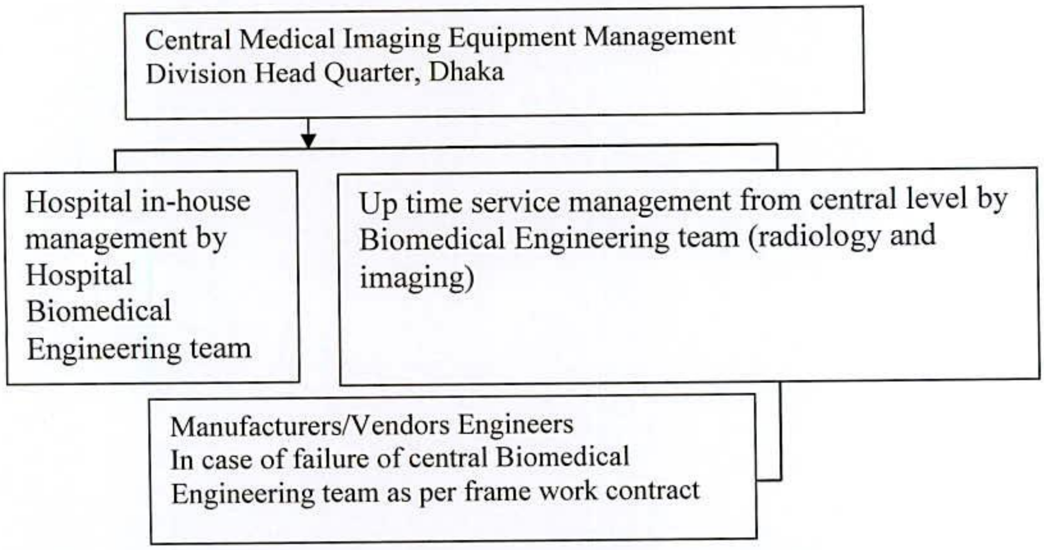

Figure 4.15: Improvement approach of MIEM Unit of National Electro-medical Maintenance Workshop and Training Center in Dhaka

4.4.2 Medical Engineering Section of Eighteen Districts Electro medical Maintenance Workshop

From the study, it has been found that more than 570 public Hospitals in Bangladesh have been using different types of medical equipment. Presently, District Medical Engineering Unit is working under the supervision of a medical doctor and as a result; poor feed back is obtained from the management. To obtain the real feed back from the DEMEWs, an improvement methodology is proposed in the Figure 4.16. Medical imaging equipments checking form is given in ***Annexure IV***.

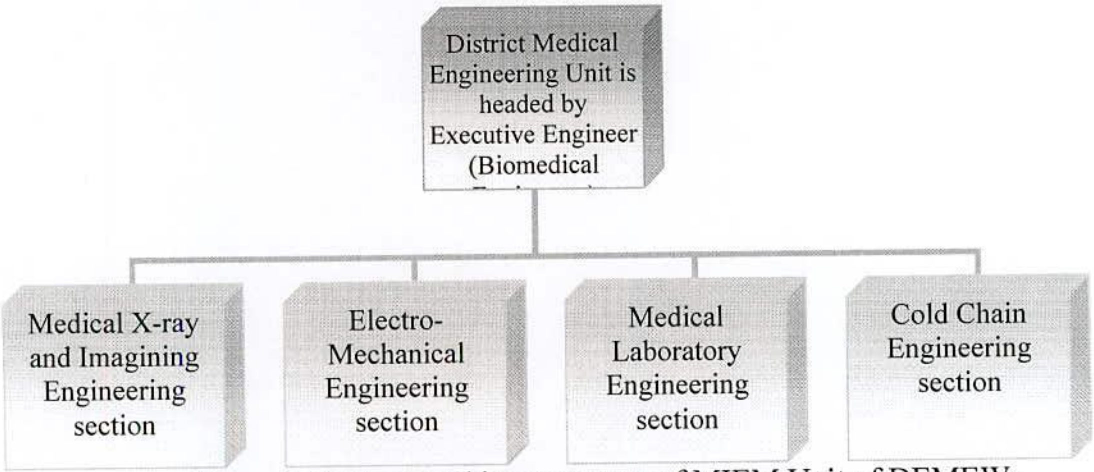

Figure 4.16: Proposed improvement of MIEM Unit of DEMEWs

4.4.3 Founding of MIEM Unit in Dhaka city / Dhaka Metropolitan Area:

Presently near about 15 million people are living in Dhaka City and the traffic jam is on the ever increase. The Government of Bangladesh has established new hospitals as per map of Dhaka city. The list of hospitals is shown in Table 4.7. There are twenty numbers of specialized and medical college hospitals in Dhaka City at different locations. Medical Equipment Management Origination was established in 1982 but meanwhile the number of hospitals increased rapidly. To reach any hospital of zones 1 & 2 from Mohakhali, it requires more than two hours. On the other hand, hospital activity regarding medical equipment in public hospitals closes at 2 PM. So, time difference and travel time due to traffic jam are hampering the activities of MIEM. In house MIEM was not established in any of the public hospitals. Considering above mentioned real situations, establishment of MIEM unit in Dhaka city / Dhaka metropolitan area is proposed for the improvement of MIEM is shown in Fig. 4.17.

Table 4.7: Proposed improved methodology as per location of hospitals

Serial no.	Zone /Area	Name of Hospital	Location	Location of MIEM
1	Zone 1	NCPHD, SSMCH,NICVD,NIKDU,NIMDH, TV Clinic, NIO, NINS,NITOR	Dhaka West – North	Mohakhali
	Sher-E-Banglanagar			
2	Zone 2	DMCH, SSMCH, GOVET SERVICE holders Hospital , TV Clinic	Dhaka South –East	
	DMCH Area			
3	Zone 3	NICDH, NICHR, IPH,IHT, TV Leprosy	Dhaka East – North	
	Mohakhali area			

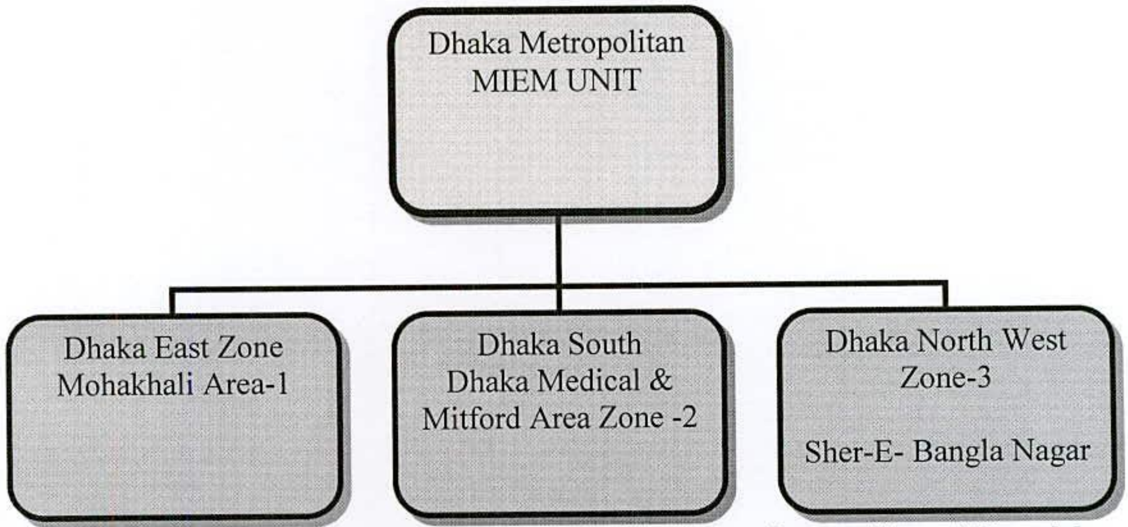

Figure 4.17: Proposed organizational MIEM sub-unit according to Metro Map

4.5 Summary of Proposal for Improvement

For the improvement of MIEM, data has been colleted from the public hospitals, CMSD, NEMEMW & TC. The existing situation in MIEM has been compared with the standard biomedical equipment management system of developed countries. A Standard Biomedical Equipment Management consists of 10 phases which has been mentioned in this chapter. Among the 10 phases of BMEMS most units have not been maintaining it properly. It was found that a major deviation in big percentage of MIEM lack of technical manpower. Though the number of MIE has increased but man power in this sector has not been increased in order to adapt with time. Generally, for any improvement well trained manpower, capital investment and updated technology are all essential. Among them technical manpower is the first and foremost national obstacle in the improvement of BMEMS.

Suggestions for Government of Bangladesh:

The following steps are very essential for the government of Bangladesh to sustain the equipment base health service to the nation.

- NEMEMW & TC can be renamed as NIBMEM because NEMEMW & TC is not well reputed to international and national
- NEMEMW & TC and can be merged and leaded from one technical administration
- Some higher post are vacant since long and it is essential to fill up the vacant post immediately
- It is very mandatory to improve and established the Biomedical Equipment Management System
- Hospital in-house Maintenance Management Unit needs to open
- One national and international Biomedical Engineer consults are need to be recruited by the Health Ministry
- Equipment Inventory and documentation can be pared a firm by EOI and RPF
- Asset inventory can be prepared through CMSD and hospitals record books
- A human resource development section is very essential to educate the existing MIEMS.
- It is very emergency issue to give the appointment near about one hundred Biomedical Engineers but now Biomedical Engineers are not available in Bangladesh.

To meet up the emergency at least 50 Degree Engineers (Electrical and Electronics), 10 Mechanical Engineers, 5 Chemical Engineers and 10 computer Engineers will be need to recruit.

- ❖ Some Biomedical can be hired from abroad for the training of new appointed engineers
- ❖ Health Services of Bangladesh to be stared an individual In-service education and Training center trough foreign grants like JICA, WHO, CIDA, ADB and World Bank

- ❖ To streamline & upgrade of NEMEMW, 18 DEMEWs, Engineering section of IPH & Cold Chain Section of EPI into one incorporated Bio-Medical Engineering Department, abbreviated as "NIBMEM" (National Institute of Biomedical Equipment Management)& Network for the purpose of management of Bio-medical/Electro-Medical Equipment of public hospitals of Bangladesh.

- ❖ Add 3500 Sq. meter working space in two floors on 6 DEMEWs, 5500 Sq. meter working space in one floor on 11 DEMEWs and 7500 Sq. meter of working space in NEMEMW by vertical and horizontal expansion. Set up three Divisional level BMED offices in Dhaka Metropolitan area; one in Sher-e-Bangla Nagar, one in old town near DMCH and one in NEMEMW to cater for the management of Bio-Medical equipment in the specialized & medical college hospital of greater Dhaka area.

- ❖ To modify 6 DEMEWs in suitable central geographical locations in each division into Divisional BMED set up (3 floors) and 11 other DEMEWS into Regional BMED set up (2 floors) by vertical extension and establish linkage with the central Bio-Medical Engineering Department set up in NEMEMW &TC at Mohakhali. Vertically extend NEMEMW to accommodate additional working space/ new offices and acquire additional land (66decimal) for horizontal expansion to accommodate the proposed Diagnostic Center with Clinical Research Laboratory.

- ❖ To re-organize the different technical & engineering staff working in different medical college hospitals, specialized hospitals, IPH, EPI, NEMEMW & DEMEWS and bring those under the unified command of central Bio-Medical Engineering Department set up. To fill up the existing vacant posts and create some additional but essential posts (Engineers, Electro-Mechanical & Bio-Medical Technician)

- ❖ To strengthen training section of NEMEMW and establish a state of the art diagnostic Center with Clinical Laboratory in the vicinity of NEMEMW for imparting practical training to fresh medical graduates in safe & proper use of Diagnostic Medical Equipment. The laboratory could be used by Govt. officials for carrying out their personal laboratory tests at reduced rates. This would contribute to some revenue income.
- ❖ To develop the training section of NEMEMW into a center of excellence to enable junior doctors from neighboring SAARC countries to receive training on safe & proper use of Bio-Medical equipment. The center thus developed shall also collaborate with public & private universities/colleges in formulation of curriculum development for teaching Bio-Medical Engineering in the country.

- ❖ To up-grade NEMEMW to such an elevation whence from she can take the responsibility as regulatory body for inspecting and issuing licenses to private clinics/hospitals.

- ❖ To strengthen and furnish NEMEMW and its satellite BMED units with the required Logistics in order to check, calibrate, limit radiation & pollution hazards.

- ❖ To strengthen and equip NEMEMW so that she is able to install & maintain safe and required power supply to hospital electro-medical equipment, thereby removing dependency on other agency for power supply/installation works.

- ❖ To enhance the capability of NEMEMW in order to gradually take over the responsibilities of procurement, installation, calibration, preparation of SOP for equipment, translation of manuals from English into Bengali, calibration, condemnation & finally disposal of medical equipment.

4.6. References

[1] Paper pubilication of Seminars on medical equipment management held on (2001, 2005, and 2008) sponsored by WHO, JICA and World Bank and data from DGHS and CMSD (1991, 2009, and 2010).

[2] Dyro J. Donation of medical device technologies. In: Dyro J, ed. Clinical engineering handbook. Burlington, Elsevier Academic Press, 2004

[3] Medical equipment maintenance programme overview. Geneva, World Health Organization, 2011.

[4] Md. Anwar Hossain and Mohiuddin Ahmad, "Improvement of Medical Imaging Equipment Maintenance Management of Bangladesh", *Proceedings of the 1st Int'l Conference on Advances in Electrical Engineering* (*ICAEE 2011*), pp. 252-257, Dhaka, Bangladesh, December 2011.

[5] Seminars on medical equipment management held on (2001, 2005, and 2008) sponsored by WHO, JICA and World Bank and data from DGHS and CMSD.

[6] Md. Anwar Hossain and Mohiuddin Ahmad, "Improvement of In-service Education and Training on Medical Imaging Equipment of Bangladesh", *Proc. of the Int'l Conference Informatics, Electronics & Vision,* (*ICIEV12*), March 2012, Dhaka, Bangladesh.

CHAPTER V

Limitations and Concluding Remarks

5.1. Limitations of the proposed research work

The proposed MIEMS system has following limitations:

- Non technical policy makers in this field are in top level MIEMS.
- Inadequate plan is prepared by government regulatory body of the Health services
- Lack of in-service education and training in Bio medical Equipment Management System.
- Alternative facilities of private Hospitals and clinics are available in the existing management. As result they felt inferiority of MIEMS

To overcome the existing system, the following steps are recommended:

- Health technology development is a continuous processes and it is creasing rapidly. It is very difficult to understand within a short time for the policy makers. So, it will better to submerge some qualified Senior Biomedical Engineer with the top-level Administration and Health Technology Management. Then, it will easy to understand Biomedical Equipment Management System of them
- National and International Biomedical Engineers consult need to be appointed to increase the capacity of existing Biomedical Equipment Management System (BMEMS).
- To allocate more budget for Seminar and International conference and hence technology will disseminate and spread out to Health Chain of Public Hospitals
- Research and training fund is not allocated and in this code, it needs to incorporate budget in the operational plan.

5.2. Conclusions

From study and practical experiment, it was found that the existing MIEMS in the public hospitals of Bangladesh is negligible with respect to MIEMS of developed countries. The BMEMS is starded in 1984 and its was named as NEMEMW & TC under the ministry of Health and Family Welfare. Under this organization a small section was opened. The name of this section was X-Ray Section. That time aproximately 200 numbers of X-ray machines were used in the Health Services and total maitenance technical personeel was 05 numbers.

Presently more than 2500 numbers of shophisticated of different catagories equipment are using in the public hospitals of Bangladesh but only one trained Biomedical Engineer is in this section and other three technical perosonal are in this section hired from other sections of this organization. But they are not trained and aged. So, from this seniro one can easily understand the exsisting MIEMS of Bangladesh.

In the developed countries the maintenance personeel and equipment ratio is 1:50 including Biomedical Engineers as per WHO standard. Not only that All private Hospitals (Example: BIRDEM and Lab Aid Hospital) Dhaka, Bangladesh are following the same guide line. But in in the present status of Public hospitals of Bangladesh this ratio is 1: 1250. Out of ten phases of MIEMS, it is concluded that technical manpower for maintenance is very negligible. As more than 80% Biomedical Technical Personeel is involved in the MIEMS eventually other phases are direcly affected due to huge shortage of Biomedical Personneel and on the other hand patient and operator safety could not ensure.

In chapter I, it is described the objective of the study and author think that MIEMS will improve subject to awareness of the Government.Considering real facts and benefits for the nation authors has submitted a suitable proposal to overcome the problems as name as 'Improvement of Medical Imaging Equipment Management System of Bangladesh'. We believe that it will be transport to improve existing Medical Equipment Management system. As a result, nation will be benefited in all respect.

5.3. Suggestions/Recommendation for Future Work

Present proposal is one of the researches of Biomedical Equipment Management System (BMEMS) only. The following future plans are recommended to sustain quality health services for the nation.

- Biomedical Equipment Management System (BMEMS)
- MIEMS could be in particular equipment in the country.
- MRI/CT/Ultrasound image processing management.
- Any phase of BMEMS
- To strengthen the Biomedical Engineering Department of KUET
- To open the Biomedical Engineering Department to each public Engineering University.
- To increase more teaching aids and lab facilities
- Education Ministry are requested to conduct with Health Ministry
- Continuous Seminar and Conference to be conducted.
- Number of publication can be increased through under graduate and post graduate students
- The importance of BMEMS of Health Services to be focused through National Journal and Electronic Medias.
- To expose the necessity of BMEMS through weekly/monthly papers
- Under Biomedical Engineering department initially Specialist Program can opened(Post graduation on Medical Imagining and Clinical Engineering)

Appendix I

Technical terms and conditions are recommended to insert in PPR 2008 for Medical imaging equipment

Technical Aspects for new procurement of Medical Imaging Equipment: Vendors/Manufacturer should have qualified Local Agent in Bangladesh

Eligibility of Local Agent:

- Enlistment is mandatory for the local agent
- Minimum one B.Sc. Engineer (Electro-Mechanical) and one Electro-medical/Biomedical Engineer with minimum 3 years experience in related field and should be member of IEB
- Two Diploma Engineers in Electro-medical discipline with minimum 3 years experience in Medical equipment
- Two Electro-medical Technician with 5 years Experience
- Logistic support and Repairing tools, testing, calibration instrument, and safety testing instrument should have
- Emergency Maintenance mobile workshop facilities should have in a car
- All technical staffs should be trained from vendors/ manufactures

Technical Specification includes

- Application is designed as salient features to be prepared by related Doctor and Biomedical Engineer
- Technical data for met up requirement
- Power supply system (Back up battery,UPS, AVS) where which applicable
- Layout and place of installation should be mentioned
- Product Quality standard certificate CE/EC/FDA/JIS
- Safety Certificate IEC

Spare parts and consumables:

- Bidders should be quoted fast and slow moving spare parts which mentioned in tender document with international price and mention validity of price for next 10 years.
- Quoted price must be includes with equipment prices and to be considered for evaluation.

Technical Terms and conditions:

- Supplier must have local agent with at least 5(five) years experience in this field
- Supplier will have to provide at least one year warranty/ (Warranty should be declared by manufactures through his qualified local agent.
- Supplier/ his nominated engineers/Local agent Experts will visit the site / place of installation and accordingly submit tender.
- Supplier/ manufactures should be complete work the installation by qualified biomedical engineer and handing over the equipment to the concern authority with full functional condition. Installation materials should be provided by the supplier.

Training:

- **Local/site**: Supplier will have to provide onsite training to Users, operators and two nominated technical personnel of NEMEMW/DEMEW.In this connection training allowance should be met up by Supplier as per WHO/UNICEF standard.
- **Foreign:** one user from hospital at manufacturing country or any famous hospital in the world. One Biomedical engineer from NEMEMW/DEMEW at Manufacturing plant for mockup and Maintenance management training.

The duration of training depends on the category of equipment.

After Sales Service:

- After sales service centre should be available in Dhaka on 24(hrs) X 7(days) X 365 (days) basis. Complaints should be attended properly, maximum within 12hrs. The service should be provided directly by Vendor/ Local Agent.
- Undertaking by the Principals/Vendors that the spares for the equipment shall be available for at least 10 years from the date of supply
- The service provider should have the necessary equipments recommended by the manufacturer to carry out preventive maintenance test as per guidelines provided in the service/maintenance manual.
- Bidders should offered a frame work contract maintenance management for the next 9 years after completion of warranty period and cost of maintenance will be added with equipment cost and evaluated.

Documentation:

To be provided during Supply of equipment

- User manual & Service manual in English version 3 copies of each
- One SOP in Bangla version with laminated
- Certificate of inspection from factory

Apendixe II
Medical imaging equipment inventory Form A1

- Name of Equipment: [ ] Model [ ] Serial [ ]
- Country of origin [ ]
- Particulars of Local agent: ---
- Source of equipment: CMSD/other (If any please specify)---
- Purchase price of equipment: [ ] Date of Installation with functioning: [ ]
- Warranty expiry date: [ ]
- Contra ct agreements terms: --
- Spare parts price mention during tender: if yes, please send---
- Have maintenance contract: If yes, Please send agreement.---
- Frequencies of breakdown: ---
- Total previous cost for repairing & maintenance: [ ]
- Last proposed cost for repairing: [ ]
- How many patients were examined by the machine: please mention no of patient with revenue collection ---
- Performance of local Vendors: Please specify preventive maintenance Schedule of company Engineer. ---
- (Weekly/monthly/yearly) during warranty period & contract Maintenance:-------------------------
- Recommendation or opinion if any: ---

Signature of

MT (Radio) Authority	Doctor of Radiology	Hospital

Appendix III

Assessment form for repairing of MIE of Bangladesh (Form- A2)

Equipment Description:

Name of Hospital..

Name of Equipment..

Model No...

Serial No..

Brand..

Manufacture..

Local Agent...

Assessment Information:

Purchase Price...

Installation date..

Installation Environment...

Maintenance Contract..

Frequency of Repaired...

Previous Cost of Repairer...

Number of Patient examined...

Performance of the Equipment..

Operational and Service Manual..

Service Contract clause:

Voltage fluctuation:

Authorized Signature of

Medical Technologist	Radiologist	Biomedical Engineer	Hospital Director

Appendix IV
Medical imaging equipment Planeed Preventive Maintenance (Form-A3)

PPM Time table

Location	J	F	M	A	M	J	J	A	S	O	N	D
CT Scan		X				X				X		
MRI			X				X				X	
X-Ray	X				X						X	
Ultrasound		X				X		X				X
Color Doppler				X		X		X				
Angiogram			X		X			X		X		X

Annexure I

Terms and conditions of repairing of MIE for Hospital & Company

1. Local agent should be provided full guarantee of replaced spare part and consumables.
2. Claimed of additional spare parts will not be permitted by the company during repaired
3. Company will be used Electric, gas and water or other related facilities
4. During rapier work the operators and expert of NEMEW should be present
5. All discard spare parts should be marked by permanent marker and preserved in the Hospital Store,
6. All new spare parts should be marked by permanent marker with dually sign and date by hospital and our expert
7. All new spare parts part/ cat numbers should be entered in your stock ledger book.
8. After completion the repairing work equipment should be tested by users and our Expert.
9. The Company will be handed over the equipment to the concern Authority with good running condition and test run period should be 15 days.
10. Hospital's authority is requested to send one copy of work order before starting repairing works
11. For covering the one year warranty 10% amount of quoted value keep as performance security as per government rules .

Signature of

Inspection officer	Chief, Medical X-ray Section	TMR	CTM

Annexure II
Medical imaging equipment Radiation safety Alarm and Precaution

Organizational responsibility

(i)General considerations

The local hospital organization for radiation protection can be authorized by the Regulatory Authority, which should ensure by inspection or other means that the regulatory requirements are being fulfilled. Responsibility in radiation protection affects all members of the administrative system in a hospital from the employing authority to the individual carrying out a nuclear medicine procedure. In any facility using radiation, (diagnostic radiology, dental, nuclear medicine, radiotherapy, research, etc.) the responsibility for radiation protection should be clearly and formally defined.

The Basic Safety Standards state that the main responsibility for radiation protection lies with the registrant or licensee and with the employer it is advisable to assign an individual to oversee radiation protection matters, designated as the **radiation protection officer (RPO)**. In small private facilities the medical practitioner-owner/employer may be the person responsible for radiation protection. The first responsibility is to assure that radiation sources under the registrant's or licensee's jurisdiction are used only by competent persons. The registrant or licensee is also responsible for providing instruction of personnel in safe operating procedures and for establishing rules for radiation safety. The responsibility for implementation of radiation protection procedures in radiological departments of medium-sized hospitals or in larger private facilities may be delegated to one or more individuals. Large facilities may benefit from the establishment of a radiation protection committee and/or the appointment of a radiation protection officer on a full-time basis.

The radiation protection officer should have a good theoretical and practical knowledge of the properties and hazards of ionizing radiation, as well as protection. In addition, the radiation protection officer should possess necessary knowledge of all the appropriate legislation and codes of practice relating to the uses of ionizing radiation in the relevant medical area (diagnostic radiology, dentistry, nuclear medicine, radiotherapy). In large institutions, the radiation protection officer is usually a qualified medical physicist or health physicist however in a small department or laboratory it may be the medical practitioner who has been trained by participation in short courses.

The radiation protection committee (see below) or the individual appointed as responsible for the day-to-day radiation protection matters should have a cooperative relationship with an occupational health service.

In larger hospitals with a separate organization or department of health physics, radiation physics, hospital physics or medical physics there may be one physicist specifically employed full time for radiation protection purposes. He/she could then combine some of the duties of both the radiation protection officer and the radiation protection supervisors.

The general medical and health care of the patient in a clinical department is, of course, the responsibility of the chief of the section who has to maintain a high standard of care. This responsibility clearly includes radiation protection. If, for example, in a request for examination, the clinical indications and the information required are obscure, he/she should arrange prior consultation with the referring physician. Also the question of suspected pregnancy must be clarified on request when appropriate.

The radiographer or technologist has a key position, and his/her skill and care determine to a large extent optimization of the patient's exposure. Medical practitioners are often involved in radiological procedures, especially in smaller departments and private practice. They should be made aware of the importance of their role in the efficient and safe conduct of radiological procedures. For an effective radiation protection outcome the efforts of various categories of personnel engaged in the medical use of ionizing radiation must be coordinated and integrated, preferably by promoting teamwork, where every individual is well aware of their responsibilities and duties. A small hospital with limited staff and competence in radiation protection in-house should consider a cooperative arrangement with another hospital.

(ii) **Radiation Protection Committee**

In large hospitals or in several cooperating small hospitals there are advantages in establishing a **radiation protection committee**, which should basically act as an advisory group for the institution's senior management.

An example of the structural organization for radiation protection in a large hospital is given in. A radiation protection committee is strongly recommended for a hospital where more than one department uses radiation sources under a general or consolidated license. The radiation protection committee may also deal with other types of ionizing and non-ionizing radiation used in the installation. The Committee also represents a forum where department heads may become informed of regulations and requirements concerning the use of radiation in their departments discuss problems and be a part of their solution. The radiation protection committee should be appointed by the hospital's senior management and should be composed of clinical staff representing the hospital departments using radiation sources, medical physicists and persons who have special knowledge of the hazards of radiation and are experienced in radiation protection. Also included should be a representative of the hospital's administrative unit, and a union or staff representative. The radiation protection officer (medical physicist or health physicist), and possibly a physician from the occupational health service should also be members. The main duty of the radiation protection committee should be to establish a radiation protection policy according to the national regulations and the specific requirements contained in the installation's license to possess and use radiation sources. It also should be the link between the facility and the Regulatory Authority.

Some specific responsibilities might be entrusted to the Committee are:

- Review and oversee compliance with, and implementation of, the radiation protection program;
- Formulate radiation protection policies to update and improve the radiation protection program
- Provide the radiation protection officer with guidance on operational aspects of the radiation protection program, and request actions on specific matters;
- Investigate any radiation incidents or accidents and provide a comprehensive report on these to the employer; and
- Assess potential hazards from foreseeable incidents and prepare contingency plans.

To meet these responsibilities, the RPC shall recommend actions to the licensee to:

- Correct identified deficiencies in the radiation protection program;
- Review new uses of radiation sources that may lead to modifications of the radiation protection program;
- Identify any amendments to the license;
- Identify staff needing personal authorization; and
- Periodically review the training program.

The radiation protection committee should also define the duties and responsibilities of the radiation protection officer and those of individuals who should be appointed in each department using ionizing radiation to be responsible for implementing the radiation protection rules. As mentioned, these persons are usually called radiation protection supervisors.

(iii) Radiation Protection Officer (RPO)

The radiation protection officer (RPO) should have a key position in the radiation protection organization and be responsible for the practical implementation of the decisions taken by the radiation protection committee. A primary function of the RPO is to administer the institution's license to possess and use radiation sources by overseeing and coordinating all aspects of radiation safety within the institution. Also he/she should actively take part in matters such as:

- Providing a link between the RPC and the users of radiation within the institution;
- Supervising operational aspects of the RPP;
- Providing practical advice on implementation of local rules and procedures;
- Identifying deficiencies in compliance with the RPP and reporting to the licensee and the RPC;
- Identifying training needs and organizing training activities;
- Systematically verifying that tasks requiring personal authorization are only performed by staff with a valid authorization;
- Monitoring source security: receiving sources and maintaining the source inventory;
- Co-operating with officers of the Regulatory Authority and facilitating internal and external audits;
- Contributing to the planning and design of any new or modified radiation facility;
- Undertaking the radiation safety assessment of new installations, processes and equipment, prior to their acceptance;
- Identifying and establishing controlled and supervised areas;
- Specifying appropriate monitoring procedures;
- Ensuring that enough radiation monitoring instruments are available and that they are calibrated and serviced as required;
- Implementing a personal and workplace monitoring program
- Systematically and periodically reviewing monitoring program in all areas where radiation sources are used, stored or disposed of;
- Analyzing and interpreting radiation monitoring data;
- Informing all radiation users of their personal doses and ensuring that these are consistent with optimization;
- Ensuring that appropriate measures are taken to control the exposure of a pregnant employee;
- Assessing potential hazard from foreseeable incidents and drafting contingency plans;
- Exercising and carrying out emergency procedures;
- Being available for consultation on radiation protection matters;

- Ensuring that appropriate action is taken when an employee reports a matter which can compromise radiation protection;
- Ensuring that appropriate radiation protection training is provided on a regular basis as part of an ongoing "radiation protection awareness program" for all users and for

those who occasionally come into contact with radiation sources (i.e. cleaning staff, security, maintenance people);

- Ensuring that necessary leak testing of sealed sources is performed;
- Supervising decontamination procedures;
- Providing instruction to nursing staff on the correct procedures for handling and disposal of soiled linen and for dealing with spillage of urine from patients receiving bone pain palliation therapy;
- Providing waste disposal procedures in accordance with the conditions of the license or as specified by the Regulatory Authority;
- Investigating all overexposures, accidents and losses of radiation sources and reporting to the RPC/Regulatory Authority as necessary;
- Maintaining required records
- Preparing a comprehensive annual report for the RPC and for forwarding to the Regulatory Authority if required.

Note: In large hospitals with diagnostic radiology, radiotherapy and nuclear medicine facilities, more than one RPO may be appointed. In such cases, one should be appointed as the co-ordinator.

The work of the radiation protection officer must be fully supported by the radiation protection committee and the hospital management.

(iv) Documentation of the radiation protection program (RPP)

All radiation users and other workers exposed to ionizing radiation sources must have available to them written documentation outlining in detail all relevant aspects of the radiation protection program within the institution. The intent of the document is to inform each worker within the institution of the requirements and obligations he/she has with respect to the safe use of radiation sources. This document, which should be issued by the radiation protection committee, should be reviewed and updated at least every two years. The document may take the form of local rules or a radiation safety manual (with the exact format usually specified by the Regulatory Authority). The Radiation Protection Program should document, with an appropriate level of detail:

- Aassignment of responsibilities for radiation protection and safety to individuals or to positions within the organization, including organizational arrangements and, if applicable (for example, in the case of contract workers), the allocation of the respective responsibilities between employers and the licensee;
- Classification of controlled or supervised areas;
- Local rules for workers to follow and the supervision of work;
- Arrangements for monitoring workers and the workplace, including the acquisition and maintenance of radiation protection instruments;
- A system for recording and reporting all the relevant information related to the control of exposures (occupational and public), safety of sources including waste management, the decisions regarding measures for radiation protection and safety, and the assessment of doses to occupationally exposed individuals;
- A system for calibration of sources and clinical dosimeter;
- A system for constraining the exposure of comforters, carers and volunteers;
- An education and training programme on the nature of the hazards, protection and safety;
- Methods for periodically reviewing and auditing the performance of the RPP;
- Plans to be implemented in case of emergency;

- ❖ A health surveillance programme for workers;
- ❖ Requirements for the assurance of quality and process improvement.

References

[1] IAEA, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources Safety Series No.115, (1996).

[2] WHO/IAEA/PAHO/EC. Manual on Radiation Protection in Hospital and General Practices, Volume 1, Basic Requirements (draft).

[3] IAEA. Practice-specific Model Regulations on Radiation Safety in Nuclear Medicine (in preparation).

Annexure III
Radiation protection guideline

Radiation Protection Instruction according to the X-ray Ordinance and the Radiation Protection Ordinance of Germany

Risk: X-ray and gamma radiation are hazardous by nature. They can cause injuries in a number of ways:
They can lead to the death of cells or to the mutation of genetic information in the cell nucleus. Experts refer to cell death as acute radiation injury, which manifests itself, e.g., in skin burns. Mutations can lead to long-term sequel such as cancer. In other cases, they don't become evident until the next generation(s) (genetic damage).

Shielding: Radiation cannot be avoided in specific work situations. In this case, we have to make full use of all options for radiation shielding.
These are:

- Never stay in the proximity of the radiation source.
- Always use the designated tools for handling or installing and dismantling
- X-ray tube assemblies. This applies in particular to the handling of line sources.
- Caution! A significantly higher value of shielding is required for the gamma radiation of the Biography System than for the X-ray radiation of the CT part.
- The tenth-value layer for lead is approx. 0.3 cm for 100 KeV and more than 2 cm for 600 KeV

Distance: Since radiation spreads radically from its source of origin, the radiation intensity (Dose rate) decreases with distance. The dose rate decreases in accordance with the inverse square law: When the distance of an object to the radiation source doubles, the dose rate drops to a fourth.

Minimizing radiation:
Only remove gamma radiation sources from their lead containers when necessary. X-ray radiation is released for training purposes only. Employees are prohibited from staying in the equipment room in the presence of radiation.

Dose determination:
According to § 40 of the Radiation Protection Ordinance, all persons in the control area must wear a personal dosimeter. Control areas are defined as areas in which a person can receive a whole-body dose exceeding 6 mSv in a calendar year. In Biography / Symbia courses, a control area only exists when radiation sources are used or when the CT is released.
In Germany, the personal dose is measured with a film badge (official personal dosimeter). If you forgot to bring your official personal dosimeter, you will be issued a film badge for the duration of the course. This badge will then be evaluated by the authorities. A pen dosimeter will be issued upon request.
CSTC / SSB (ar) 04.2008

Occupational disallow:
Pregnant women are not allowed to enter the control area. Please notify your instructor if you are pregnant or suspect you may be. The instructor and the responsible radiation protection officer are obligated to keep this information confidential. The radiation protection officer will decide on further steps.

System handling: Biography/Symbia devices may only be operated by persons who have received proper instructions for handling them and have attended the corresponding radiation protection training.
At the end of every instruction day, all removable radiation sources must be stored in a safe. Without gamma radiation in the equipment room, there is no gamma radiation hazard. When the CT device is not under high voltage, there is no risk of X-ray radiation. The procedure for long-term measurements is described in the radiation protection instructions.
Check: Check the function of the safety devices for radiation protection before starting work.
Set-up/changes:
Set-up and changes that may impact radiation protection must be reported to the radiation protection officer. In this case, the system may not be started until it has been assessed by the radiation protection officer. Never disable the existing safety mechanisms under any circumstances, not even for training purposes.

Defects: If you detect or suspect any defects in radiation protection, immediately discontinue the use of the radiation device or gamma radiation source and notify the radiation protection officer. Similarly, the radiation protection officer must be notified right away if there is reason to suspect that someone received an elevated radiation dose.
Note: Approach your work with caution and professional expertise, observing all applicable radiation safety rules mentioned above.

Please do not hesitate to contact your instructor with any additional questions you may have

Annexure IV
Medical imaging equipment Does checking Form A4

Report Form for Personal Dose Monitoring with Pen-Dosimeter

Visitor [X] Monitoring following German regulation: [ ]

X-ray [X] Radiation Protection (StrlSchV)

Category A Person [ ] Category B Person [ ] Other Person [X]

Name:	First Name:	Monitoring Month(s)/ Year:

Department:	Pen-dosimeter no:	Monitoring Month(s)/ Year:

Day	Reading in mSv		Location(users -ID)/ remarks	Day	Reading in mSv		Location/ remarks
	Morning	Evening			Morning	Evening	

- Pen-dosimeters should be charged the evening before the working day, in order to evaluate self-discharging. In case of using them several days, however, a daily charging is not necessary. If the indicated values do not exceed about 30% of the full scale reading.
- The user of the Pen-dosimeter has to enter the morning and evening readings into the report sheet and sign it at the end of the course.
- Pen-dosimeters and report form have to be returned to the instructor at the end of the course. The instructor will submit it to the radiation protection officer (RPO) responsible for the department. The PRO has to confirm the receipt on this report sheet.

Received by PRO	Signature by PRO	Signature of user

[1]. **Healthcare Training Center Erlanger, Germany, 2009**

[2]. Md. Anwar Hossain and Mohiuddin Ahmad, Biomedical Engineering Department, KUET, Khulna, Bangladesh 2011.

Annexure V
Leakage current of Medical imaging equipment

The origin of the misleading notion that medical equipment leakage current can be dangerous dates back to an article entitled "Hazards of Electrical Apparatus"1 by John M. R. Bruner in 1976. The author states that it is a limited review to consider the "ways in which line operated devices may cause ventricular fibrillation." He states at the beginning that the cases of electrocution from medical devices are not known and probably no meaningful estimates of incidents would become available. The review cites one "prophetic warning', three "believed to have occurred" , one from a soldering iron repairing an intracardiac pacemaker lead and a number of cases associated with catheters in use during cardiac catherization. In summary he states "Improved electrical safety requires use of three-conductor plug and cable. Isolation by added transformers or by battery-operated equipment plays a minor role.

In 1969, Carl Walter, a surgeon at Brigham Hospital in Boston stated that there are 1200 electrocutions in U.S. hospitals every year, but he gave no evidence of these events. A Time magazine comment on his statement was that hospital equipment at that time did not have a standard such as UL for household devices. In 1971 Ralph Nader quoted Dr Walter in a Ladies Home Journal article and increased the number to 5000 deaths, again, no evidence.

In 1972, Bruner2 reported that there were 2 incidents of ventricular fibrillation induced by leakage currents in a 42 month period at one hospital. Another study by Snider3 in which the current used to cause ventricular fibrillation prior to open heart surgery showed that only one in 40 cases required less than 180μA.

These articles led to the adaptation of standards to measure leakage current in medical devices and arrived at "unsafe" levels of current that medical devices must control by testing devices every six months. The supposedly unsafe levels were arbitrary however, and subsequently the levels have increased over time through consensus but still arbitrary. Along with the unsafe levels of current, there was another term introduced to further protect patients, that of the patient vicinity. This was an imaginary sphere with a 6 foot diameter centered on a patient. The rationale was that this is the maximum distance that a patient could reach with both arms extended and come in contact with devices which would have the patient as a conduit to leakage current between two devices or a device and ground. Since the only documented cases of patient harm are those with intracardiac leads who should only be found in catherization labs, cardiac surgery or intensive care units, this restriction has no basis. It seems illogical that someone can use a laptop computer at home but as soon as they enter a hospital, the laptop becomes dangerous.

Anexure VI
List of tools for Medical imaging equipment maintenance.

The most important tool is dose meters to measure the dose and the other tool is called panthom. It is used for callibration of X-ray, CT Scan, angiogram other radiological equipments.

Socket Set - 1/4" Drive

- 1/4" - 1/2" Standard Depth (6 Point)
- 1/4" - 1/2" Deep (6 Point)
- 6mm - 12mm Shallow (6 Point)
- 6mm - 12mm Deep (6 Point)
- Ratchet
- Extension - 3", 6"
- Flex/Universal Joint

Socket Set - 3/8" Drive

- 5/16" - 3/4" Standard Depth (6 Point)
- 3/8" - 3/4" Deep (6 Point)
- 9mm - 19mm Standard Depth (6 Point)
- 9mm - 19mm Deep (6 Point)
- Ratchet
- Extension - 3",6",12",18"
- Universal Joint
- Fractional Universal Impact Socket Set 3/8" - 3/4"
- Metric Universal Impact Socket Set 9mm - 19mm

Socket Set - 1/2" Drive

- 7/16" - 1 1/8" Standard Depth (6 Point)
- 7/16" - 1 1/8" Deep (6 Point)
- 10mm - 25mm Standard Depth (6 Point)
- 10mm - 25mm Deep (6 Point)
- Ratchet
- Breaker Bar
- Extension 3",6",12"

Combination Wrenches

- 1/4" - 1" Standard
- 7mm - 24mm Metric

Tubing Wrenches

- 3/8" - 3/4"
- 10mm - 18mm

Hex (Allen) Wrenches

- 050" - 3/8" Fractional
- 2 mm - 7mm Metric

Screw Drivers

Torx Bits Tamper Proof (Screwdriver or Sockets)
T-8, T-10, T-20, T-25, T-27, T-30, T-40, T-50, T-55

Pliers

- Slip Joint 6"
- Needle Nose 6"
- Diagonal Cutter 7"
- Channel Locks 12" (water pump)
- Long Reach End Cutter (Channel Lock #748)
- Vise Grip Pliers 10" (10WR)

Snap/Retaining Ring Pliers

- Internal Retaining Ring Pliers
- External Retaining Ring Pliers
- Snap Ring Pliers (Snap-On SRP2 style)

Files with Handles

- Flat 10" Mill Bastard
- Round 8" - 10"
- Three Cornered

Hammers

- 16oz Ball Peen
- 16oz Soft Faced Dead Blow
- Hand Drilling 3 to 4 lb.

Punch and Chisel Set

- Center Punch
- Pin Punch - 1/8", 3/16", 1/4", 5/16"
- Taper Punch 3/8", 1/2", 5/8"
- Brass Punch - 3/4"
- Cape Chisel - 5/16"
- Cold Chisel - 3/8" - 3/4"

Pry Bars

- Rolling Head 16"
- Straight 16"

Brake Service Tools

- Brake Spring Pliers
- Hold Down Tool

Safety Equipment

- Safety Glasses
- Hearing Protectors (recommend ear muff type)

Electrical Tools

- Digital Multi meter
- 12 volt test light or LED circuit Tester
- Remote Starter Switch
- Insulation piercing test probes

Small Tools

- Pocket Flash Light
- Pocket Knife
- "O" Ring Pic
- A/C, fuel line disconnect set
- Inspection Mirror
- Spark Plug Feeler Gauge (gap tool)
- Feeler Gauge (Blade type)
- Flexible Pick Up Tool (magnetic and claw type)
- Tape Measure 12"
- Hack Saw
- Tubing Cutter
- Gasket/Carbon Scraper (putty knife)
- Air Blow Gun (Meeting OSHA requirements)

Tool Box

- Roll Away with Key Lock

Special Tools

- Torque Wrench - 1/2" Drive (Snap-On Quality)
- Micrometer - 0-1" or dial caliper 0-6
- 3/8" Drive Air Ratchet
- 1/2" Drive Air Impact Wrench
- Socket Set - 1/2" Drive Impact 1/2" - 1"
- Crankshaft Pulley Puller
- Cylinder leakage tester
- Pry Bar Screwdriver style 30" or larger
- Hand Operated Vacuum Pump
- Compression Gauge
- Radiator Pressure Tester
- Feeler Gauge (Go-No-Go, blade type)
- Door Panel Removal Tool

Anexure VII
Regulated AC Power Supply for Medical Imaging Equipment

The load management is improper in Bangladesh. The fluctuation of voltage is very high and load shading is a regular phenomenon. MIE is very sensitive to voltage fluctuations. Accurate diagnostic result depends on regulated power supply. Most of the upazilla health complexes are running without substation. Moreover most of the substations are running in hospitals without power factor improvement (PFI) plants and as result power factor correction is not possible. Generally single-phase 220V~, 50Hz is used for MIE. But 3-phase, 50Hz is used for sophisticated medical imaging equipment. But both of the systems are providing unregulated voltage and which is damaging costly electronic board of MIE and interrupting diagnosis result of patient. In these circumstances, sophisticated Automatic Voltage Stabilizer (AVS) is recommended to insert in technical specification with machine. On the other hand UPS with built in stabilizer is important for image processing Equipment.

My publications

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[2]. **Md. Anwar Hossain**, Mohiuddin Ahmad, Md. Rafiqul Islam, and M. A. Rashid "Improvement of Medical Imaging Equipment Management System in Public Hospitals of Bangladesh", *Proceedings of the Int'l Conference on Biomedical Engineering* (*ICoBE 2012*), Penang, Malaysia, February 2012.

[3] **Md. Anwar Hossain** and Mohiuddin Ahmad, "Improvement of In-service Education and Training on Medical Imaging Equipment of Bangladesh", *Proc. of the Int'l Conference Informatics, Electronics & Vision*, (*ICIEV12*), May 2012, pp-22 paper ID -144, Dhaka, Bangladesh.

[4]. **Md. Anwar Hossain**, Engr. Babul Mia, Dr. Mohiuddin Ahmad, Dr. Hamayan Kabir and Engr. Nazrul Islam, "Develop training guide book: 3 days training on proper use and preventive maintenance of medical equipment for SN, MT of DGHS", January 2012, Book procedinings of 2nd phase national training ,PP-3, Serial no. 29, Dhaka, Bangladesh.

[5] **Md. Anwar Hossain**, A. B. M. Siddique, "Improvement of medical imaging equipment inventory and documention system in public hospitals of Bangladesh", First Forum of Asian Clinical Enginering (FFACE 2012), pp-49 April ,2012, Osaka, Japan.

[6]. **Md. Anwar Hossain** and Mohiuddin Ahmad, "Improvement of Medical Imaging Equipment Inventory and Documentation System in Public Hospitals of Bangladesh, Proceedings of the ICNIT12, Korea,(Accpeted).