ASSESSMENT OF MEDICAL EQUIPMENT UTILIZATION AND ASSOCIATED FACTORS IN HOSPITALS OF TIGRAY REGION, NORTHERN ETHIOPIA

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A THESIS SUBMITTED TO SCHOOL OF PHARMACY, FACULTY OF HEALTH SCIENCES, INSTITUTE OF HEALTH, JIMMA UNIVERSITY: IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR MASTER'S DEGREE IN PHARMACEUTICAL SUPPLY CHAINS MANAGEMENT

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SCHOOL OF PHARMACY

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Abstract

Background: Provision of medical equipment plays a very significant role in the health care delivery system. All over the world, particularly developing countries have difficulty of managing the delivery of health care under limited resource conditions, as medical equipments are very expensive. Like all developing countries in Ethiopia, lack of proper utilization of medical equipment has limited the capacity of health facilities to provide adequate health care. The main objective of this study was therefore to assess the utilization of medical equipment and to identify the reasons that affect the use of medical equipment in hospitals of Tigray region, northern Ethiopia.

Objective: This study was conducted to assess the utilization of medical equipment and the contributing factors in selected hospitals of Tigray regional state, northern part of Ethiopia.

Methods and material: -Health facility based descriptive cross-sectional study and multi case study designs were employed for quantitative and qualitative methods respectively to assess the utilization of medical equipment in selected hospitals of Tigray regional state from March 1, 2019 to April30, 2019. Descriptive analysis was used to summarize the data. Logistic regression analysis and chi-square tests were used to identify factors associated with medical equipment utilization. For the analysis of qualitative data, the interviews were audio-recorded, transcribed verbatim and thematically analyzed.

Results: Six selected public hospitals were included. This study showed that 60.2 % of the medical equipment was currently in use. The significant associated factors for the medical equipment utilization were the condition of medical equipment during the delivered time (adjusted odds ratio (AOR):3.87, 95% CI:1.406–10.645), lack of local expert to operate and maintain (AOR: 2., 95%CI: 1.358–3.248), facility infrastructure power supply associate problem (AOR:0.599, 95%CI: 0.366–0.979), lack of regular and responsible monitoring to the equipment (AOR: 0.599, 95%CI: 0.366–0.979).

Conclusion and Recommendations: About 40% of the medical equipment were found out of service. The significant factors affecting the utilization the medical equipment were the absence of skilled professionals, condition of the medical equipment during the delivery time, power supply associated problems, and lack of regular monitoring of the medical equipment.

Hence, all concerned stakeholders including the medical equipment management of the hospital, pharmaceutical supply and fund agency, Regional Health bureau, and Minister of Health should work together to make better use of the medical equipment through enhancing the medical equipment procurement and donation policy procedures, strengthen facility infrastructure, training local experts, and providing regular and responsible monitoring.

Keywords: equipment, medical equipment, utilization, Tigray regional state.

Acknowledgement

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Last but not least, my thanks goes to those studied hospital management staffs, respondents, bio-medical work departments who managed their time to provide me essential and detail information about the medical equipment, and I also thank the supervisors, respondents, data collectors gathered and verified the information**.**

Table of contents

List of figures

List of tables

Abbreviation and Acronym

AIDS	Acquired Immune Deficiency Syndrome
EFY	Ethiopian Fiscal Year
ETB	Ethiopian Birr
HIV	Human Immune Deficiency Virus
HSDP	Health Sector Development Program me
IPM	Inspection and Preventive Maintenance
MEC	Medical Equipment Committee
MEMU	Medical Equipment Management Unit
MoH	Ministry of Health
PFSA	pharmaceutical Fund and Supply Agency
PM	Preventive Maintenance
WHO	World Health Organization

1. Chapter One: Introduction

1.1. Background

Health is one of the basic rights for human beings. So, according to the WHO framework for health systems, a well-functioning health system ensures equitable access to and sound scientific use of essential medical products, vaccines, and technologies of assured quality, safety, efficacy, and cost-effectiveness. Supported by the health infrastructure, which is the fundamental feature includes the availability of health facilities and medical equipment, roads for transportation, access to water, electric, and network/ telecommunication supplies, and computers for medical recording[1, 2].

Medical technologies are an important component of medical care, provide significant benefits to patients, advance the identification and treatment of disease, more comfortable treatment and reduce pain, offer new treatment options for ill individuals existed, provides a safer for both patients and providers. Medical technology includes all hospital equipments used for the diagnosis, therapy, monitoring, rehabilitation, and care. The effective medical technology management is required for efficient utilization of equipments to ensure continued highn quality patient care[1, 3].

Medical device as which are part of medical techinology, any instrument, appliance, material, or other articles, whether used alone or in combination including the software necessary for the purpose of diagnosis, prevention, monitoring, treatment, or alleviation of the disease; alleviation or compensation for an injury or handicap; Investigation, replacement, or modification of the anatomy or of a physiological process; Control of conception and which does not achieve its principal intended action in or on the human body by pharmacological, immunological, or metabolic means but which may be assisted in its function by such means[4].

Medical equipment is part of medical devices requiring calibration, maintenance, repair, user training, and decommissioning activities usually managed by clinical engineers. Medical equipment is used for the specific purposes of diagnosis and treatment of diseases or rehabilitation following disease or injury; it can be used either alone or in combination with any accessory, consumables, or the other piece of equipment. Medical equipment excludes implantable, disposable or single use medical devices [5, 6].

Essential equipment can be defined as that which supports the health care needs of the majority of the population. Be available and functional at all times in adequate quantity and quality, in technically sound condition and at a medically acceptable standard for health care facilities [7].

Quality of diagnostic and treatment care provided to patients largely depends on the availability of sophisticated medical equipment. Regular equipment maintenance helps in providing quality care and maintaining utilization coefficient of the medical equipment.Equipment utilization is the evaluation of medical equipment necessity, appropriateness, and efficiency of the use in diagnosing and treating a patient[8].

Required equipment may range from sophisticated life-support equipment in a tertiary hospital setting to simple equipment needed for effective diagnosis and safe treatment of patients in a primary health care setting[9]. However, the basic requirements are the same across all settings: clear policies, technical guidance, and practical tools for effective and efficient management of health care technology [10]**.**

Identification of appropriate equipment, and its acquisition and utilization, require massive investment, and related decisions must be made carefully. To ensure the best match between the supply of technology and health system needs, the appropriate balance between capital and recurrent costs, and the capacity to manage throughout its life must be maintained[11]. The medical equipment acquisition has been done without prior assessment of health needs, or of local capacity for equipment repair and maintenance or of budgetary support to these services. As a result, most of the equipment is nonfunctional and health services have been compromised due to insufficient equipment maintenance. Promotion activities of equipment manufacturers have created demands far greater than actual needs. Since over 40% of the total health budget in most developing countries is spent on health technologies the result has been an increase in the cost of health care or reduction in funds available for other services[7, 12].

Today's medical environment is highly dependent on various types of medical equipment to complete the diagnosis and treatment for patients with care. These medical equipment must be kept in good condition to prevent from injuries occurred in patients as well as in users. Moreover, to face the tough competition environment and complex health care system, the hospital should take the appropriate cost controls in response to that situation. The clinical engineering department in the hospital is responsible for the patient and clinical staff safety

in using medical devices. Besides, the cost control in related operational activities of medical equipment (such as purchase, contract, repair, and maintenance) is another important job for this department. For these goals, CED is responsible for purchase assessment, safety installation, warranty assurance, correcting repair, contrast monitoring, preventive maintenance, and identifying discard to provide safe, effective, and economical services and equipment that are necessary for patient care research and community service. To promote the operating performance, it is needed with a systematic managing strategy[13, 14].

The absence of planned preventive maintenance program, breakdowns requiring extensive and expensive repairs cost**.** The chronic lack of functioning medical equipment is generally regarded as an importantcontributor to the poor quality of health care delivery in those countries.This particular problem of poor medical equipment performance is a special case of a more general issue, which is the widely varying effectiveness in using imported equipment and technical systems in developing countries [15].

According to the 2007 census projection, the region has a total population of 5,055,999 in 2007 EFY. Public health care services are delivered through 15 hospitals, 218,health centers and 668 health posts[2]. In Ethiopia ofcourse the number of hospitals varies from region to region in response, partly, to differences in population size. However,when ranked in terms of the hospital-population ratio, Tigray's population-hospital ratio is much lower than all of the other predominantly rural regions of Ethiopia[16].

In Ethiopia in the last decades there was different health reform programs and massive health institution expansion throughout the country as well as the demand of advanced medical equipment were increased. While that the utilization the medical equipment either improved or decreased is not clearly recognized all over the country, especially in the regional public hospitals the status of the equipment is not known. Assessment conducted by the federal Ministry of Health shown that functional medical equipment in the Regional Hospitals was near to 50%.

Based the above reasons this study was conducted in tigray Refional State to determine the current condions of medical equipment utilization, medical equipment management system, and the major influncial factors to afefect the utilization of the medical equipment problems related to madical equipment accusation, sparparts,accessaries, professional experts, equipment monitoring, consumables, instalation, as well as facility related factors that affects the medical equipment utilization was identified in the selected Public Hospitals of tigray Region and would be provided to the consernd body to give sustainable solution in the region as well as throught the country.

1.2. Statement of the problem

Provision medical equipment plays a very significant role in the health care delivery system. Essential medical products must be functional and available at all times at the appropriate level within the health care system to predict, prevent, diagnose and cure many illnesses, and to alleviate functioning problems using treatments and technologies. Despite the fact, medical equipment are indispensable for all aspects of healthcare, many appropriate technologies are inaccessible to the majority of people who need them, particularly in low and middle-income countries[8, 17].

Inventory reports were analyzed from 1986 to 2010, from hospitals in sixteen countries across four continents. The study examined 112,040 pieces of equipment. An average of 38.3% (across countries0.83–47%) in developing countries was out of service. Ethiopia was included in this study 39% equipment out of service. The three main causes were lack of training, health technology management, and infrastructure[15]. And 70% of medical equipment in sub-Saharan Africa is out of service. The Director General(WHO) stated at the Medical Device Meeting 2010 ‘‘about 70% of the more complex medical devices do not function when they reach their destination.’’ [18].

Lack of working equipment has a devastating effect on healthcare in resource-poor settings. It is often said that most of the medical equipment in the developing world is broken with estimates ranging up to 96 % out of service. More than 50 % of the laboratory and medical equipment in resource-poor settings are not in service[19].

unfortunately, medical equipment designing for the developing world market presents unique challenges not seen elsewhere as world health organization estimates that 70% of medical equipment coming from the most developed nations does not work in developing hospitals. over 95% medical equipment in public hospitals are imported with very poor quality and is not working after 5yaers. 39% donated never worked due to lack of training, manuals or accessories[20, 21].

In many hospitals most costly medical equipments are lying idle or functionless, which are either never installed or out of order for want maintenance, spate part or luck of availability of medical technologists, lack of consumables, due to a lack of proper user manuals and tools, lack of clarity in specification development and communication, sometimes medical equipment must be available distilled, deionized water[22, 23].

Based on the WHO report biomedical engineers estimate that from 70% to 90%medical equipment not in use in the developing world. This is almost due to lack of the experts needed to maintain biomedical equipment and sometimes even the capacity to use it effectively more over equipment is often donated without user or maintains manual [24]. And Study conducted in Papua New Guinean hospital it estimates that up to 70% of equipment in sub-Saharan African gather dust in some reason that at least half of all medical equipment in the developing world is unusable and the researcher add that donation is a well-established method for doors to dispose of old equipment's while on the recipient's side donation have strong appeal as ready solution to gap in service. Unfortunately, they can be a poor substituent for the appropriate technology and genuinely sustainable development so badly needed in the developing world[18, 25].

Currently, many donations consist of disposed old or unneeded equipment that recipients generally welcome to fill the gaps in their health facilities even if the supplies are not beneficial. Although the majority of donations are given with honest intentions to strengthen the hospitals donors often overlook the deficiencies of infrastructure, such as stable electricity and purified water of the receiving facilities[15, 26].

Medical equipment should be maintained at a higher safety level than other types of equipment. Most of sophisticated and complicated machines found in the intensive care unit, have their electrical connection existing between the equipment and patient. The equipment may be used on the patients who are not able to respond to hazardous conditions or pain while other types of medical equipment function as life support and their failure may result in the patient's death when the machine is in use[27].

Public hospitals hold a vast array of medical equipment ranging from small inexpensive items costing less than $100 to expensive complex items costing several million dollars. At 30 June 2002, the book value of medical equipment held by Victoria's 91 public hospitals, was approximately $507 million. This represents 13 per cent of the non-current assets of all public hospitals[28].

The report of Health Sector Development Program me (HSDP) performance in 2006E.C, the Pharmaceutical Fund and Supply Agency(PFSA) has distributed pharmaceuticals and medical equipment worth ETB 9.19 billion. This can help us to approximate the cost of medical equipment per year and show very huge figure for country like Ethiopia [29].

In Ethiopia, lack of proper management of medical equipment has limited the capacity of health institutions to deliver adequate health care. It is estimated that only 72% of medical equipment found in Addis Ababa public hospitals are functional and in some hospitals in the regions functional equipment are near to 50%[30].

The increasing number of these non-functional medical equipments are due to Poor equipment handling and utilization, frequent power surges, the age of the equipment, lack of operator training, lack of preventive maintenance, lack of spare parts, lack of maintenance capacity, and minimal knowledge regarding sophisticated equipment[30].

Therefore, this study was conducted to determine the utilization of the medical equipment and to identify the contributing factors to affect utilization of the medical equipment in the selected hospitals of Tigray region.

1.3. Significance of the Study

As explained earlier in developing countries over 95% of medical equipment in public hospitals is imported. There is no essentially local production of medical equipment.
Hence, Ethiopia is one of the developing countries and affected by the lack of functional medical equipment and has a devastating effect on health care.

This study aimed to explore the major causes of non-functional medical equipment related to the status of the medical equipment during delivering to the organizations, source of medical equipment, installation, maintenance, accessories, regular monitoring, supply of consumables, spare part, facility infrastructure, skilled human resource, medical equipment management's and to suggested appropriate measures for improving the utilization in the selected governmental hospitals in Tigray regional state, northern Ethiopia. In addition, this study will serve as a blueprint for policymakers, health regulatory authorities, health facilities, MoH to develop national health technology policy, procuring agency and public procurement stakeholders, regional health bureau, and academic to further exploration of this issue.

2. Chapter two: Literature review

Medical equipment forms the core of any health care institution for the diagnosis, therapy and surgery. Therefore, it is essential that medical equipment provide accurate information and operate to the optimum limit in order to allow proper diagnosis and ensure patient's safety during therapeutic and surgical interventions. On the other hand, in any health care institution medical equipment consume greatest capital investment. Hence, it goes without saying that health service provider ought to make the most out of these investments. This can be achieved only when these assets are used efficiently and effectively. Medical equipment management, in broader sense, is the right way to ensure patient's safety and obtain the maximum benefit out of these physical assets of a hospital[31].

The medical equipment sector is one crucial area where its practice would yield tremendous benefits contributing to the sustainable development goals of health and poverty alleviation. But it is difficult for many developing countries to access medical equipment necessary for healthcare. This impacts their capability to diagnose, prevent, monitor or treat diseases and injuries. This challenge is gruesome considering that majority of the world's population reside in developing countries where this acute shortage of functional medical equipment is experienced the most. Consequently, developing countries are characterized by high mortality rates over conditions that could be treated or monitored successfully if the necessary resources and technologies such as were available[32].

Relation to poor management of medical equipment indicates that purchase of sophisticated technologically equipment for countries which is not used due to lack of skills of operating accounts for 20-40% of the equipment cost. Short life of equipment due to maltreatment by operating and maintenance staff costs 30-80% of life time of the equipment, lack of standardization result in 30-50% extra spare parts cost and down time due to inability to use or repair costs 25-35% cost of the equipment[31].

Inventory reports were analyzed from 1986 to 2010, from hospitals in sixteen countries across four continents. This study examined 112,040 pieces of equipment. An average of 38.3% (42,925, range across countries 0.83–47%) in developing countries was out of service. The reason they found that the state of the equipment was dependent on factors beyond the equipment itself in three major

categories: infrastructure and resources, health technology management (HTM), and training[33, 34].

Health technology management problems were also common. Regardless of fault, users sometimes failed to report equipment problems to technicians or administrators. Regular preventative maintenance schedules were rarely followed leading to early breakdown and escalation of problems. In most systems, administrators or donors were left making procurement decisions without technical advice. Adding to the systemic burden of non-functional equipment is the fact that many hospitals reported no system for disposal of irreparable or outdated devices[33-35].

Medical equipments are currently one of the most expensive items in the national budget of both developed and developing countries. Almost 40–50% of costs in a tertiary hospital setup, the medical equipment through cutting edge at the time of purchase poses the threat of inevitable obsolescence within 6–7 years of installation. These high costs are determined by several factors; some of these are not obvious and are thus difficult to identify, but most come from the use of innovative technologies in a field where the competition is very poor and the added value is very high. In addition to the high cost of purchasing, the high cost of maintenance must also be considered, although this is not often taken into account in the initial budget[36, 37].

The World Health Organization (WHO) report biomedical engineer estimates that 50% to 80% of equipment remains non-functional and the most commonly cited reasons are, poor maintenance culture and lack of highly trained technicians. According to statistics on medical equipment failures from WHO about 80% of all medical equipment failure cases are caused by preventable factors and failures due to inadequate maintenance alone account for about 60% of all the medical equipment performance cases. In addition to this, failures due to inappropriate handling, environmental stress and wear-out account for about 20% of all the failure cases. There are several types of maintenance practices that are carried out on medical equipment. These include inspection, predictive maintenance, preventive maintenance, repair/corrective maintenance[38, 39].

As pointed earlier, a huge proportion of the existing stock of equipment in health facilities is not working. The health care literatures provide numerous examples of the poor performance of medical equipment in developing countries. It is estimated, for example, that in Brazil 20 to 40

percent of the $2 billion to $3 billion worth of public sector medical equipment is not functioning [40]. It has been estimated that 60 percent of the equipment in medical units in a typical third world country is not usable. It was indicated that the problem of poor operational performance of equipment is more evident in public sector health facilities and less severe in privately owned medical institutions[41, 42].

Several studies revealed that much of the medical equipment and laboratory in resource poor settings is out of service. The most commonly mentioned justifications are lack of spare parts and a lack of high level trained technicians. Even so, there is little data to encourages these hypotheses, or to generate evidence based solutions to the problem. As they studied 2,849 medical equipment repair requests of which 2,529 were out of service medical equipment from different 60 resource poor hospitals located in 11 nations in Africa, Asia, Europe, and Central America. So a total of 1,821 pieces of medical equipment were placed back into service by using only local material, or 72%, without requiring the use of imported spare parts. As a result, they found that six domains of knowledge were required to accomplish 99% of the repairs. These are electrical 18%, mechanical 18%, power supply 14%, plumbing 19%, motors 5%, and installation or user training 25%[43].

Some types of sophisticated medical equipment are designed by industrialized countries where the environment, disease patterns, trained users, and maintenance capabilities are different. When such equipment is used in developing countries, it may not actually give as many benefits as the promoters' claim. Rather, it may bring problems of operating costs, use and maintenance, not to mention the waste of capital expenditure[43].

Capacity building is frequently considered in the medical ranks, but it is also a problem with medical equipment. However, technicians are not the only ones who should understand their equipments. Users, administrators, and donors need a base level of knowledge. In many systems, users were not trained in the proper use or handling of equipment, leading to avoidable break downs. When technicians were available to attempt repairs or maintenance, there was often a gap between their knowledge and the level of technology. Unfortunately, technicians with even minimal training were reported to be rare. More than half of the technicians, and even maintenance department heads in some regions, were not formally trained biomedical technicians. Increased capacity must be coupled with increased repair infrastructure. One aspect of repair infrastructure

is the service and operator manuals, with at least 50% of each type not found in the surveyed health systems[33, 34]

Medical equipment procurement management is one of the vital elements that ensure equitable access of quality medical equipment. UNOPS defines procurement as "the acquisition of property, plant and/ or equipment, goods, works or services through purchase, hire, lease, rental or exchange" and is taken to include "all actions from planning and forecasting, identification of needs, sourcing and solicitation of offers, evaluation of offers, review and award of contracts, contracting and all phases of contract administration until delivery of the goods, the end of a contract, or the useful life of an asset." When procurement incorporation" [44].

Hospitals need to adopt a long-term approach (say 5 years) to planning for their medical equipment needs, including regular monitoring of equipment life expectancy and condition and developing strategies to address funding uncertainty and gaps where they exist. The uncertainty surrounding funding makes it all the more important for hospitals to have good asset management information and planning. All equipment should be appropriate to the setting of the hospitals, be of assured quality and safety, be affordable and cost-effective, be easily used and maintained, conform to existing policies, plans and guidelines. These selection criteria should then be used during the procurement process, when hospitals evaluate and decide between different offers from suppliers [28, 45].

Medical equipment can be procured in three ways: purchasing, receiving donation and hiring. In purchasing, the hospital buys the medical equipment using funds from government. In donation, the pieces of equipment are chosen and supplied free of charge by nongovernmental organizations, charities, individuals, and private businesses. This can range from gifts of small quantities of items to substantial equipment procurement projects. Leasing, renting, may be an alternative to outright purchase of equipment for or hiring those with limited budgets or cash flow problems [45].

The Ethiopian hospital reform implementation guide line (EHRIG) recommends all hospitals to prepare five years purchase plan with consideration of medical equipment development plan. medical equipment. It also indicates the considerations to be made during the procurement of medical equipment including appropriateness to the setting of the hospital, quality and safety, affordability and cost, and ease of utilization and maintenance[46].

Medical equipment has become an important component of modern health services. But the related management or maintenance is particularly weak in the developing. The growth in capabilities to manage, control and maintain medical equipment has lagged far behind the rate of deployment of equipment. In addition to the traditional operation management, the patient safety, operation performance in cost/efficient analysis, and risk evaluation and control are the important issues for using medical equipment in hospital[47, 48].

Effective equipment management and decision-making requires a comprehensive assessment of the relative costs of continued maintenance versus replacement. However, the decisions of hospitals were based on inadequate information and poor analysis of relative costs, the age and condition of equipment, utilization levels, expected future service provision and benefits from new technologies. None of the 19 hospitals had established proper asset management planning processes to identify their equipment needs, including funding requirements, beyond a 12-month period nor had they developed strategies to address funding gaps. Only one hospital was developing an asset management plan at the time of the audit[28].

African countries have been dependent on donations of devices and supplies for several decades. While this dependency persists, many African countries have made significant progress in HTM in the past 20-30 years. Most HTM initiatives started with external investments and assistance but signs of self-sustaining efforts are clearly visible. For example, HT policy has been established in Ethiopia[49].

Medical equipment must be kept in good condition to prevent from injuries occurred in patient as well as in users. Moreover, to compete with the dynamic environment and complex health care system, health institutions should take the appropriate controls and monitors in response to that situation. Hospitals are responsible for ensuring the condition of their medical equipment is adequate and in particular that it can be used safely and effectively. This requires maintaining equipment in a condition that enables it to perform the functions for which it is intended, and complies with the relevant health and safety standards. Information about the condition of medical equipment is critical for informing decisions on modification, refurbishment, finding an alternative use for, or disposal of, such assets[50].

As medical equipment assets have to be replaced or upgraded at some point in time, it is important to identify the life expectancy of each item and monitor its physical condition. However, factors

other than age can influence the life expectancy of medical equipment (or extent of use beyond its projected life expectancy) including: utilization levels is the equipment used at full capacity**,** maintenance practices**,** has the equipment been maintained in accordance with generally accepted standards**,** technological change has the equipment become obsolete due to technological advances**,** availability of replacement parts are parts available as and when required, and changes in clinical practices**,** are clinicians required to use the equipment in the normal course of treatment, and performance is monitored continually[28]**.**

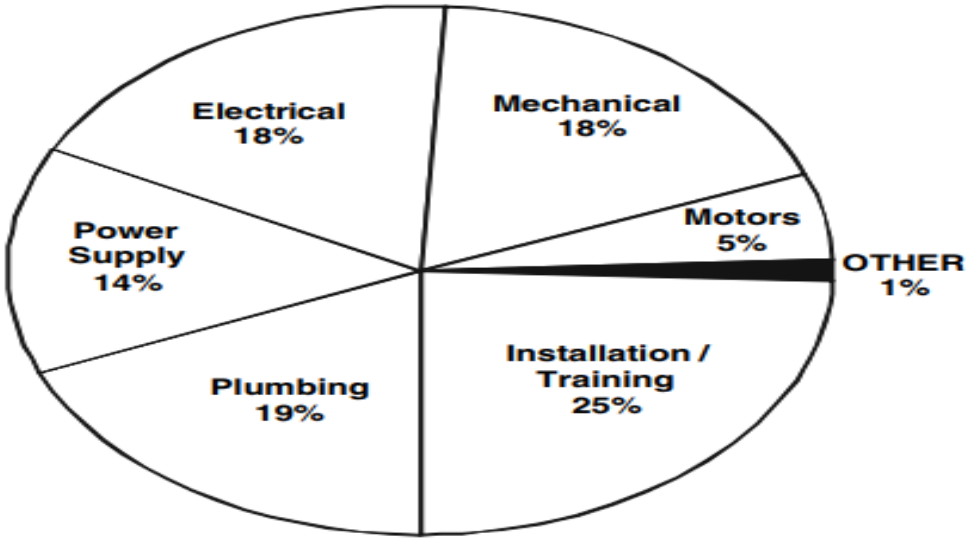

Fig. 1 The evidence presented here shows that six areas of knowledge were required to accomplish 99% of the repairs recorded here. Without the use of imported spare parts and without extraordinary financial resources or specialized tools, engineering volunteers were able to put 72% of the equipment back into service using these six domains of knowledge

Figure 1:Evidence based domain of knowledge for Equipment maintenance

[43].Medical equipment maintenance is a combined effort of all technical and administrative actions including supervision action, intended to retain an item in, or restore it to a state in which it can perform a required function. So, maintenance is an action or combination of actions carried out to retain equipment in or restore it to an acceptable condition[3].

2.1. conceptual framework.

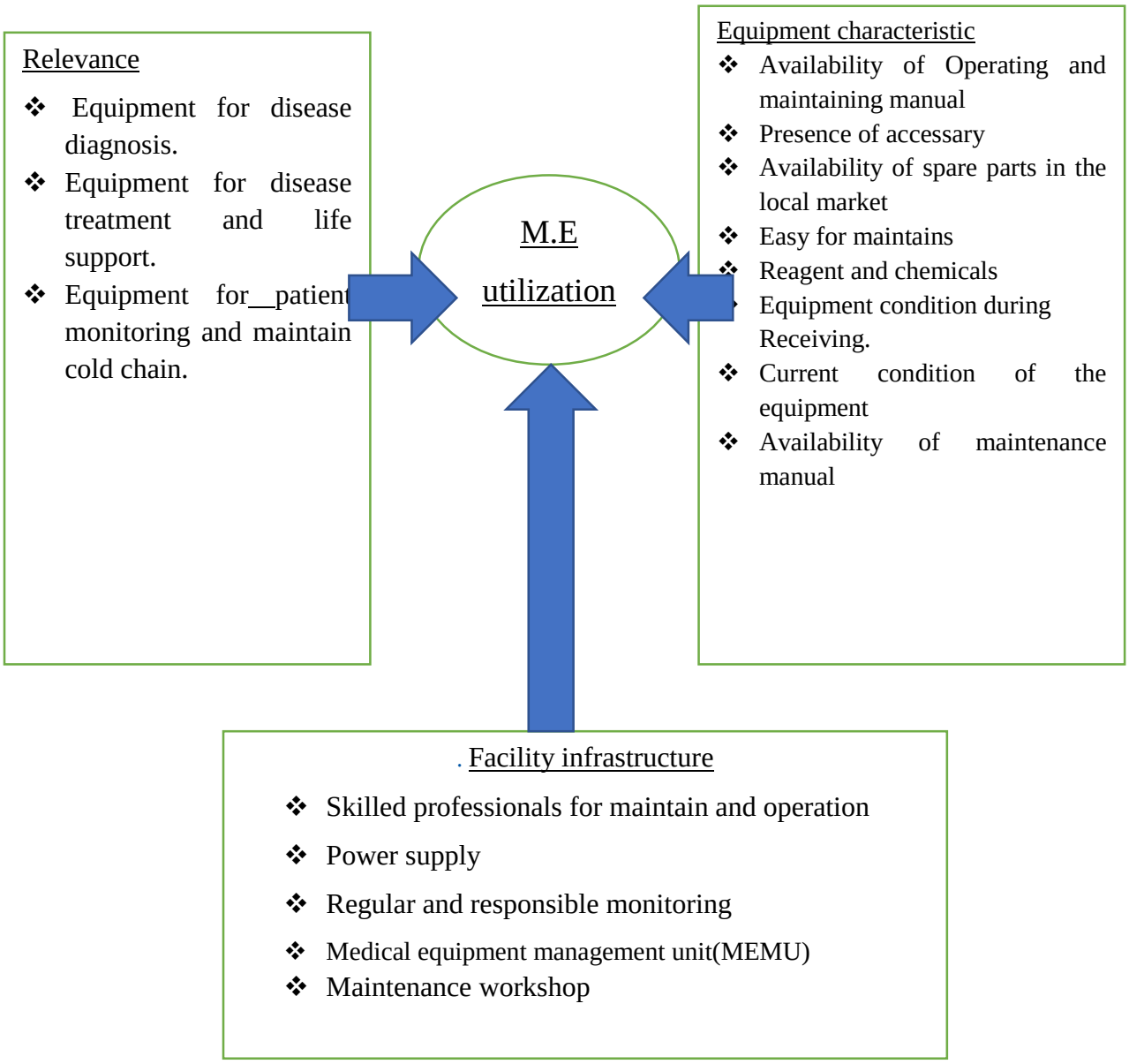

Figure 2:Conceptual framework for utilization of the medical equipment as well as the possible contributing factors that can affect was developed after literatures review.

[28, 30, 33-35, 37, 43, 51-54].

3. Chapter Three: Objectives of the Study

3.1. General Objective:

- To assess the overall utilization of the medical equipment and the contributing factors affecting its utilization.

3.2. Specific Objective

- To determine the current condition of medical equipment
- To identify the factors affecting the utilization of the medical equipment.
- To identify the relevance of the medical equipment related to health facility level infrastructure.
- To identify the most common challenges of medical equipment utilization

4. Chapter four: Methods and Materials

4.1. Study Area and Period

The study was conducted in selected public hospitals of Tigray regional state, northern Ethiopia. Tigray regional state is located in the northern part of the country. The total area of the region is about 54,569.25 km² and according to the 2014 GC census projection, the total population of the region were 5,055,999 (49.2% male and 50.8% female). The regional state has six administrative zones and 52 woredas (districts). The regional state currently has 15 hospitals, 218 health centers, and 668 health posts [55, 56]**.** The study was conducted from March 1,2019 to May 30,2019.

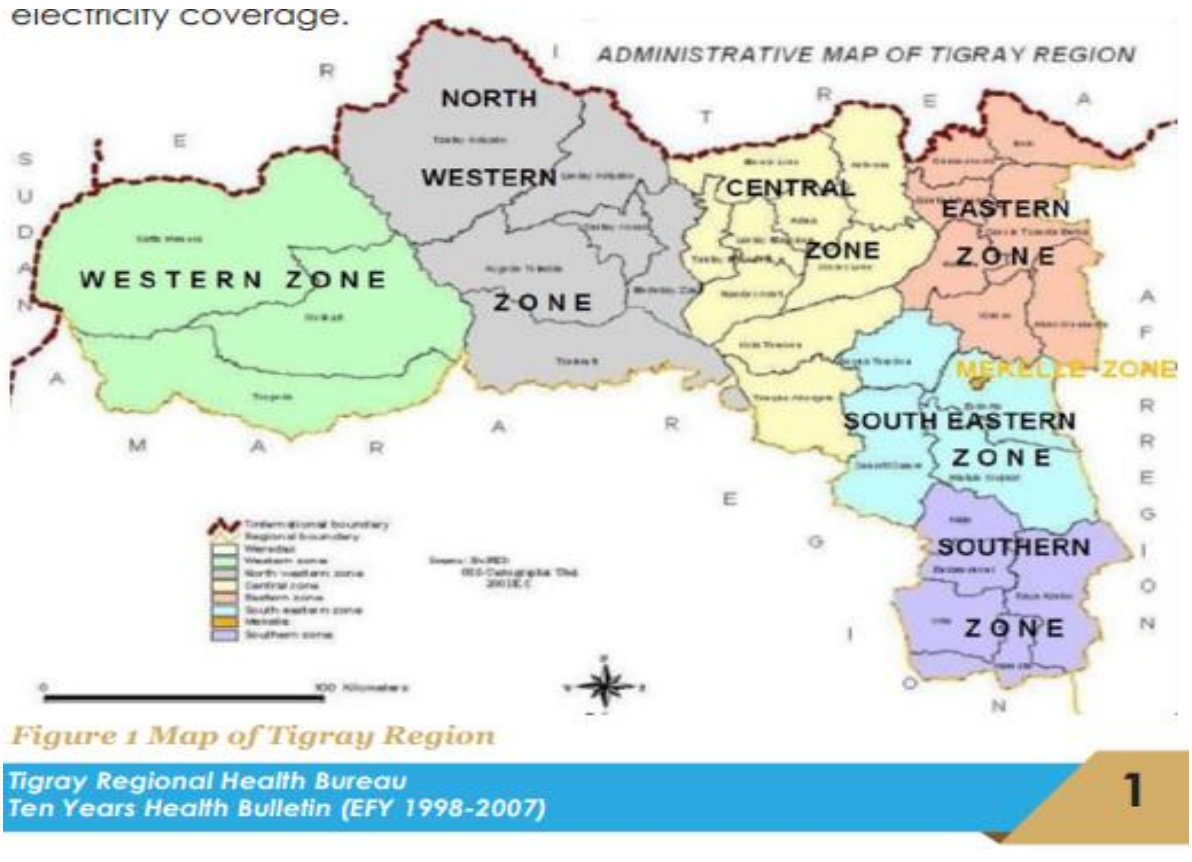

Figure 3:Tigray regional administrative Zones

4.2. Study Design

Institution based cross-sectional study was carried out to describe the utilization of the medical equipment, and the associated factors in the selected Public Hospitals of Tigray Region using quantitative, and triangulated with multiple case qualitative data.

4.3. Source Population

All various types and categories of medical equipment received by the Public Hospitals of Tigray Region.

4.4. Study Population

All types of medical equipment received by the Public Hospitals from any source for the last five years that fulfill inclusion criteria. Health professionals involved in the operation, handling, and maintaining of these medicals equipment were included-in the study population consisting of CEOs, medical directors, medical technologists, biomedical technicians, laboratory attendants, and procurement officials.

4.5. Inclusion Criteria

All medical equipment received by the selected hospitals in the last five years between 2015 and 2019 meets the definition of medical equipment were included.

4.6. Sample Size determination and Sampling technique/sampling procedure

4.6.1. Facility Sample Size Determination

The sample for health facilities was calculated by using the USAID | DELIVER PROJECT, Task Order 1. 2008. Logistics Indicators Assessment Tool (LIAT)**.** Arlington, Va.: USAID | DELIVER PROJECT, Task Order 1.

This document suggests a minimum of 15% of the total health facilities are enough in case of resource constraints**.** Otherwise, it suggested using a standard sampling formula for a statistically significant sample which often yields a large sample size. Accordingly, 40% of the health facility = 0.4X15=6 Hospitals were used for this study.

4.6.2. Facility Sampling Technique

Currently, there are 15 hospitals in Tigray regional state. Those fifteen hospitals were clustered into six administrative zones which are western zone Tigray, northwest zone Tigray, central zone Tigray, eastern zone Tigray, Mekelle zone and southern zone Tigray. Then by using two-stage cluster sampling technique, six hospitals were selected randomly with the assumption clustering.

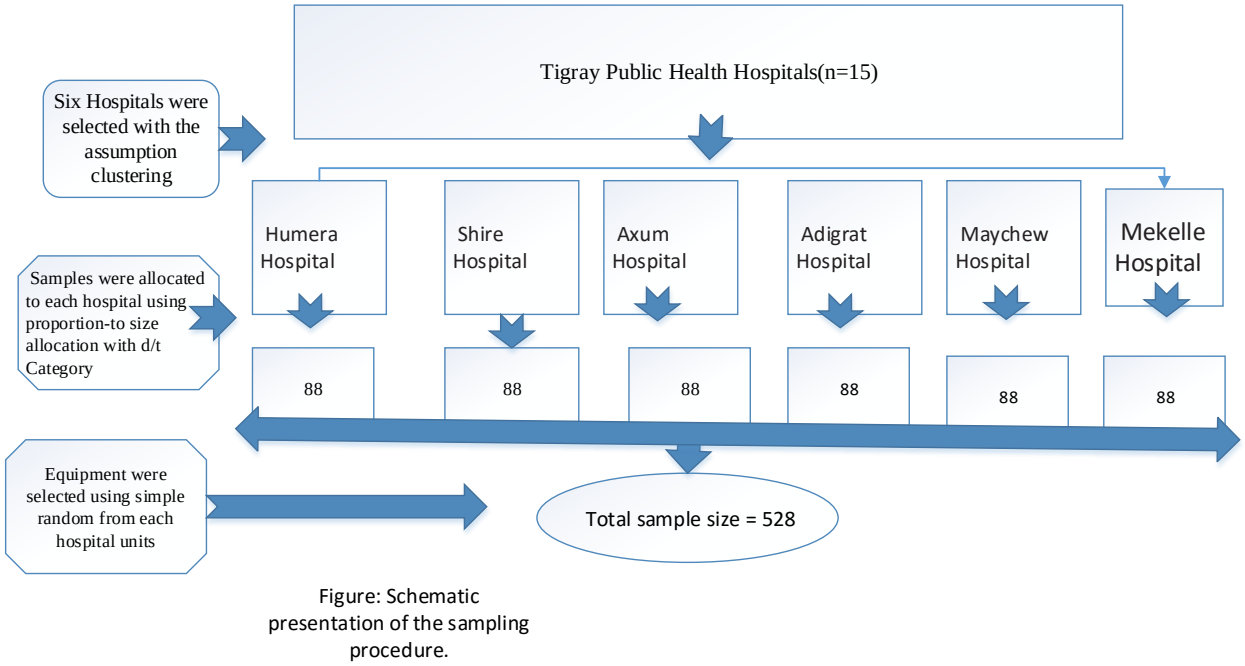

Figure: Schematic presentation of the sampling procedure.

Figure 4:Schematic presentation of the sampling procedure.

4.6.3. Equipment Sample Size Determination

The sample size was calculated using proportion sample size estimating formula.

$$\boldsymbol{n} = \frac{\boldsymbol{p(1-p)z^{\alpha}/_2}^{\ 2}}{\boldsymbol{d^2}} = 384,\ d=0.05,\ p=0.5,\ z\alpha/2=1.96$$

Where n = Sample size, P= Proportional of the medical equipment utilization, Z=Confidence interval, d= Margin of error to be tolerated.

A contingency of 10% was added for incomplete data(384X.01=38.4) giving 422 samples. To reduce the assumed high variability that may be introduced due to the nature of the cluster sampling techniques, a design effect of 1.25 was used to adjust the sample size. Therefore, a total of 528(422X1.25=527.5≈ 528) medical equipment was include in the study.

4.6.4. Equipment Sampling Technique and key informants.

Based on the above techniques, two-stage cluster sampling was used to select study samples. Each region considered as a cluster, then after, six hospitals were selected out of fifteen by using a random sampling method. Afterward, the specific sample size (528) was allocated to each hospital by using the equal allocation technique which was 88 (528/6=88).Then within every selected hospital a complete enumeration list of medical equipment was prepared from various records of the departments, sections including purchase file, donation file, different vouchers, inventory registers, logbooks and service records of individual medical equipment received for the last five years to develop a complete listed sampling frame. This complete enumerate list of medical equipment was used as a sampling frame of the medical equipment in every hospital, functioned as a sampling for random sampling by type. Later, the allocated sample size (88) was allocated to each equipment category by using the probability proportional to size **(PPS)** allocation technique. Then, from each category, medical equipment was selected using a simple random sampling technique. (annex I).

proportional allocation technique inside the facility

Let $N_s = N_1 + N + 2... + N_6$

Ns= The total estimated sample.

N1 = Allocated sample for facility1, N2 = Allocated sample for facility2 .... N6

And

$$n = n_1 + n + 2.... + n_k$$

Then the sub sample n_1 will be selected from sub group N_1 Can be computed

By: $n_i = \frac{n*N1}{N}$;

n_i = total number item, N = total each facility population,

n = number of, N_1 = total number each item.

Where i = 1, 2, 3....k

For the qualitative information of in-depth interview, six key informants were selected used triangulated sampling technique according to their positioned and provided riche information's in the hospitals such as biomedical engineering departments, Hospital CEO, pharmacy department, procurement department, and other departments were involved.

4.7. Data Collection Tools

The data were collected using an observation checklist and semi-structured questionnaire to guide in-depth interview which adapted from WHO guideline's, and developed by reviewing different relevant literature and questionnaires used previously in similar studies[37, 57-59]. Pre-test was done in one hospital to review validity of the questionnaire, logical flow and time adjust for the interview. Accordingly, comments were incorporated from the key respondents, and time adjustment was made. The checklist included different indicators for independent and dependent variables in detail and for qualitative part guideline were adapted from WHO guideline and national guidelines.

4.7.1. Data Collection Procedure:

Data were collected using observation checklist and in-depth interview methods. Six biomedical technicians for data collection and three supervisors was assigned. Medical equipment were categorized according to their function. Subsequently, data were collected by face-to-face interview using a semi-structured questionnaire for medical equipment users. The key informants in-depth interview was conducted by the principal investigator. The key informants participants were hospital CEOs, biomedical engineering department directorates, laboratory department, pharmacy department, hospital procurement department directorate, radiology department, ophthalmology department head, intensive care unit (ICU) department head, and surgery department. About 50 minutes was given for each interview. Selection of the key informants rely on triangulated sampling methods for the reason that have rich information and direct relationship with using medical equipment.

4.7.2. Data Quality Management And Analysis Procedures

The collected data were checked for completeness and consistency, categorized, and coded before data entry for the quantitative data. The data were entered using Epidata entry client (v4.2). It was then exported to and analyzed using the Statistical Package for the Social Sciences (SPSS), version 23 software. Different frequency tables, charts, graphs and descriptive statistics summaries were used to describe the study variables and findings. The association between dependent and independent variables was determined using logistic regression and & chi-square tests. Variables with a P value of <0.05 was considered statistically significant. The interviews were audio-recorded, transcribed verbatim and thematically analyzed.

4.7.3. Data Quality Assurance

Training was given for the data collectors and supervisors for three days on the objectives of the study, data collection tools and procedures to ensure consistency of interview and data collection. The supervisor and investigator were carrying out close supervision of the data collection. Data were checked for its completeness by supervisor and investigator daily.

4.8. Study Variables

4.8.1. Dependent variables

- Utilization of the medical equipment

4.8.2.Independent variables for medical equipment utilization utility

- Type of medical equipment
- Availability of accessary to the medical equipment
- Availability of spare parts in the local market.
- Availability of consumable to the medical equipment.
- Availability of operational manual.
- Source of the medical equipment.
- Equipment condition during receiving
- Medical equipment maintenance workshop
- Availability of maintenance manual.
- Medical equipment year of received
- Medical equipment management unit

4.9. Ethical consideration

Ethical clearance was obtained from the institutional review board (IRB) of Jimma University. After obtaining ethical approval, written permission was obtained from Tigray regional health bureau (TRHB). All participants were informed about the purpose of the study and individual verbal informed consent was obtained. The information obtained from the respondents was identified by their code numbers and participants were informed about purpose of the study and requested to provide accurate & honest response.

4.10. Dissemination Plan

The finding of the study would be presented to Jimma university, Jimma University Research Publication Office, and submitted to Jimma University Library. In addition, based on the study finding, recommendations will be provided to Tigray Region Health Bureau, Ministry of health, and PSA (pharmaceutical fund and supply agency). Attempts will be made to publish on scientific journal and present the finding at scientific conferences.

4.11. Operational Definition

Medical device: apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose in the hospital. but not by means of pharmacological, immunological or metabolic means.

Utility: Those medicals equipment received by the Hospital is operationalized for its purpose of received in terms of the purpose it is intended.

Relevance: Those received medical equipment help for the organization in terms of disease diagnosis, treatment, patient monitoring and maintain cold chain.

Safety testing: A series of procedures undertaken to establish that equipment is in a condition which is safe for the operator and patient.

Calibration: The comparison of the readings of a piece of equipment with those of a standard, followed by any adjustments required to ensure the equipment's performance meets the standard.
Corrective maintenance: restore the physical integrity, safety and/or performance of the equipment after a failure.

Inspection and preventive maintenance (IPM): scheduled activity necessary to ensure a piece of medical equipment is functioning correctly and is well maintained in the hospital.

Preventive maintenance (PM): maintenance performed to extend the life of the equipment and prevent failure in the hospital.

Spare parts: For equipment, items which make up the machine, need replacing as they wear out, and may be specific to a particular model (e.g. bearings, bulbs, printed circuit boards) in the hospitals.

Consumables: For equipment, those items which are used up during the operation of equipment in the hospitals. (e.g. film, reagents, gel).

Accessory parts: a secondary, supplementary or subordinate function by accompanying as a subordinate; aiding in a secondary way; being additional; being connected as an incident or

subordinate to a principal; contributing or being contributory. Such as mains lead, patient cables, hand-pieces to be functional the equipment.

Decommission: Take out of service; dismantle and make safe; board. The process of condemning or writing off equipment and disposing of it.

Chemicals: Any basic substance that is used by the equipment in or produced by a reaction involving change s to atoms or molecules

Operating Manual: a book that gives you practical instructions on how to do something or how to use something, such as a machine: operating system, , precaution sterilization system, closed or open system, frequency of maintains for the equipment in the hospital.

Installation: The process of fixing equipment into place in the hospital; can range from building equipment into the of a room to simply plugging it into an electrical socket.

Lifetime: Lifespan. For equipment, the length of time of the equipment by proper maintenance that an item will work effectively, dependent on the type of the equipment and parts used in its manufacture.

Maintenance materials: items used up during the maintenance of equipment, and generally available from many sources (e.g. washers, oil, fuses, paint).

Medical equipment: any instrument that can be used diagnosis, life support, treatment of a disease in the inner or outer part of the human body. That can include variety of sections such as radiology, laboratory, surgery etc. in the hospitals**.**

Workshop equipment: Equipment used in a workshop, such as hand tools, bench tools or test instruments.

Standard: conventional level of quality attainment set by a recognized authority, used as a measure, norm, or model for all aspects of health services and healthcare technology.

Supplier: Someone who provides equipment, such as a manufacturer, manufacturer's representative, wholesaler, salesman.

Inventory: An inventory is a detailed itemized list of assets held by hospitals or institution.

End user: A person who apply/uses the medical equipment to patient for disease diagnosis, treatment and rehabilitation in the hospitals.

5. Chapter Five: Results

The study was carried out to identify the status of utilization of medical equipment and associated factors in selected hospitals of Tigray region. Six public hospitals namely Mychew hospital, Mekelle Hospital, Adigrat Hospital, Aksum hospital, Shire hospital, and Humera hospital were included. A total of 528 medical equipment were sampled from the equipment which were received during the last five years. Mixed methods study were used involving quantitative and qualitative methods, which comprise observation checklist and in-depth interview (6 key informants from each hospital) respectively.

5.1. General source of the medical equipment

The source of the medical equipments were through donation for264(50%) of the equipment whereas 229(43.4%) were purchased, and the sources of 35(6.6 %) of the medical equipment were unspecified.

Key informants were asked for their opinion and came across with the providers (e.g. PSA, Donors) regarding the issues of the medical equipment and the sources:

"...medical equipment is still in the push system, once arrived at the facilities no rejection procedures even, irrelevant and non-functional equipment. Especially the capital equipment all the functions are run centralized and equipment come with no clear sources and full information no operation manuals, accessories, spare parts etc... mainly donation sources....." (biomedical profs).

"...I don't think currently there is no medical equipment pre-import registration different equipment come directly to facilities through donors, individuals and with no source. so, sometimes those, equipments difficult to install to the having facility infrastructures and also to use with incomplete information...and also delivering obsoleted equipment is the common one practice we have different equipment... totally the accessories, consumables, spare parts out of the markets..." (biomedical profess).

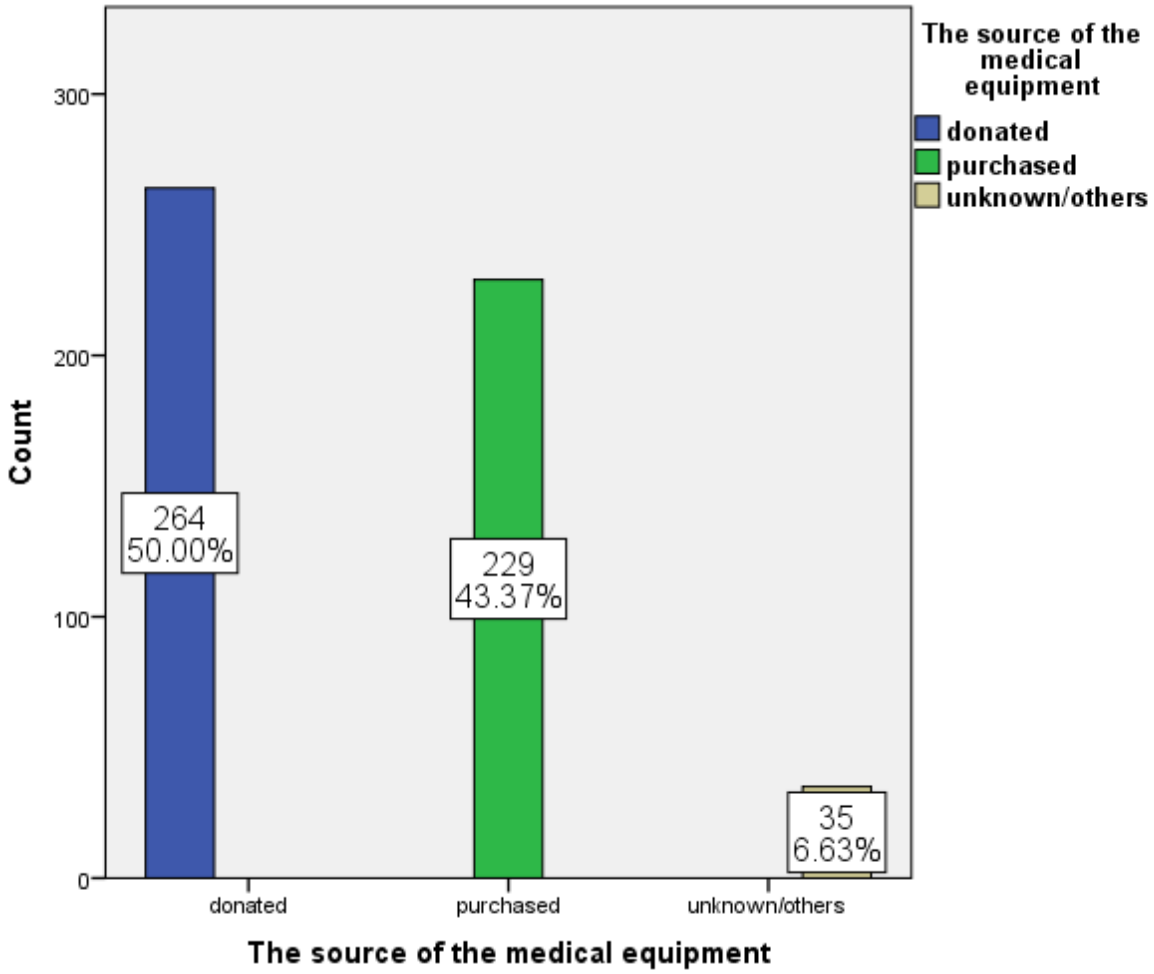

Figure 5:The General source of the Medical Equipment in the last five years in selected Public Hospitals of Tigray region.

5.2. Current status of the received medical equipment

Regarding the current general condition of the medical equipment, 318(**60.23**%) of the medical equipment were working and in use, 53(10.04) were not working and not in use or equipment were permanently damaged either before receiving or after arrival in the facilities, 68(12.88%) were working but not in use, 81(15.34%) were not working but can be repairable, and 8(1.52%) of the medical equipment status were unknown.

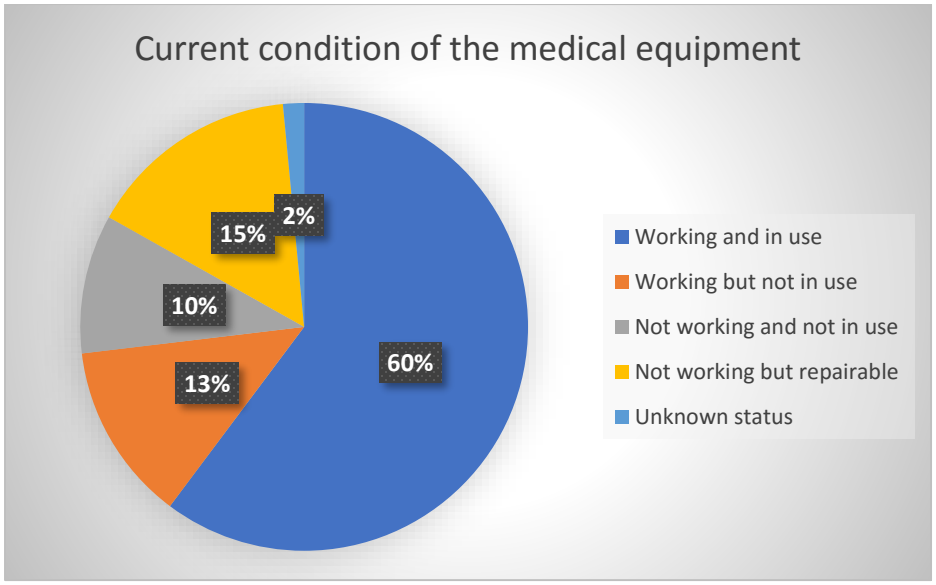

Figure 6:Current status of medical equipment in in selected hospitals of Tigray region, Ethiopia February-April, 2019.

5.3. Equipment type, Relevance and utility:

According to purpose of the medical equipment, 259(49.1%) were for diagnostic, 183(34.7%) were for treatment, and 86(16.2%) were for monitoring patients and maintain cold chain. Based on the this result all the medical equipment's were relevant to their intended purpose (Table.1). Regarding the utility, 318**(60.2%)** of the medical equipment were currently in use and **210(39.8%)** were not in utilization at the period of assessment.

5.4. Characteristic of the medical equipment:

5.4.1. Condition medical equipment during receiving time:

The status of medical equipment during receiving time to the hospitals were assessed and out of the total medical equipment, 390(73.9%) were new, 83(15.7%) were old, 28(5.3%) were refurbished, and 27(5.1%) of the medical equipment had unknown status. Regarding the presence of accessory during deliver time at the hospitals, only 128(24.9%) equipment were accompanied with accessory, whereas 386(75.10%) of the medical equipment had not accessory during supplied time. Out of 528 received medical equipment for the last five years, only 137(26.5%) had user's operation manual during the receiving time. The study showed that out of the sampled equipment only 59(11.6%) were possible to maintain easily by the local experts. Regarding the availability of restoring and maintenance manual, only 137(26.7%) medical equipments had manual (table 1).

5.4.2. Spare part availability in local market

Spare parts are the sensational components of medical equipment and most of the time they are a burden for the developing countries. According to the results of the study, 133(25.7%) of the medical equipment were available in the local market, whereas 384(74.3) of the medical equipment did not have spare parts that could be used in case breakdown or demands replacement. 5.5. Facility/receiver infrastructures:

5.5.1. Availability of local professional expert

Regarding the availability of local professional experts to maintain the equipment, there were no local expert for 345(67.3%) of medical equipments, whereas only168 (32.7%) equipment was able to be maintained by local expert.

5.5.2. Responsible and regular monitoring

Regarding the follow-up of the medical equipment condition through regular and responsible monitoring, 358(70.8%) of the medical equipment had regular monitoring, but 148(29.2) did not have regular monitoring and a responsible person to follow the status of the equipment.

Table 1:Summary of important characteristics that measures utility of medical equipment in selected Public hospitals of Tigray Region, Ethiopia, February –April 2019.

Variable	Category	Frequency (%)
Purpose of MEQ	Diagnostic	259(49.1)
	Treatment	183(34.7)
	Monitoring patients and maintain cold chain**.**	86(16.2)
Utility of the equipment	Yes (Utilized)	318(60.2)
	No(Not-in-Utilized)	210(39.8)
Medical equipment condition during receiving time	New	390(73.9)
	Old	83(15.7)
	Refurbished	28(5.3)
	Un its condition	27(5.1)
Availability of spare parts in local market	Yes	288(55.8)
	No	228(44.2)
Medical equip which have an accessary	Yes	257(69.1)
	No	160(39.1)
Availability of local expert for maintains and operation of equipment	Yes	168(32.7)
	No	345(67.3)
Operating manual availability	Yes	137(26.5)
	No	380(73.5)
Medical equipment restoring and maintenances manual along machine?	Yes	137(26.7)
	No	337(73.3)
Medical equipment easily maintainability by local expertise?	Yes	59(11..6)
	No	451(88.4)
Regular monitoring for the medical equipment ?	Ye	358(70.8)
	No	148(29.2)

5.6. Medical Equipment regarding the different source:

Concerning the current condition of the medical equipment regarding the different source of the equipment from 264(50%) donated sampled equipment, 162(61.4%) were working and in use, 30(11.4%) were functional but not in use, 28(10.6%) were not functional and not in use, 42(15.9%) were not functional but can repairable, and2(0. 8%) were unknown status. From the purchased source, 229 sampled equipment 136(59.4%) were working and in use,32(14%) were functional not in use, 24(10.5%) were not functional and not in use, 31(13.5%) were not working but repairable, and 6(2.6%) were unknown status (table 2).

Table 2:Current status of supplied medical equipment of the selected public hospital of Tigray corresponding different sources (February–April -2019)

Variables	Category	Frequency	% of working in use	% of functional but not in use	% of not functional not in use	% of not working but repairable	% of unknown status
General source of the medical equipment	Donated	264	162(61.4)	30(11.4)	28(10.6)	42(15.9)	2(0.8)
	Purchased	229	136(59.4)	32(14)	24(10.5)	31(13.5)	6(2.6)
	Unknown source/unspecified	35	20(57.10	6(17.1)	1(2.9)	8(22.9)	0

5.7. Predictors of medical equipment utilization in public hospitals of Tigray

Logistic regression was performed to assess the impact of a number of factors on medical equipment utilization. The final model contained thirteen independent variables. The full model containing all predictors was statistically significant as estimated by the Hosmer and Lemeshow test of model fit **[** Chi square (χ^2) =17.614, df=8, p= .024**]** with prediction capacity of 64.3%, and the overall predictive accuracy is 77.3%., indicating that the model was able to distinguish between variables that relate medical equipment utilization. Collinearity diagnostics was also conducted to test for multicollinearity to see whether the logistic regression assumption was fulfilled. The variance inflation factors (VIF) was between 1.040 and 2.775 and this is suggestive of no multicollinear variables.

Initially, a bivariate logistic regression analysis was performed to determine the association of each independent variable with the utilization of medical equipment. Subsequently, variables with a p-value <0.25 in the bivariate analysis were included in the multivariable logistic regression model to assess the predictive factors of medical equipment utilization.

The results of the multivariate logistic regression indicated that medical equipment which were refurbished (Adjusted odds ratio (AOR): 3**.**87**,** 95% confidence interval (CI): 1.41-10.65) and unknown status (AOR= 3.99, 95% CI: 1.44-11.08) during receiving time were more likely to become non-utilized compared new received medical equipment. Absence of regular monitoring of the medical equipment had almost seven times more to be nonfunctional/utilized (AOR: 6.71, 95% CI: 4.231–10.633) compare with the equipment having a regular equipment monitoring. Medical equipment which do not have power consumption problem were less likely to be nonfunctional/ (AOR: 0.599, 95% CI: 0.366– 0.979) compared to equipment having power consumption associated problem. Similarly, absence of local expert for maintaining and operation of the medical equipment were two times more likely to be non-utilized (AOR: 2.1, 95% CI: 1.358–3.248) compared to medical equipment having local expert to maintain and operate for the specific equipment (table 3).

Table 3:Factors contributing to utilization of the medical equipments in the public hospitals of Tigray region, 2019

Variables	Category	Utility of equipment		COR (95 CI)	P-value	AOR (95 CI)	P – value
		YES	NO				
Medical equipment condition during receiving time	New	257	133	1		1	
	Old	45	38	1.63(1.010–2.637)*	0.046	1.51(0.852–2.678)	0.158
	Refurbished	8	20	4.83(2.073–11.26)*	<0.001	3.87(1.406–10.645)**	0.009
	Unspecific status	8	19	4.59(1.957 10.761)*	<0.001	3.99(1.439–11.08)**	0.008
Regular monitoring of the medical equipment	Yes	268	90	1			
	No	42	106	7.52(4.890–11.551)*	<0.001	6.71(4.231–10.633)**	<0.001
Any power supplied problem associated with this equipment	Yes	72	66	1		1	
	No	240	137	0.623(0.420–0.924)*	<0.001	0.599(0.366–.979**	0.041
Availability of local expert for maintain and operation the E	Yes	220	101	1		1	
	No	94	103	2.39(1.656–3.440)*	<0.001	2.10(1.358–3.248)**	0.003
Have appropriate spacing in the org.	Yes	263	85	1		1	
	No	51	121	7.341(4.879–11.045)*	<0.001	.881(0.405–1.950)	0.749
All accessory during delivery time	Yes	243	114	1		1	
	No	70	90	2.741(1.868–4.022)*	<0.001	1.644(0.848–3.187)	0.141
Supplied based on the specification demand	Yes	74	29	1	.	1	
	No	234	167	1.821.(1.135–2.923)*	0.013	1.56(0.808–2.883)	0.92
Medical equipment users training	Yes	68	27	1		1	
	No	242	178	1.85(1.139–3.012)*	0.013	1.404(0.562–3.025)	0.386
Spare parts availability in local market	Yes	204	84	1		1	
	No	111	117	2.560(1.78–3.681)*	<0.001	0.845(0.446–1.66)	0.605
User operation manual	Yes	235	82	1		1	
	No	82	126	4.404(3.027–6.406)*	<0.001	1.554(0.476–2.223)	0239
Consumables, reagents and spare parts during delivery	Yes	75	66	1		1	
	No	240	134	0.634(0.428–.939)*	0.023	1.012(0.589–1.734)	0.967
Reparable and maintenance manual	Yes	205	90	1		1	
	No	107	109	2.230(1.61–3.339)*	<0.001	1.166(0.618–2.20)	0.636
Easily maintained by local expertise	Yes	46	16	1		1	
	No	266	182	1.967(1.08–3.582)*	0.027	1.644(0.649–4.164)	0.295

*Statistically significant at P<0.05 in the crude analysis *Statistically significant at P<0.05 after adjusting odd ratio***

Qualitative information to strengthen the quantitative part:

In the qualitative information, 36 in-depth interviews were conducted. Six key informants from each hospital were participated in the in-depth interview. The work experiences of the respondents ranged from 3 to 13 years. The participants in the qualitative study were biomedical engineering, biomedical technicians, CEO, medical directors, pharmacy department. radiology department, laboratory, head nurse and the users of medical equipment.

In-depth interviews were conducted focused to gather information about the current condition of the medical equipment, the major contributing factors that affects the utilization of the medical equipment, and suggestions for improving the utilization of the medical equipment in their facilities.

Several issues, reasons were raised and mentioned by the key informants as contributing factors for affecting the utilization of the medical equipment in their facilities. the current facility infrastructure regarding the medical equipment, major issues regarding the source of medical equipment, availability skilled man power to utilize/functionalize the existing medical equipment, presence of responsible and regular monitoring of the equipment, availability of policy and guidelines document regarding the medical equipment, management system of the medical equipment.

In the in-depth interview except two hospitals, none of the hospitals have biomedical engineer professional to manage the medical equipment and three of them established biomedical management unit with no adequate office, four hospitals have equipment mini workshop, and only two hospitals have established medical equipment management committee responsible to oversee the medical equipment activities in the hospitals as well as only hospital used equipment risk classification management. Most of the hospitals have one or two biomedical technicians, which are new graduates. In addition to the human resource, the availability of different resource required for the management of maintenance of medical equipment in the hospitals were assessed the hospitals in terms of availability of, reference materials, spare parts, accessory and the common challenges for utilization of the medical equipment.

Facility infrastructure regarding the medical equipment: Almost all key informants agreed that facility infrastructure is one of the problems in the utilization of the medical equipment. Most of the delivered medical equipment were not compatible with the existing infrastructures.

One respondent said that:

"*most of the time capital equipment they incurred additional costs, they are not easily compatible with our premises and facilities infrastructures... until restructured and installed they take long time even after restructure the building, to get and waiting installer is another challenges ...and long idle for the medical equipment.... up to two years and more...in the store.... our facilities are not established considered the modern medical equipment and the health technologies....*"

Key informants were asked for their opinion and came across with the providers (e.g. PSA, Donors) regarding the issues of the medical equipment and the source:
"...medical equipment is still in the push system, once arrived at the facilities no rejection procedures even, irrelevant and non-functional equipment. Especially the capital equipment all the functions are run centralized and equipment come with no clear sources and full information no operation manuals, accessories, spare parts etc... mainly donation sources....." (biomedical profess).

Another

"...I don't think currently there is no medical equipment pre-import registration different equipment come directly to facilities through donors, individuals and with no source. so, sometimes those, equipment difficult to install to the having facility infrastructures and also to use with incomplete information...and also delivering obsoleted equipment is the common one practice we have different equipment... totally the accessories, consumables, spare parts out of the markets..." (biomedical profess)

Key informants reflected that major sources of equipment were donated source as well as purchased source. Equipment sourced from both purchased and donation from non-governmental and governmental organizations including FMHACA, regional Health bureau, zonal and town

health office, ICAP Ethiopia, programs/projects like CD4 machine by HIV related programs, CDC, UNDP and Human Bridge and some medical equipment through individual charities and professionals, through virtual communication were supplied to these hospitals and this was common in all selected public hospitals of the Tigray region.

The existing medical equipment procurement process in Ethiopia had classified in to two categories, routine medical equipment and capital medical equipment. The routine medical equipment procurement was performed by the individual public hospitals, whereas, capital medical equipment was performed by centralized procurement process.

A statement made by one key informant demonstrated this fact:
"*...I don't think one factor could be contributing for utilization of the medical equipment in our facility; it is a result of various internal and external factors such as shortage of skilled professionals (biomedical engineers), even biomedical technicians; to maintain and monitor the equipment, spare parts, no chin of communication with PSA, no training, motivation even no structure to hire for bio medicals degrees, maintenance materials....*" (Biome).

Key informants on in-depth interview in four hospitals (Mekelle Hospital, Mychew hospital, Aksum hospital, and shire hospital) pointed out that there is a problem not only in the way of utilization but also in the type of equipment purchased, such as availability of spare parts and accessories and proper maintenance. All the key informants also reported that the equipment is purchased with bids that requested cheap price which in-turn affect the quality. This problem is mainly related with the system of purchasing/ procurement and the way bids were done. In procurement of some equipment, as four hospital key informant stated "If we need quality equipment, we have to pay more; the equipment bought with low price will be out of use immediately; for example, if we see digital pulse oximeter, after reading once, it will start to have false reading**.** The study identified the presence and process of different approaches of medical equipment procurement process. For instance, among the selected hospital CEO, four respondents said *"purchasing is not done based on the request and specification of each department. Procurement committee is not composed of different professionals including matron, auditors, CEO, and pharmacist. Due to centralized procurement process different equipment are procured out of specification demand and premises and also difficult for installation and takes time for a long time out of service."*

But two hospital CEOs, and biomedical professionals respondents revealed that "purchasing is done based on the request and specification of each department. Procurement committee is composed of different professionals including matron, auditors, CEO, and pharmacist. Different equipment are procured from clear bid announced by our hospital and the one with cheap price will win. Whatever the quality of the equipment the cheap one is preferred. Sometimes poor equipment quality may come."

As one bio medical technician and one CEO interviewee from these two hospitals stated "*there was CBC machine, but it takes more than a year to install by the company which should come from Addis Ababa by that time the reagent expired. Chemistry machine is available but the company did not come to install and we had not have skilled expert*."

Among the causes for non-functionality of the equipment's, the source of the medical equipment purchased were a common problem in all selected hospitals. The key informant revealed that "donated source of equipment are not donated based on the donation guideline, no operation manual, old and refurbished, no maintenance manual, absence of spare part, consumables, accessories in the local market, and lack of responsibility for installation. Pushing of obsoleted medical equipment is also a common problem as we do not reject pushed equipment during receiving time." *Another issues for the causes of non-functionality of the equipment were purchasing of nonstandard equipment such as microscope, refrigerators and incubators etc. since the equipment were purchased with bids that requested cheap price which in-turn affect the quality. This problem was mainly related with the system of purchasing/ procurement and the way bids are done. As three CEO interviewee reported "*purchased medical equipment start functioning and they fail soon. Being in poor country should not be a reason for using medical device which is below the standard/of poor quality"

Another bottleneck in the selected hospitals were the infrastructure. Out of six hospitals, only two hospitals had maintenance workshop and medical management committee., Another burden was lack of skilled man power among the professionals. Two biomedical engineer, among the key informant said that" *due to lack of skilled expert there is no preventive and urgent corrective maintenance, we have many broken repairable equipment which are essential for the service like dental chair, autoclave* etc."

6. DISCUSSION

This study aimed at assessing the overall utilization of medical equipment, the major contributing factors for the utilization and the major source of medical equipment. This is important because, in today's world, health technologies are essential to the proper functioning of the health system.

The main sources of medical equipment in the present study were through donations. Inline to this study a study conducted by Frank Eric Zomboko et.al showed that many of the medical equipment in developing countries are donated [60].

The study revealed that about 50% of the equipment were used for diagnosis purpose, 34.7% of the equipment were used for treatment, and about 16.2% of were for monitoring patients and cold chain maintenance purposes (Table 1). This result is in agreement with a study conducted by dzwonczyk et al in seven different hospitals[61].

In the present study, the utilization of medical equipment in the selected hospitals were about 60%. The finding of this study was similar to a study conducted by Parry et al which reported only about 40% of medical equipment in resource limited settings is out of service[15], and also supported by study conducted . The possible reason for this could be lack of adequate maintenance, repairing, and lack of stringent donation and pre purchased evaluation policy. To underscore this point 40% of all the equipment was delivered within the last five years even some nonfunctional was under warranty.

The study also determined the contributing factors for utilization of the medical equipment.

Medical equipments which were refurbished and unknown status during receiving time were more likely to become non-utilized compared to newly received medical equipment. Similarly, the European remanufacturing network market studies show that many developing countries are destinations for used medical equipment sold or following poorly conducted recovery process, a situation which has contributed to the abundance of poor quality medical equipment. Refurbished medical equipment may have a quality standard which is lower (e.g. a shorter warranty) than the original. The driving reason for the refurbishment and pre-owned of medical equipment is reduced cost for the developing countries. Refurbished and remanufactured equipment can be sold for 60-

70% of the original price[62]. Keeping the refurbishment cost effective is not without its challenges. Even companies experienced in remanufacturing and refurbishing face challenges in balancing the cost effectiveness of new equipment manufacturing with refurbishing/ remanufacturing[63].

Despite of not found comparative literatures, the percentage of received refurbished and unknown status in this study finding was not much huge figure. The possible reason for this could be the implantation of medical equipment procurement policy and implementation the medical equipment donation policy in the last five years have been enhanced.

Another principal issue is availability of skilled professionals with in the local area were one of the significant factors to the utilization of medical equipment's. Lack of available skilled local expert for maintaining, operation, calibration, and installation on time was two times more likely less utilized compared to equipment which have local experts. This finding is similar with a Study conducted by Malkin RA et al which reported that lack of highly trained technicians were one of the most commonly cited reasons for medical equipment underutilization[35].

The result of this study is also reliable with the study conducted by R. Malkin, and A. Keane,

Findings of 2,529 medical equipment were reported out-of-service from 60 resource-poor hospitals located in 11 nations in Africa, Europe, Asia, and Central America. But without the use of imported spare parts and without extraordinary financial resources or specialized tools, engineering volunteers were able to put 72% of the equipment back into service[43]. and also in Central England university of Gloucester, WHO 2000 report, research conducted by THET global partnership [64, 65]. which was similarly found that trained profession was the main problem in developing world to maintain, calibrate and install the medical equipment properly.

Power supply associated problems were also the principal influential factor for the utilization of the medical equipment. This study revealed that equipment which have not power supply associated problem in the facility were more likely utilized than equipment compare which have power supply associated problems. This study finding pertained to the emphasize of power supply "Nowadays, hospitals in industrialized countries are practically unable to function without electricity" and "Electrical power supply security levels in German hospitals"[66]. This is also shown the significance of power associated problem with medical equipment in the different

developing world study conducted by R. Malkin and A. Keane about 32% of the equipment reported out-of-service in their study required only power supply and electric repairs such as plugs, batteries, contacts**,** light bulbs**,** and fuses. Unlike technicians in the United States, technicians in a resource poor setting must be familiar with their local voltage, frequency, and outlet configuration, as well as that of the origins of their equipment; perhaps requiring them to know the voltage, frequency, and outlet configurations for several European countries, the US and Japan. Replacing fuses nearly universally required substituting a fuse available in the local market for the part recommended by the manufacturer[43]**.**

Accordingly, the health infrastructure is of the devastating factors for the utilization the medical equipment in our health since tremendous power supply interruption and surge in the health set up.

Monitoring medical equipment is another significant factor for the utilization of the medical equipment. According to this study equipment which had not regular monitoring were seven times less likely utilized compared to equipment which have had regular and responsible monitoring.

This can be enhanced by implementation of hospital policy/guideline which promotes monitoring of medical equipment regularly. Since it is difficult to procure cost-effective equipment for health care sectors in low income countries[67] sufficient advisory and supervisory capacity needs to be developed at all health facilities for maintenance and monitoring which operated by skilled professionals.

Even the absence of regular and responsible monitoring of the functionality medical equipment will have negative impact on patient outcome since medical equipment can create risk to patients and staff [68]. which obligate the hospital administrators to give attention on regular monitoring and **s**cheduled maintenance plan. In line with the present findings, a study conducted in 19 hospitals of Victoria found that the utilization of major equipment items were not monitored on a regular basis. [28].

7. Conclusion and Recommendation.

7.1. Conclusion

Based on the study finding, all medical equipment delivered to the Public Hospital organizations were relevant.

The utilization of the medical equipment delivered in the last five years to the public hospital of Tigray region were 60.2%. The major source of medical equipments were donated and purchased.

The significant associated factors hindering the utilization of the medical equipment's were refurbished or unknown sources of medical equipment during receiving time, lack of skilled experts in the local organization, having infrastructure power associated problem, and lack of regular monitoring of the medical equipment.

7.2 Recommendation

According the result of the study the following recommendations were made for Federal Ministry of Health, PSA, FMHACA, Tigray Regional Health Bureau and hospitals to take corrective action for the better utilization of the medical equipment.

The medical equipment procured by PSA and the hospitals are registered by FMHACA. Hence, in order to avoid poor quality of medical equipment FMHACA has to introduce stringent regulatory requirements for the registration of medical equipment.

PSA should give attention to quality of medical equipment beyond the compliance to the proclamation of public procurement. One way of doing so is to advocate for standardization of medical equipment in the public hospitals.

PSA should have to focus strengthen the consideration of installation of the medical equipment, availability of consumables, reagent spare parts and presence of local agents in its future procurements.

PSA has to involve the biomedical professional of its clients on the evaluation of tender.

Tigray Regional health bureau has to enforce management of medical equipment through proclamations, regulation and directives that promote improved utilization of the medical equipment in the Public Hospitals.

Regional health bureau has to enforce the establishment of medical equipment management committee and implementation of the EHRIG in all hospitals managed by the bureau.

The Regional health bureau should have hired biomedical engineers and technicians.

Verify the status/ condition of the medical equipment during delivery time either a new, refurbished, or old equipment**.** verify the life time performance and availability of spare parts.

Recipient should have to approve maintenance manual, operation manual, and all accessory come together with the medical equipment during delivery time for all source of equipment.

Medical equipment warranties, and available service contracts should be demanded and used when available.

Hospitals should have to enhance and develop regular and responsible monitoring system the utilization of major medical equipment items.

The Public Hospital organization should have to adopt the practices of regular equipment auditing. There is a need for periodic evaluation of the quality of performance of the medical equipment in the hospital. It will be advantageous to all concerned, namely hospital, professional, government, and the management so that better utilization of the medical equipment can be ensured.

8. Limitation of the Study:

The study was conducted only in selected public hospitals of Tigray region.
The assessment of this study was used only equipments received in the last five years.

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Annexes: I

Medical equipment Delivered for each selected Public Hospitals of Tigray Region in the last five years. Table 1: Mekelle hospital

Serial №	Type of Equipment	Equipment Proportionality (88÷136=.64)	No of equipment sampled	Remark
1	Anesthesia s machine	6*.64	4	
2	Autoclave	12*.64	8	
3	CBC Machine	2*.64	1	
4	CD4 Analyzer	2.*.64	1	
5	Centrifuge	3*.64	2	
6	Chemistry An	3*.64	1	
7	CT-Scan	1*.64	1	
8	Cyragym	1*.64	1	
9	Defibrillator	1*.64	1	
10	Dental chair	4*.64	3	
11	Dental X-Ray	2*.64	1	
12	Dryer Machin	2*.64	1	
13	Electro-surgical	4*.64	3	
14	Electrolyte	2*.64	1	
15	Extractor Machine	1*.64	1	
16	Film printer	3*.64	2	
17	Genexpert	2*.64	1	
18	Infant Incubator	4*.64	3	
19	Infant Warme	1*.64	1	
20	Infusion pum	2*.64	1	
21	Ironing Mach	1*.64	1	
22	Microscope	4*.64	3	
23	OR Lamp	5*.64	3	
24	Oxygen Conce	6*.64	4	
25	Patient Moni	3*.64	2	
26	Phototherapy	3*.64	2	
27	Physiotherapy	1*.64	1	
28	Refrigerator	23*.64	14	
29	Shaker	1*.64	1	
30	Suction unit	15*.64	9	
31	Surgical tab	5*.64	3	
32	Ultrasound,	7*.64	4	
33	Washing Mach	2*.64	1	
34	X-ray System	3*.64	2	

Table 2: Humera hospital

Serial№	Equipment type	Equipment Proportionality (88÷167=.52)	No of equipment sampled	Remark
1	Anesthesia Machine	3*.52	1	
2	Autoclave	9*.52	4	
3	Baby scale	1*.52	1	
4	Bed	4*.52	2	
5	Cbc Machine	3*.52	1	
6	Cd4 Analatzer	2*.52	1	
7	Centrifuge	6*.52	3	
8	Chemistry Analayzer	2*.52	1	
9	Cpap	3*.52	1	
10	Crayo Terapy	1*.52	1	
12	Ctg Machine	1*.52	1	
13	Defibrilator	2*.52	1	
14	Dental Chair	1*.52	1	
15	Ecg	1*.52	1	
16	Electro Light	1*.52	1	
17	Electro Surgical Unit	3*.52	1	
18	Extractor	1*.52	1	
19	Film Dryer	1*.52	1	
20	Heater	2*.52	1	
21	Hematology	1*.52	1	
22	Incubator	3*.52	1	
23	Keratometer	1*.52	1	
24	Laundry Machine	1*.52	1	
25	Mecanicalventlator	3*.52	1	
26	Microscope	19*.52	9	
27	O2concentrator	12*.52	6	
28	Or-Light	3*.52	1	
29	Oxygen Concentrator	17*.52	9	
30	Oxygen Concentrator	1*.52	1	
31	Patient Monitor	6*.52	3	
32	Patient monitor	1*.52	1	
33	Patient monitor	1*.52	1	
34	Patient Monitor	1*.52	1	
35	Photo Therapy	3*.52	1	
36	Radiant Warmer	2*.52	1	
37	Refrigerator	16*.52	8	
38	Suction Machine	20*.52	10	
39	Teadmill	2*.52	1	
40	Ultra Sound	4*.52	2	

41	Water Distiller	1*.52	1	
42	Wight scale	1*.52	1	
43	X- Ray	1*.52	1	

Table 3: Aksum Hospital

serial№	Equipment type	Equipment Proportionality(88/279=.3)	No of equipment sampled	Remark
1	Anesthesia system	6*.3	1	
2	Anesthesia System	5*.3	1	
3	Autoclave	27*.3	7	
4	Autorefractor	1*.3	1	
5	CBC Machine	4*.3	1	
6	CD4 Analyzer	2*.3	1	
7	Centrifuge	9*.3	3	
8	Chemistry analyzer	3*.3	1	
9	Chemistry Analyzer	2*.3	1	
10	CT-Scan	1*.3	1	
11	Cyragym	1*.3	1	
12	Defibrillator	2*.3	1	
13	Dental chairs	4*.3	1	
14	Dental unit	1*.3	1	
15	Dental X-Ray	2*.3	1	
16	Dryer Machine	2*.3	1	
17	EKG machine	1*.3	1	
18	Electro-surgical unit	7*.3	2	
19	Electrolyte Analyzer	2*.3	1	
20	Exam light	5*.3	1	
21	Extractor Machine	1*.3	1	
22	FACS count	2*.3	1	
23	Film printer	3*.3	1	
24	Genexpert	4*.3	1	
25	Hormone Analyzer	1*.3	1	
26	Infant Incubator	7*.3	2	
27	Infant Warmer	3*.3	1	
28	Infusion pumps	2*.3	1	
29	Ironing Machine	1*.3	1	
30	Lensometer	1*.3	1	
31	Microscope	10*.3	3	
32	OR Lamp	12*.3	3	
33	Oxygen concentrator	20*.3	5	
34	Oxygen Concentrator	6*.3	2	
35	Patient Monitor	11*.3	3	

36	Phototherapy	9*.3	3	
37	Physiotherapy cycle	1*.3	1	
38	Pulse oximeter	5*.3	1	
39	Refrigerator	23*.3	5	
40	Respironic	3*.3	1	
41	Shaker	1*.3	1	
42	Slit Lamp	4*.3	1	
43	Suction unit	33*.	8	
44	Surgical table/hospit	11*.3	3	
45	Ultrasound, general	9*.3	3	
46	Ultrasound, ocular	1*.3	1	
47	Ventilator	1*.3	1	
48	Washing Machine	2*.3	1	
49	X-ray System	5*.3	2	

Table 4: Mychew hospital

serial№	Equipment type	Equipment Proportionality(88/162=0.54)	No of equipment sampled	Remark
1	Adjustable pipette	2*.54	1	
2	Anesthesia machine	4*.54	2	
3	Autoclave sterilizer	2*.54	1	
4	CD4 analyzer	1*.54	1	
5	CD4 cell counter	2*.54	1	
6	Centrifuge	3*.54	1	
7	Ceragem machine	1*.54	1	
8	Chemistry analyzer	2*.54	1	
9	Cisa autoclave	1*.54	1	
10	Conventional x-ray with fluoroscopic unit	1*.54	1	
11	Dental chair	2*.54	1	
12	Dental x-ray	1*.54	1	
13	Diathermy unit	2*.54	1	
14	DR x-ray	1*.54	1	
15	Dry oven	2*.54	1	
16	ECG machine	3*.54	1	
17	Emergency eye washer	1*.54	1	
18	Fetal/maternal monitor	2*.54	1	
19	Fixed pipette	1*.54	1	
20	Fluorescence microscope	1*.54	1	
21	Gas analyzer	1*.54	1	

22	Hematocrit centrifuge	1*.54	1	
23	Hematology analyzer	3*.54	1	
24	Hormone analyzer	1*.54	1	
25	Indirect ophthalmoscope	1*.54	1	
26	Infant incubator	3*.54	1	
27	Infant scale	3*.54	1	
28	Infant warmer	4*.54	2	
29	Infrared	1*.54	1	
30	Infusion pump	1*.54	1	
31	Ironing machine	1*.54	1	
32	Laundary machine	3*.54	1	
33	Light microscope	4*.54	2	
34	Mammography	1*.54	1	
35	Mechanical blood mixer	1*.54	1	
36	Mechanical ventilator	3*.54	1	
37	Micro hematocrit	1*.54	1	
38	Micro hematocrit centrifuge	1*.54	1	
39	Opthalmoscope and othocsope unit	1*.54	1	
40	OR light	5*.54	3	
41	OR microscope	2*.54	1	
42	OR table	3*.54	1	
43	Oxygen concentrator	30*.54	15	
44	Patient monitoring unit	10*.54	4	
45	Phototherapy light	1*.54	1	
46	Portable ultrasound	1*.54	1	
47	Radiant warmer	2*.54	1	
48	Refrigerator	6*.54	3	
49	Rethinoscope	1*.54	1	
50	Shaker	2*.54	1	
51	Slit lamp	1*.54	1	
52	Steam autoclave	3*.54	1	
53	Suction machine	16*.54	8	
54	Tonometer	1*.54	1	
55	Ultrasonic scaler	1*.54	1	
56	Ultrasound unit	5*.54	3	
57	Water distiller	2*.54	1	

Table 5: Adigrat Hospital

serial№	Equipment type	Equipment Proportionality (88/143=.61)	No of equipment sampled	Remark
1	Anesthesia System	5*.61	3	
2	Autoclave	15*.61	8	
3	Autorefractor	1*.61	1	
4	CBC Machine	2*.61	1	
5	Centrifuge	6*.61	3	
6	Chemistry analyzer	3*.61	2	
7	Defibrillator	1*.61	1	
8	Dental unit	1*.61	1	
9	EKG machine	1*.61	1	
10	Electro-surgical unit	3*.61	2	
11	Exam light	5*.61	3	
12	FACS count	2*.61	1	
13	Genexpert	2*.61	1	
14	Hormone Analyzer	1*.61	1	
15	Infant Incubator	3*.61	2	
16	Infant Warmer	2*.61	1	
17	Lensometer	1*.61	1	
18	Microscope	6*.61	4	
19	OR Lamp	7*.61	4	
20	Oxygen concentrator	20*.61	12	
21	Patient Monitor	8*..61	5	
22	Phototherapy	6*.61	4	
23	Pulse oximeter	5*.61	3	
24	Respironic	3*.61	2	
25	Slit Lamp	4*.61	2	
26	Suction unit	18*.61	11	
27	Surgical table/hospital bed	6*.61	4	
28	Ultrasound, general	2*.61	1	
29	Ultrasound, ocular	1*.61	1	
30	Ventilator	1*.61	1	
31	X-ray System	2*.61	1	

Table 6: Shire Hospital

serial№	Equipment type	Equipment Proportionality (88/168=0.32)	No of equipment sampled	Remark
1	Autoclave/dry oven	8*.32	2	
2	3Autoclave/steam	2*.32	1	
3	Automated hematology analyzer	4*.32	1	
4	Automatic microton	1*.32	1	
5	Automatic osmometric	1*.32	1	
6	Automatic Tissue processor	1*.32	1	
7	Balance	6*.32	1	
8	Cd4 analyzer	1*.32	1	
9	Cell dyn	1*.32	1	
10	Centrifuge	13*.3	4	
11	Centrifuge/hematocrit	4*.32	1	
12	Chemistry analyzer	3*.32	1	
13	Chlorid analyzer	1*.32	1	
14	Cold centrifuge	2*.32	1	
15	Cool plate	2*.32	1	
16	Dark room microscope	1*.32	1	
17	Defibrillator	2*.32	1	
18	Dry cabinet	1*.32	1	
19	Ecg	4*.32	1	
20	Echo machine	1*.32	1	
21	Echo ultrasound	1*.32	1	
22	Electrolyte analyzer	3*.32	1	
23	Endoscopy	2*.32	1	
24	Facs caliber	1*.32	1	
25	Flouro scanner	1*.32	1	
26	Head light	1*.32	1	
27	Heamatology analyzer	1*.32	1	
28	Hot plate&paraffin dispenser	1*.32	1	
29	Humaclot DUO	1*.32	1	
30	Imaging trolley	1*.32	1	
31	Incubator	9*.32	2	
32	Laser machine	2*.32	1	
33	Light source	3*.32	1	
34	Microscope	32*.32	10	
35	Microton	3*.32	1	
36	Mixer	4*.32	1	
37	Multipurpose Microton	1*.32	1	
38	Or light	1*.32	1	

39	Oven	1*.32	1	
40	Patient bed	14*.32	4	
41	Patient monitoring	34*.32	10	
42	Perfuser	1*.32	1	
43	Ph meter	3*.32	1	
44	Photometer	1*.32	1	
45	Pt-pttt	1*.32	1	
46	Refrigerator	15*.32	3	
47	Rotatory microton	2*.32	1	
48	Safety cabinet	4*.32	1	
49	Shaker	1*.32	1	
50	Spectro photometer	1*.32	1	
51	Stethescope	1*.32	1	
52	Suction machine	16*.32	4	
53	Tissue processing machine	1*.32	1	
54	Ultrasound	7*.32	2	
55	Ventilator	7*.32	2	
56	Vortex mixer	3*.32	1	
57	Water bath	8*.32	1	

Anex: II

Dear Madam/Sir

My name is Abraha Tareke. Currently, I am a Masters graduating student in Pharmaceutical supply chain management(PSCM) at the school of pharmacy, Faculty of Health Science, Institute of Health, Jimma University. I am conducting a study entitled Assessment of the Medical Equipment Utilization and the Associated Factors in Tigray Regional State: in selected public hospitals of Tigray Region.

The ultimate purpose of this study is to promote the optimum utilization of medical equipment, to assured quality, and safety by collecting information on the challenges facing the Selected zonal hospitals during medical equipment utilizing, donation, installation, monitoring, availability of spare parts, maintenance manual and repair, availability of skilled professional, and medical equipment condition during delivery time and related challenges in our country as the results of the survey could be used as an input for the improvement of the medical equipment utilization systems and to develop national health technology policy.

Thinking about its main objective, your response is indispensable for the successful accomplishment of this study. Consequently, you are kindly requested to give your genuine response that will offer a big value for me. Your information will be kept strictly confidential. your participation is voluntary.

Thanking you for your willingness to participate in this study, I politely ask you to encircle your answer and for the parts that need writing, to write your answer neatly and shortly as possible.

Section I**:**

Facility General Information

Name of the facility _____

Gender a. Male ----------b. Female ----------

Age ----------

Profession: A) Biomedical Engineer B) Biomedical Technician

C) Pharmacist D) Nurse E) Director F) Others Specify----------

4. Educational level A) Diploma B) Bachelor Degree C) Master D) Doctor and above

5. Work experience in this organization _____

6.Does your health facility have a separate biomedical engineering/health care technology department? Yes ☐ No ☐

7. If no why**?** _____

	Medical equipment facility check list			
S№		Yes	No	Remark
1	A medical Equipment management Unit has been established			
2	Medical equipment management unit have workshop that meets the minimum workshop standard lay out			
3	Medical equipment management unit with an operational plan			
4	Medical equipment management unit with required staff and led by a Biomedical engineer biomedical technician personnel			
5	Medical equipment management committee has been established			
7	An inventory management system to manage medical equipment has been established			
8	An inventory management system to manage spare parts of medical equipment has been established			
9	An equipment history file system has been established			
10	There are policies and procedures for medical equipment acquisition			
11	There are policies and procedures for medical equipment commissioning and decommissioning			
12	There are policies and procedures for medical equipment donations			
13	There are policies and procedures for medical equipment disposal			

14	A maintenance notification and work order system has been established			
15	Preventive maintenance of medical equipment is scheduled and con ducted			
16	Inspection and testing of medical equipment is scheduled and conducted			
17	All new equipment undergoes acceptance testing			
18	Identify Equipment those need regular calibration and made calibration as per the manufacturer recommendations			

19	Is there a clear guideline for procurement of medical equipment?			
20	Are the specifications clear and viable to procurement?			
21	Do the instruments procured /donated installed and work properly?			
22	Do you have enough personnel to operate the machines?			
23	Do you have log book for equipment's, list of important spare parts and consumables?			
24	Do you have written procedures for the use of all medical equipment?			
25	Do you have a maintenance workshop equipped with testing devices			
27	Are the medical equipment donated as per your demand?			
28	Do you have a system how, and when to decommission medical equipment?			
29	Are the equipment removed as per the lifetime of the medical equipment ?			
30	Do you have a system to track donation of medical equipment?			
31	Occupational safety and Hazard			
32	Do you have occupational safety guideline?			
33	Does the procurement of medical instrument include after sales service?			
34	Is there any specification on handling and storage of this equipment?			
35	Does the facility have regular preventive maintenance schedule?			
36	Does the facility take corrective maintenance measure for the equipment?			
37	Electricity is available 24 hours a day, 7 days a week			
38	Water is available 24 hours a day, 7 days a week.			

39. What are the most common medical equipment maintenance practice in your facility?

Preventive maintenance ☐ Corrective maintenance ☐

Emergency maintenance ☐ Shutdown maintenance ☐

No maintenance at all ☐ Others ☐ please specify ----------

What are the most common reasons for under-utilization the medical equipments

Please indicate the following

Serial№	Factors	Yes(1)	No(2)	
1	Non availability of consumables and accessories			
2	Breakdown			
3	Unavailability of trained man power			
5	Obsolescence			
6	Maintenance delays			
7	Non availability of spare part			

Section: II

Key informant interview Guideline checklist.

serial No	Open ended question	Ways of probes
1	How your organization get medical equipment? What are the major sources of medical equipments of the hospital?	If purchased what is source of money? Was donation requested by your organization? If yes how often? When? Why? Whom did your organization request? Type of equipment?
2	Have you ever across any communication on donated medical equipment supplied to your organization before equipment arrival?	
3	How do you install and maintain donated/purchased medical equipment in your facility?	Are there adequate professionals in your organization for installation and maintaining equipment? If yes is there necessary tool to maintain the equipment? If no why? Who install the equipment? How do you

		deal with them? Purpose of Having professionals in the organization and lack of having them in the facility?
4	Are there training for user on handling of medical equipment? Please would you tell me how this equipment handled in your organization?	Was training given to professions on how to use ? If yes when? By whom? Number of attendant? If no why? What was the difficulty?
5	Delivered/supplied medical equipment to your organization has warranty? Tell me about donated and procured equipments	What was the status of this equipment when you receive? Is there installation document?
6	Was donation based on your organization need?	If no why? Are all donated equipment help full to your facility? How/ if no why? Are there technologically appropriate?(in terms of capacity, specify and sensitivity ?to test sample? easy to use
7	Are these donated medical equipment registered on the national medical equipment list?	If no why?
8	Is there any donation from the local non-government organization or individual from the domestic product?	If yes from whom or which organization Type of equipment Are these equipment are technological appropriates Are there clinical appropriates?
9	How is the involvement of appropriate professionals in the order, purchase, and procure of medical equipment ?	

10. How do you plan for medical equipment procurement? ----------

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11. How do you schedule preventive maintenance for the medical equipment? how often?

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12. How do you monitor equipment status? (life cycle cost, maintenance cost, equipment replacement)

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13. How are medical equipment problems traced out? ----------

15. Does the hospital do medical equipment risk classification? ---------- if yes based on what? ----------

16. what do you think are major problems with medical equipment in your unit?

Section III:

Questioners/checklist for the medical equipment users and experts

General information of medical equipment

1. Name the medical equipment _____

2. Purpose of the medical equipment ----------

3. Years of received the medical equipment ----------

4. The source of the medical equipment ☐ Purchased ☐ Donated ☐ unknown/unspecified

4.2.1. Country of origin/specify ----------

4.2.2. Manufacturer of the equipment ----------

4.2.3. Year of manufacture ----------

4.2.4. if donated who donated? NGO ☐ Individuals ☐ governmental ☐ other/non-specified

_____

4.2.6. Reside unit in the hospital ----------

4.2.8. is there responsible person of the equipment? Yes-☐ No ☐

5. Medical equipment during receiving time:

A) New

B) Old

C) Refurbished

D) Others/ ----------

6.Current condition of the received medical equipment.

a) Working in use------

b) Working but not in use------

c) Not working not in use-------

d) Not working but repairable------

6. Does this medical equipment appropriate for your organization? In terms of

a) Spacing ----------

b) Patient comfortability----------

c) Environmental friendly ----------

d) Performance/capacity to do for intended purpose ----------

d) other please specify ----------

7. Capacity of performance according to its standard unit

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9. Depending on its nature and type, the label of received medical equipment shall at least include

A. the name of the medical equipment ---------- A) Yes B) No

B. model number or serial number ---------- A) Yes B) No

C. manufacturing date ---------- ---------- A) Yes B) No

D. life span or expectancy---------- ------- A) Yes B) NO

E. name and address of the manufacturer ---------- A) Yes B) No

F. handling and storage requirement Label ---------- A) Yes B) NO

G. technical direction for use ---------- ---- A) Yes B) No

H. An indication, if applicable, that the medical equipment is intended to be used only for clinical or performance investigations before being supplied----------A) Yes B) No

I. For a sterile medical equipment, the word “Sterile” and where appropriate, description of methods of re-sterilization Indicated -------A) Yes B) No

J. Is the device being a refurbished, an indication of the device as refurbished device ----------A) Yes B) No

K. if the device is intended for presentation or demonstration purposes only, it must be labeled as “for presentation or demonstration purposes only, not for use on human.

----------A) YES B) No

L. if the device emits radiation for medical purpose, details of its nature, type and appropriate, the intensity and distribution of this radiation.

----------A) Yes B) No

M. if the equipment is to be installed with or connected to other medical device or equipment, or with dedicated software, in order to operate as required for its intended use, sufficient details of its characteristics to identify the correct device or equipment to use in order to obtain a safe combination----------A) Yes B) No

N. if the device is an in vitro diagnostic medical device it must be labeled as “in vitro” diagnostic ----------A) Yes B) No

O. The intended purpose of the medical equipment, the intended user of the medical equipment, and the kind of patient on whom the medical equipment is intended to be used.

----------A) Yes B) No -----

Serial №	Questions or criteria for medical equipments	Yes (1)	No (0)	Remark
10	Does this medical equipment need consumables, chemicals and reagents?			
11	Does the chemical, consumables and reagent available in local market?			
12	Has this Equipment consumables reagents and spare parts during given to your organization?			
13	Does these spare parts available in local market for this equipment?			
14	Does have this medical equipment user operation manual when it supplied to this unit?			
15	Does have this medical equipment reparable and maintenances manual along machine?			
16	Is there list of spare parts, which is replaceable along with equipment?			
17	Does it have all accessary included when it delivered to your unit?			
18	Is there any power supplied problem associated with this equipment such as high power consumption or surges, power shortages?			
19	Is this equipment utilize standard voltage (240V/50Hz)			

20	Is there any estimated life span of the equipment on machine? such as model no, manufacturer date, new or reconditioned?			
21	Is the machine closed system?			
22	Is the machine open system ?			
23	Do the reagent need special refrigerators?			
24	Are there professionals for maintaining this equipment in the facilities?			
25	Is the supplied medical equipment to your unit easily maintained by local expertise?			
26	Does it need special professions to operating the equipment? like software engineers?			
27	Have you take any training on this equipment?			
28	Is this equipment labeled any safety precaution to you?			
29	Is this equipment have responsible and regular monitoring? Schedule (daily, weekly or monthly)?			
30	Is this equipment comfortable for patients, validity, specificity and sensitivity of test result?			
31	Is the equipment name labeled on it?			
32	Is there any description how the equipment sterilized?			
33	Is there any specification for which patient this equipment will apply?			
34	Are the medical equipment supplied/delivered as per your specification demand?			
35	Are the equipment removed as per the lifetime of the medical equipment ?			
36	Occupational safety and Hazard			
37	Do you have occupational safety guideline?			
38	Does the procurement of medical instrument include after sales service?			
39	Is there any description how the equipment sterilized?			
40	Is there any specification for which patient this equipment will apply?			
41	Does the equipment need calibration?			
42	If so, does the facility have regular calibration schedule?			

ASSURANCE OF PRINCIPAL INVESTIGATOR

The undersigned agrees to accept responsibility for the scientific, ethical and technical conduct of the research project and for provision of required progress reports as per terms and conditions of the Faculty of Health Science, Institute of Health, Jimma University in effect at the time of grant is forwarded as the result of this application.

Name of student: ----------

Date ---------- signature ----------

Approval of the advisor

Name of advisor**: ----------**

Date ---------- signature ----------