East Africa's Center of Excellence in Biomedical Engineering and E-Health (CEBE)

Master's of Science in Biomedical Engineering

Master's Thesis

ASSESSMENT OF MEDICAL EQUIPMENT AND FACILITIES NEED FOR EFFECTIVE HEALTHCARE DELIVERY IN RWANDA

A thesis submitted in partial fulfilment of the requirements for the award of Master of Science in Biomedical Engineering.

The thesis was done and submitted by

UWINEZA FLORENTINE (Ref. No: 221002782)

Supervised by:

1st Supervisor: Dr. Philibert Nsengiyumva

2nd Supervisor**:** Dr. MORUFU O. IBITOYE

DECLARATION

This Thesis is my original work and has not been presented for a degree in any other university.

Signature:
Date: 01/10/2023

FLORENTINE UWINEZA

Certification

This thesis has been submitted for examination with our approval as the University

Supervisor:

Main Supervisor Name: Dr. Philibert Nsengiyumva

Signature: ..... Date.....

Co-Supervisor Name: Dr. MORUFU O. IBITOYE

Signature: ..... Date.....

Biomedical Engineering Master's program Coordinator Name:

Dr. Rushingabigwi Gerard

Signature: ..... Date.....

DEDICATION

This work is dedicated to my husband Vincent NIYIGABA, and my Kids Niyigaba Aime Yannick, Niyigaba Kevin Bernard, and Niyigaba Ange Eunice. It is also dedicated to my brothers and Sisters and last but not least my parents for the support and moral guidance provided to me while doing this thesis.

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List of Acronyms

***WHO**:* World Health Organization

***UN**:* United Nations

SDGs: Sustainable Development Goals

LMICs: Low-and Middle-Income

Countries

MDs: Medical Devices

***UHC**:* Universal Health Coverage

***HSSP**:* Health Sector Strategic Plan

***NISR**:* National Institute for Statistics of Rwanda

***PHECS**:* Pre-Hospital Emergency Care Service

KFH: King Faisal Hospital

CHU-K: University Teaching Hospital-Kigali

CHU-B: University Teaching Hospital of Butare

MHRA: Medicine and Health Products Regulatory Agency.

EAC: East African Community

SPSS**:** Statistical Package for the Social Sciences

MOH: Ministry Of Health

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Abstract

In the last ten years or so, Rwanda has made unprecedented progress in health indicators, e.g., reducing maternal deaths by more than 50% and infant and child deaths by more than 40%, and increasing the overall use of health services. The government has continued to prioritize the development of the health sector and is facilitating this with corresponding budget allocations. In addition, the government is now encouraging private sector participation in the provision andfinancing of high-quality health care through public-private partnerships (PPP) in the development and implementation of health care delivery. The healthcare sector is thus undergoing important improvement, giving rise to potential business opportunities. Despite these gains, the country faces the critical challenge of limited healthcare services in hospitals because machines and equipment are notenough in all hospitals. Another challenge is that there are no guidelines on the equipment needed in each hospital's clinical department based on the number of patients to be managed.

Therefore, the main objective of this project was to assess the medical equipment and facility needs in selected Rwandan public hospitals for effective healthcare delivery in Rwanda. To achievethe main objective of this research study, a site survey was conducted using the standard tools for data collection. A specifically structured questionnaire was used for the assessment. The collected data was analyzed quantitatively and qualitatively. For quantitative analysis, SPSS **(**Statistical Package for the Social Sciences) software (SPSS Inc., Chicago, IL 60606 United States) was used, where graphs were presented to infer a deep interpretation of the results. At the end of this research study, the results showed that critical equipment are not available in all Rwandan hospitals. In assessed hospitals, maximum number of Doctor is 17 doctors to manage patients above 10,000 per year, nurses and midwifes are 89 at maximum, 50% of assessed hospitals do not have biomedical engineer. For medical equipment availability, dialysis machine, ventilator, endoscopy, mammograph and CT Scan are available at 33% for each and anesthesia machine, autoclave, echography, X-Ray are available at 83%.There is 20% of insufficiency of bed compared to the patients they have to manage and the infrastructure are not at standard level. Based on the services provided in each hospital, norms and guidelines describing what types of medical equipment should be available to guide procurement was developed.

Keywords: Medical equipment, health services, health care, health facilities.

Chapter 1: GENERAL INTRODUCTION

1.1 Introduction

The United Nations (UN) 2030 Agenda for Sustainable Development includes 17 Sustainable Development Goals (SDGs), which include good health and well-being and strive to ensure healthy lives globally, emphasizing access to quality essential healthcare services, which is currently inequitable at the expense of low- and middle-income countries [1], [2]. Technology innovations have changed the way industry professionals approach the idea of healthcare. While many of these innovations are positive, facilitating patient care and ensuring more effective traditional treatments, they also present some unique challenges. This is because some of these technology innovations are new to the industry. Patients and healthcare providers in Low and Medium Income Countries(LMICs) including Rwanda have limited access to medical devices (MDs). One way to ensure adequate medical equipment availability in the healthcare sector is to objectively assess medical equipment and facility needs in Rwanda hospitals.

1.2 Problem Statement

During the sixtieth World Health Assembly, the World Health Organization (WHO) recognized the severe implications of the inappropriate provision of technologies in healthcare to support the quality of health in developing countries. The lack of appropriate technologies was recognized as a barrier to the achievement of the SDGs, specifically SDG 3 with its specific target on universal healthcoverage (UHC), which impacts the guarantee of human rights [3]. As reported in a WHO document[4], patients and healthcare providers in LMICs have limited access to medical devices. According toPiaggio et al. (2019) [5], one barrier to the accessibility of medical technologies is the lack of funds and the high cost of imported medical devices. As this is not the only challenge, medical device donations from overseas have also not solved the problem. Another challenge is that despite technological advances, many facilities still in use in LMICS including Rwanda are out-of-date technologies [6]. With the expectation that technology innovations will change and shape the medical industry for decades to come, healthcare sector in Rwanda still has a long way to go as thereare no specific documents indicating the equipment and facilities the country needs. Unfortunately, this situation is similar to most countries in the East African Community (EAC). Improvements in technological advancement have brought about many changes in the type of medical equipment needed for specific treatment for patients in hospitals [7]. Understanding the medical equipment and facility appropriate for every clinical department in hospitals based on the nature of the clinical population or patient they manage in those departments is also an issue to be addressed, as there are

currently no standard guidelines to follow in the establishment of the hospital equipment and facility needs in Rwanda. The current research project therefore sought to provide these guidelines.

1.3 Research Questions (Hypotheses)

This research has the following questions:

- Do all Rwandan district hospitals have sufficient biomedical engineers and technicians?
- What is the best patient-to-staff ratio in different Rwandan hospitals compared to the international standard?
- What is the capacity of different district hospitals in Rwanda?
- Do all Biomedical Engineering Departments in Rwandan hospitals have sufficient medical equipment

1.4 Study Objectives

1.4.1 General Objective

The main objective of the project is to assess the medical equipment and facility needs of selected Rwandan hospitals for effective healthcare delivery in Rwanda.

1.4.2 Specific Objectives

To achieve the main objective, the following are the specific objectives:

- Identification of three government hospitals and three private hospitals from three Rwandan provinces, as well as all clinical and non-clinical departments available in these chosen hospitals.
- Identification of available medical equipment and facilities in the identified clinical departments in the selected hospitals.
- Identification of the patient population being managed daily, monthly, and annually in each hospital.
- Generate data on the staff strength and their cadres in each of the clinical departments.
- Generate data on the patient-to-staff ratio and the available medical equipment for patient management and compare the results with international standards.

1.5 Study Scope

This study is focused on the assessment of the available medical equipment and facilities in the district hospitals in Rwanda. It focused also on the patient to staff ratio by elaborating on the number

of patient to be managed every day, month and year and the number of staff in different levels of study. This study compares the results with international standards by providing needs and guidelines.

1.6 Significance of the Study

This research will help the policy makers in need of information about the medical equipment need in district hospitals in Rwanda. Specifically, the data can be used for the Ministry of Health to understand the gap in the district hospitals and take decisions for the purpose of increasing the quality of health in Rwanda as this is their target and priority. The data could also be used for setting the guidelines used in the establishment of the new hospital in Rwanda.

1.7 Organization of the Study

This thesis is organized into five Chapters as follows. Chapter 1 that covers the introduction information including background and motivation, problem statement, study objectives (both general objective and specific objectives), hypothesis questions, scope of study, significance of study, and organization of the thesis. Chapter 2 presents the Literature Review about the Health care delivery status in Rwanda, factors affecting quality of healthcare, the role of medical equipment in providing an effective healthcare, essentials facilities in need by providing effective healthcare, finally the gap was identified. Chapter three explains the methodology followed in the whole study. Chapter four deals with the data analysis and interpretation. Finally, conclusion and recommendations are provided in Chapter five.

Chapter 2: Literature Review

2.1Introduction

The revision and analysis of publication papers, scientific articles and reports relate to the thesis topic was done in order to have enough information about quality of healthcare services in Rwanda and the needs based on medical equipment and facilities in order to achieve effective healthcare delivery in Rwanda. Several books and Internet resources were used for completing the literature review of the thesis and directing the whole project. This method helped to find out the gap in healthcare services and the research problems of this research.

The maximum practicable level of health is envisioned as a vital right of every human being in the WHO Constitution from 1946. Common Health Coverage places a high priority on quality, which includes both actual and perceived quality of service. Safe (preventing harm to those for whom the care is meant); Effective (offering evidence-based healthcare services to those who need them); and People cantered are qualities of quality healthcare services (providing care that responds to individual preferences, needs and values) [8].

Healthcare services must be timely by minimizing waiting times and potentially dangerous delays in order to receive the benefits of high-quality healthcare. There is need to have equality in the quality of care regardless of a patient's gender, race, geography, or socioeconomic standing. The full rangeof health services are made available through care that is both integrated and efficient, maximizing the use of resources while minimizing waste [9].

As excellent quality of lives is of priority to individual, people are always searching for high-quality healthcare services Enhancing structures and procedures for having quality healthcare services and excellent results in less waste, and delays, and at cheaper costs promote the reputation of any industry [10], including healthcare industries. Only when healthcare delivery engineering techniques and concepts are applied can the quality, efficiency, and sustainability of the healthcare system be truly improved [6]. Evidence-based medicine is practiced by certified healthcare professionals (i.e., those who can give healthcare, treatment, and advise based on formal training and experience) in order to deliver healthcare services effectively. Because of the dynamic nature of health andhealthcare delivery, the body of medical evidence is always changing. Changes in service provision, patient care, and individual wellness management consequently occur often [11]. To meet this highlydynamic field, developing countries including Rwanda must be ready to embrace internationalstandards in making available the tools for delivering seamless healthcare services.

2.2. Health System in Rwanda

According to the Government of Rwanda, the overall goal of the health sector is to guarantee that all Rwandans have access to equitable and inexpensive, high-quality preventative, curative, rehabilitative, and promotional services that are both geographically and financially accessible [11]. The following four strategic objectives will be used to achieve this important program: (i)improving demand, access, coverage, and quality; (ii) strengthening policies, resources, and management; (iii) organizing the services effectively at all levels; and (iv) strengthening decentralization, partnership, coordination, aid effectiveness, and financial management.

The Fourth Health Sector Strategic Plan (HSSP4) for Rwanda proposes a paradigm change by connecting it to the concepts of Universal Health Coverage (UHC), Rwanda's National Constitution, Vision 2050, the Health Sector Policy 2015, NST, and the Sustainable Development Goals (SDGs). The goal of HSSP4 is to respond to the nation's desire to develop into a high-income nation with an improved population quality of life. Health is a Human Right, according to Article 41 of the 2015 amended Rwandan Constitution. In terms of health, all people have rights and obligations. In order to promote good health, the State must encourage its citizens to participate in activities and provide support for their execution. According to their qualifications and skills, every individual has the right to equitable access to public services.

The HSSP4 directs Rwanda's health sector to directly support the fulfilment of the nation's, regions, and the world's commitments to health and other development goals. In support of this, is also the Sustainable Development Goals (SDGs) are a set of 17 goals that, when fully realized, would result in Universal Health Coverage. At the global level, the HSSP4 supports the accomplishment of the SDGs, notably SDG 3 to ensure healthy lifestyles and promote well-being for all people at all ages (UHC). HSSP4 will help the EAC Vision 2050 and the Africa Agenda 2063 on a regional level.

Accreditation standards have been created, disseminated, and put into practice. Future efforts must focus on expanding infrastructure to include areas without health centers or cells without health posts, improving the IT infrastructure in healthcare facilities, offering specialized services at the secondary and tertiary levels, and bolstering emergency and pre-hospital care.

The core level, the intermediary level, and the peripheral level are the three levels that make up Rwanda's pyramidal-shaped health sector (See Figure 2.1 for more information).

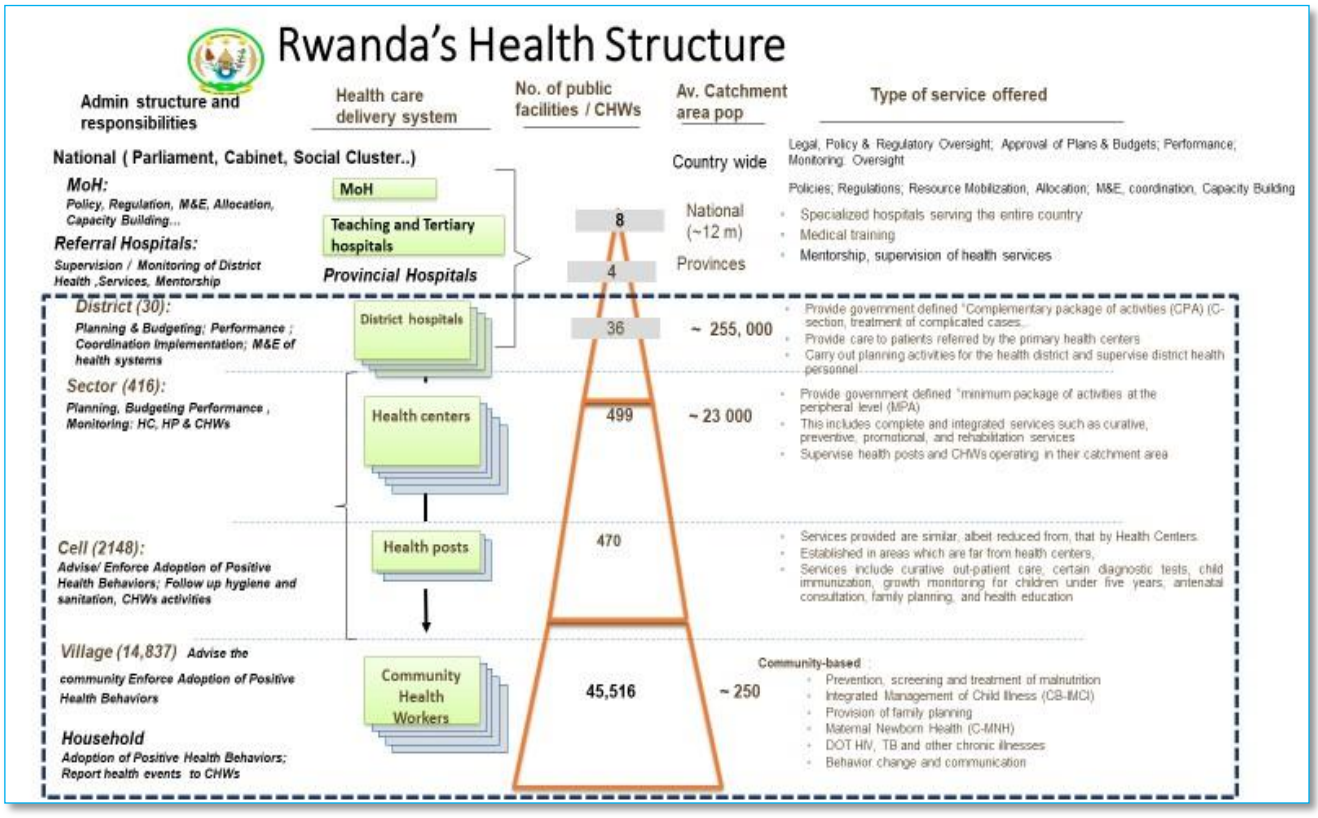

Figure 2.1 : Rwanda's Health Structure

Rwandan health system was made up of a network of five referral hospitals, 42 district hospitals, 30 district pharmacies, five blood transfusion centers, 466 health centers, 16 prison dispensaries, 60 health posts, 45,000 community health workers at the household level, 60 private sector health facilities, including clinics, 114 dispensaries, and 14 laboratories and pharmacies [12]. There is an increased effort by government to continue to improve geographical accessibilities to medical infrastructure with special emphasis on sustainability. Government is also making effort to ensure anincrease in the number of public and private health facilities across the country. The current data on this is as shown in Table2.1.

Table 2.1: Trends of numbers of Public Health Facilities in Rwanda in 2016-2019

Heath Facility type	2016	2017	2018	2019
National Referral Hospital	8	8	8	8
Provincial Hospital	4	4	4	4
District Hospital	36	36	36	36
Health Center	499	503	504	509
Prison Clinic	14	13	13	13
Health Post	471	505	703	885
Private Dispensary	125	130	130	123
Private Clinics and polyclinic	123	128	128	149
Private Hospital	5	5	8	8
Total	**1285**	**1332**	**1534**	**1735**

The Pre Hospital Emergency Care Service (PHECS) known as **SAMU** (Service d'Aide Médicale d'Urgence) is also currently fully operational in all districts in Rwanda with 213 ambulances (i.e., a minimum of five ambulances fitted with tracking system in each district is the requirement fitted with tracking system) and a call center coordinating the flow. In 24 healthcare establishments, emergency rooms have been built, although more capacity is necessary (i.e., human resources, equipment, infrastructure, and management). There is a strong and well-established laboratory network for laboratory services, administered by the National Reference Laboratory Division of RBC, however, there is a shortage of skilled human resources for maintaining laboratory suppliesand equipment in healthcare institutions.

As a major effort to enhance the quality and safety of healthcare, Rwanda has embraced healthcare facility quality assurance methodologies and criteria for certification. King Faisal Hospital (KFH), the University Teaching Hospital-Kigali (CHUK), and the University Teaching Hospital of Butare (CHUB) were the first teaching hospitals in Rwanda to begin the accreditation process. Other healthcare institutions within the Country are also now going through the accreditation process.

Inadequacies in data use and further harmonization of data collection in some areas, the proliferation of software platforms established with partner support, delays in the deployment of the nationwide fiber optic network, and the lack of an affordable national data center are all issues that health information systems are still dealing with.

Strong political support inside the Ministry of Health (MOH) and throughout Rwanda as a whole is advantageous to the nation's health research. There are several prestigious research organizations with extensive global networks. The primary difficulties in the field of health research include: Insufficient research infrastructure, including a lack of efficient coordination mechanisms, restricted research capacity, a shortage of trained and experienced researchers, and a lack of financing for all essential and desirable research are among the problems [12].

The mission of the Rwanda Health Sector is to provide and continually improve affordable primitive, preventive, curative and rehabilitative health care services of the highest quality, thereby contributing to the reduction of poverty and enhancing the general well-being of the population. To be able to fulfil this mission, the Rwanda Ministry of Health emphasizes on the strengthening of the Health System in all its components (i.e., health service delivery, health workforce, health information systems, access to essential medicines, health systems financing leadership and governance [13]**,** [11]**)**.

The number of skilled health professionals is expected grow in the industry. To support this, 1,492 medical doctors, including 850 general practitioners and 642 specialists, were employed in both private and public health institutions as of the end of 2019. Using the Rwanda population of 12,374,397 as projected by the NISR for 2019, this amounts to one doctor for every 8,294 persons nationwide, which is more than the national objective of 7,000 people by 2024 specified in HSSP IV. [13]. However, other areas of interest to facilitate healthcare delivery, such as healthcare facilities, need improvement.

2.3 Factors affecting effective healthcare delivery

Healthcare management engineering refers to a systematic approach to creating managerial choices for the effective allocation of material, human, and financial resources needed for the delivery of high-quality care using quantitative methodologies.

2.3.1 Collaboration between nurses and medical doctors: Effective and efficient healthcare delivery requires seamless communication between nurses and medical doctors. In order to achieve this, physicians and other healthcare professionals must collaborate in order to offer care to patients. This collaboration must be built on mutual respect, trust, and understanding of each other's relevance and value [14].

2.3.2 Capacity: Capacity refers to the number of beds needed for a department or unit, the number of operating rooms, procedure rooms, or equipment necessary for certain services.

2.3.3 Staffing: In order to best meet operational and service performance goals, a unit (department) will need the appropriate number of nurses, doctors, and other professionals for a given shift.

2.3.4 Scheduling: Staff optimization, schedules that support providing patients with safe and effective treatment as well as taking into consideration the convenience and preferences of the staff.

2.3.5 Patient flow: To meet the system throughput objectives, the patient flow at the service stations must be acceptable.

2.3.6 Resource allocation: Utilizing specialized or shared (interchangeable) resources efficiently (i.e., operating/procedure rooms, beds, equipment, and staff).

2.3.7 Forecasting: To predict future transaction or patient volumes for short- and long-term budgeting and other planning needs.

2.4. Medical Equipment

According to *Perry and Malkin* [15] ,an estimated 40% of medical equipment in resource-poor settings is out-of-service**.** In response to this unfortunate trend, charity organization, governmentsand multilateral organizations have donated billions of dollars' worth of medical equipment to these settings. From 1997 to 2001 the World Bank alone invested 1.5 billion USD in medical equipment. Annual global medical equipment donations could reach 15 billion of Dollars [16] - [17]. Some of the equipment are donated as new or used, that means the recipient hospital owns the equipment but pays no acquisition cost. Some of the equipment are purchased through a tender process and being typically new, it means the hospital owns the equipment and an acquisition fee was also paid. And some of the equipment are loaned, meaning ownership rests with a third party and the hospital pays aleasing fee – typically only when the device is in-service. No matter how the equipment is acquired, little is known about why a substantial fraction of this medical equipment are out-of-service and unable to treat patients as expected. Several factors have been proposed to explain the lack of access to working medical equipment. First, more biomedical engineers and technicians are needed to maintain and repair equipment in low and medium income country (i.e., Africa, Latin America and some Asia countries) [18]. Second, for donated equipment, aid organizations that provide equipment often do not support the total cost of ownership including: spare parts, utilities, accessories, consumables like reagents, test equipment, technician training and service contracts or other meansof supporting installation, preventative maintenance, corrective maintenance and decommissioning [19]**.** Third, many donations of used equipment are inappropriate, especially considering the environmental factors and power supply requirements, or the equipment may be non-functional when donated.

According to a medical surplus donation study done by the Catholic Health Association of the United States (2011), [20]**,** of the Health Association's members' survey, 60% reported sending broken equipment. Finally, local access to spare parts, accessories, and consumables for all equipment and appropriate infrastructure to support equipment are limiting factors in many countries[21];

According to E. Geisler [7]**,** with many developments becoming known every day, health care facilities must be prepared to accommodate whatever the future holds. According to D. Woodroffe [22]**,** all health service providers want the best service to be provided and delivered, and to enable them to do so, they need to actively manage health service assets by ensuring that they are used effectively. The health service's most valuable assets are its human resources and physical assets, such as facilities and healthcare equipment [23].

If you say you work in a healthcare facility, most people think of a hospital or clinic, but even a brief look at the healthcare industry will show there are many options out there that might not be top-of-mind [24]. As more people seek accurate, holistic, and cost-effective care, the healthcare industry is opening new options and expanding its reach [25]. According to Tumukunde et al. [26]**,** specialized clinics and outpatient centers have appeared to help ease the burden on hospitals, and more long- term care facilities are rising to accommodate patients who need months or years of assisted healing [27]. Many people do not think twice about these facilities unless they need them. However, healthcare isa hot career destination for many, and it is good to know more about the facilities you may end up working in if you choose to pursue a healthcare career [28]. The presentation of the existing literature has been done to show the gaps in this literature and therefore the relevance of this thesis tosolve some of the highlighted gaps in the contest of Rwanda.

Chapter 3: Research Methodology

3.1 Introduction

The aim of this thesis was to assess medical equipment and facilities need in selected Rwanda hospitals for effective healthcare delivery in Rwanda. To get all required information one of methods used is the distribution of structured questionnaires in different district Hospitals. This session will also describe the site visited (i.e., where the data were collected from).

The results obtained were analyzed by the use of SPSS software (SPSS Inc., Chicago, IL 60606 United States). The statistical analysis was used for quantitative data analysis of the collected data. Additional method used was the reading of published articles and other projects related to the qualityof healthcare services, role of medical equipment in healthcare delivery and essential facilities in effective healthcare services. Thereafter, the analyzed data was compared with the international standards in order to present the gaps in medical equipment and facilities in Rwandan Hospital andto propose practical guidelines for the policy makers in healthcare sector in Rwanda.

In order to accomplish the project objectives, the steps illustrated in Figure 3.1 were followed.

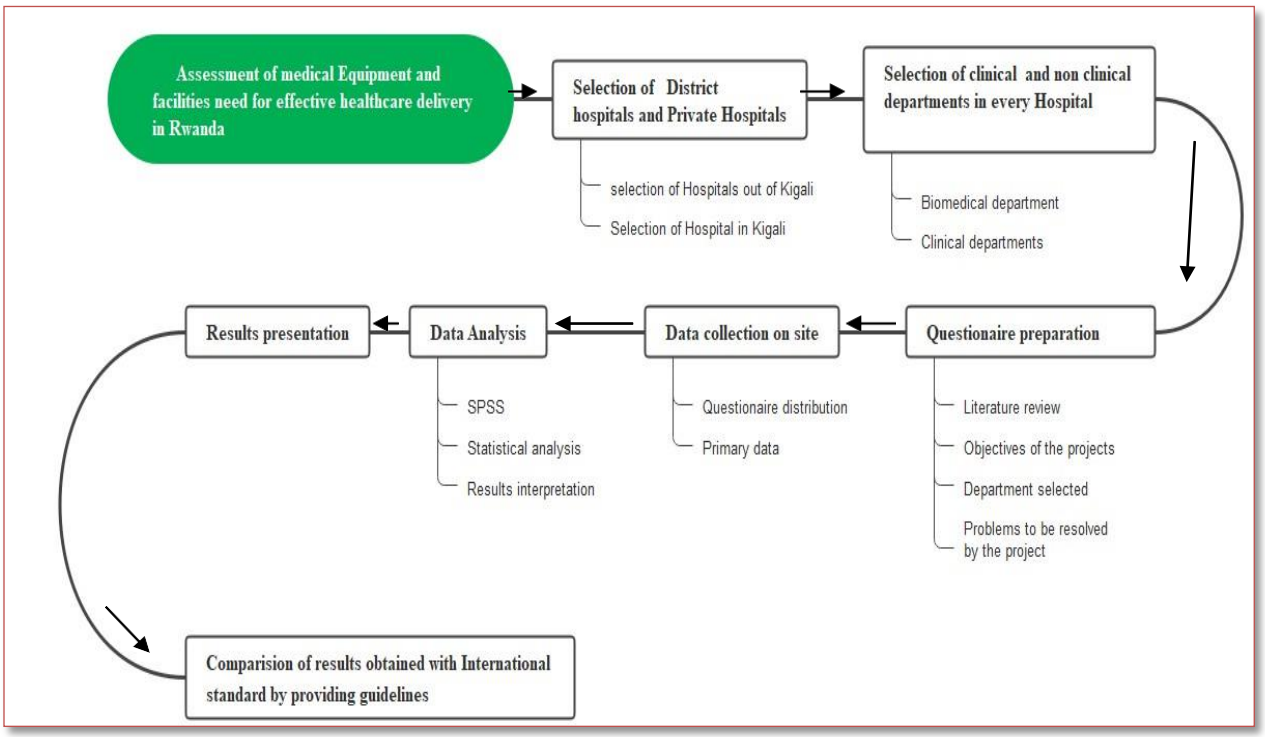

Figure 3.1: System component

3.2 Data Collection

The data collected and used in this research came from two sources: primary data and literature review data. Primary data are data that has been generated by me through surveys, specially designed for understanding and solving the research problem at hand.

3.3.1 Questionnaire Preparation

The questionnaire was designed in a way that captures the different views of management and the maintenance personnel as well as the equipment end users. The questionnaire was comprised of closed-ended and open-ended questions. Questions pertaining to equipment availability, available facilities; staff strength and service delivery were included in the questionnaire. Those questionnaires were distributed to the stakeholders in the clinical departments and in biomedical department in each of the hospitals selected and including the maintenance teams as well.

3.3.2 Settings and Participants

The study was carried out at six hospitals in Rwanda (i.e., five public hospitals, and one private hospital from three Rwandan provinces: East, West and Kigali). In each hospital, two or three respondents were chosen to answer the questionnaire. One respondent was from biomedical department (non-clinical) and another one from clinical department. In-depth, this study relied on medical equipment available in each selected hospital and facilities available as required factors affecting healthcare quality.

3.4 Data Analysis

The data which was obtained from the questionnaires was analyzed quantitatively and qualitatively. Under quantitative analysis, SPSS was used to present graphs and make comprehensiveinterpretation. SPS software is one of the easy-to-use, flexible and scalability statistical software program available and it is used in statistical analysis. The data obtained was also compared with theguidelines based on international standards.

Chapter 4: Results and Discussion

4.1 Introduction

Results of available medical equipment and facilities in different district hospitals and privatehospital in Rwanda are presented in this Chapter. Specifically, the staff strength and patients to be managed daily, monthly and annually are presented and discussed in this Chapter. The reasons why different district hospitals are not yet accredited are presented and discussed in this Chapter as well. The evidence based of many medical equipment in LIMCs, where Rwanda is located, are often outof services is presented and discussed in this Chapter. Guidelines that can help policy makers based on international standard are also presented in this Chapter.

4.2 Results

4.2.1 Questionnaire

The final questionnaire (see Appendix 1) consisted of 35 questions, organized in two parts: Part one is related to clinical departments and is composed of 22 questions on hospital information; staff performance, capacity building, patient population; capacity of the hospital and facilities. Part Two is related to biomedical department and is composed of 12 questions based on available medical equipment; process to extend life of equipment, medical equipment management team and facilities. The questions were of different type of dichotomous (Yes/No); multiple choice and part of them was quantitative assessment. The assessment was done based on two main departments of hospitals which are clinical department and non-clinical department. In the respondent view of the data from the field, for the clinical data around 78% of the respondents were female, while 22.2% were male (Figure 4.1) but for non-clinical department (i.e., biomedical department) all respondents weremales. This was because; no female was available to fill the questionnaire in the selected hospitals.

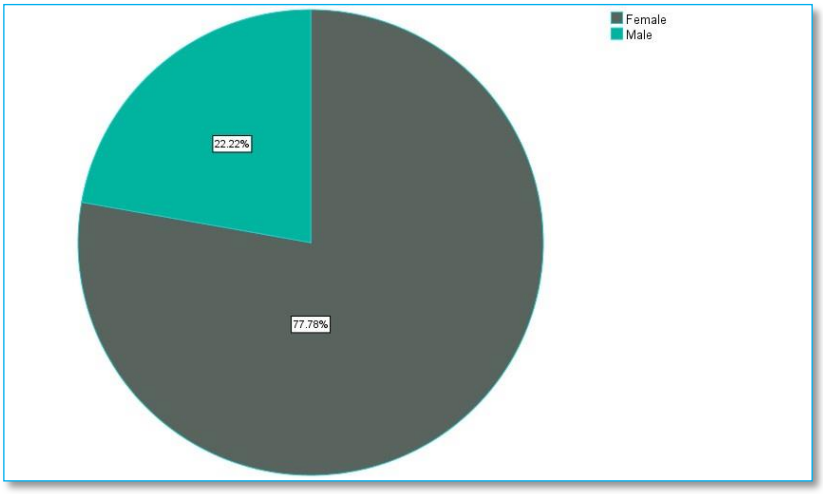

Figure 4.1: Respondents Gender

4.2.1.1 Questionnaire Part one.

This questionnaire is composed with two sections. The first covers personal identification of respondent. The second covers hospital information, process to extend life of equipment and Medical Equipment and facilities.

Figure 4.2 presents the respondent position (They are 6 respondents) based on their qualification and years of experience.

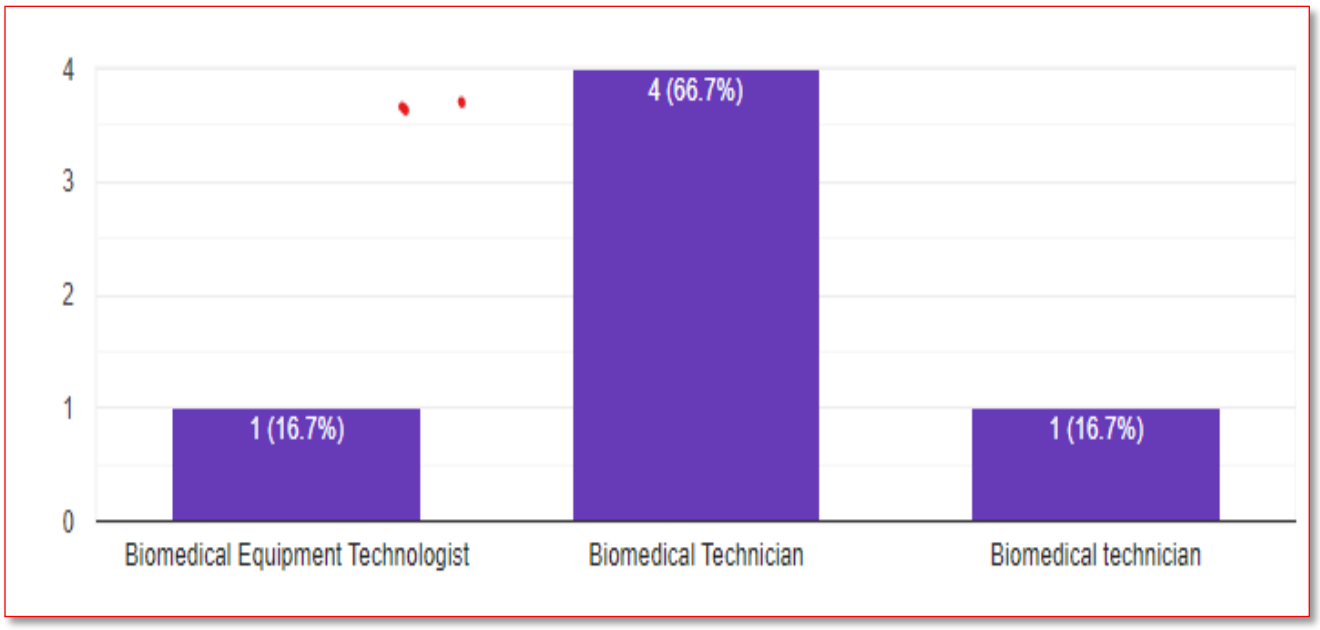

Figure 4.2: Respondent Position (Questionnaire I)

Figure 4.3 shows respondent index. It is clear that all respondents are male.

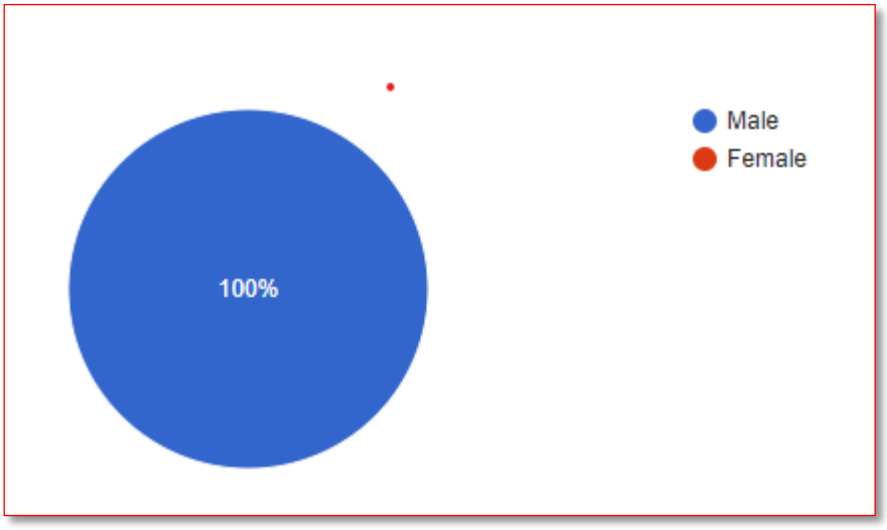

Figure 4.3: Respondent Index (Questionnaire I)

Figure 4.4 represents the respondent qualifications. There are four different qualifications namely Advanced diploma, Bachelor and Master Degree and also PhD holders. Respondents were only Bachelors 33.3 % and Advanced diploma 66.7%.

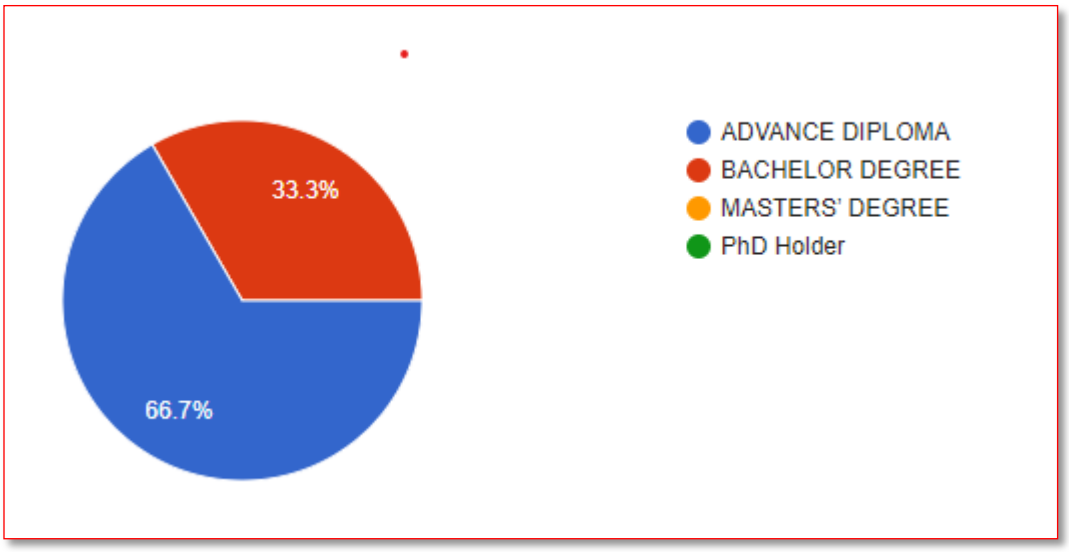

Figure 4.4: Respondent Qualifications

Figure 4.5 represents the respondents view on the requesting if they have an inventory in their hospital. It is clear that all hospitals have inventories.

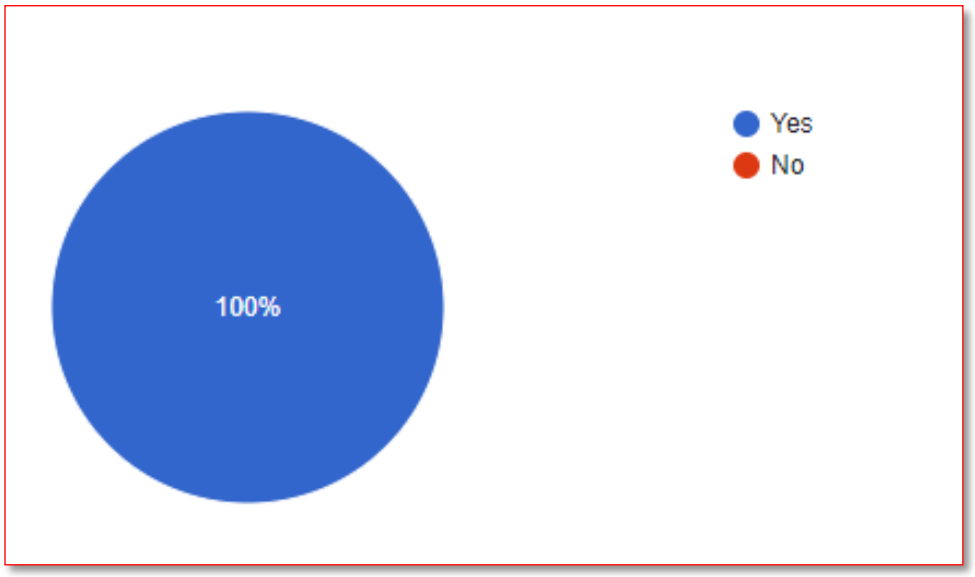

Figure 4.5: State of an inventory in different hospitals.

Figure 4.6 represents the number of equipment available in different hospitals. Maximum number was found to be 1003and minimum was 146.

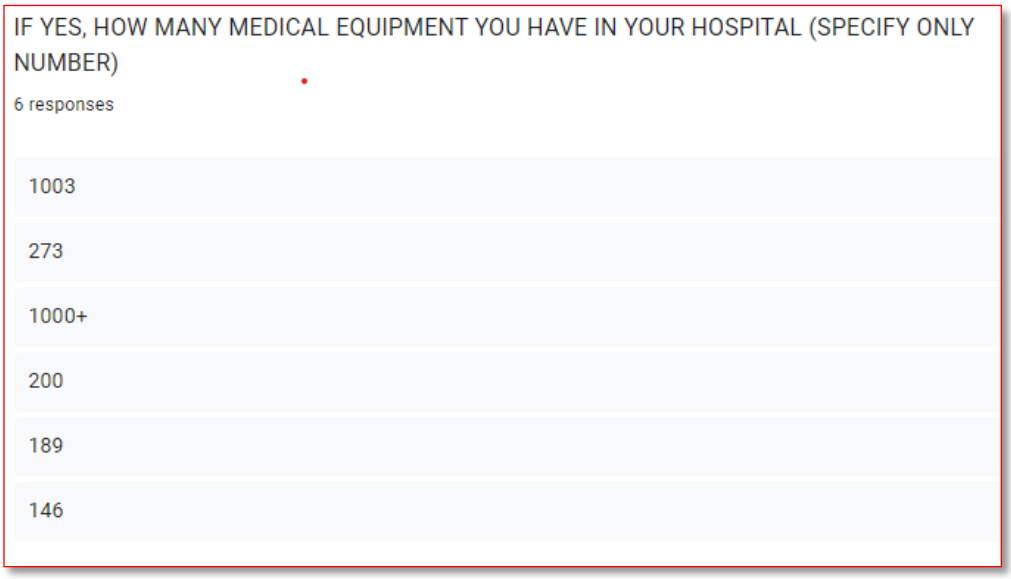

Figure 4.6: Number of Medical equipment in Hospital

Figure 4.7 represents the respondents' views on the availability of critical equipment in different hospitals.

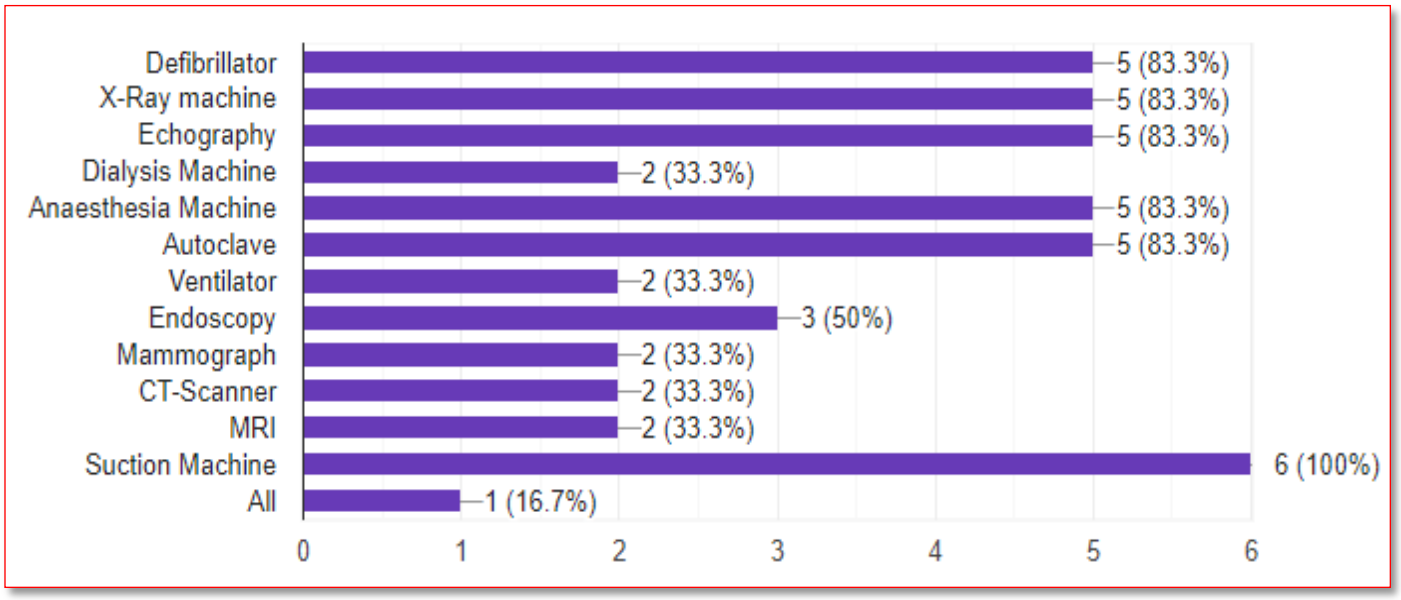

Figure 4.7: Availability of Clinical equipment in different Hospitals

Figure 4.8 represents the respondents' views on the types of facilities in different Hospitals

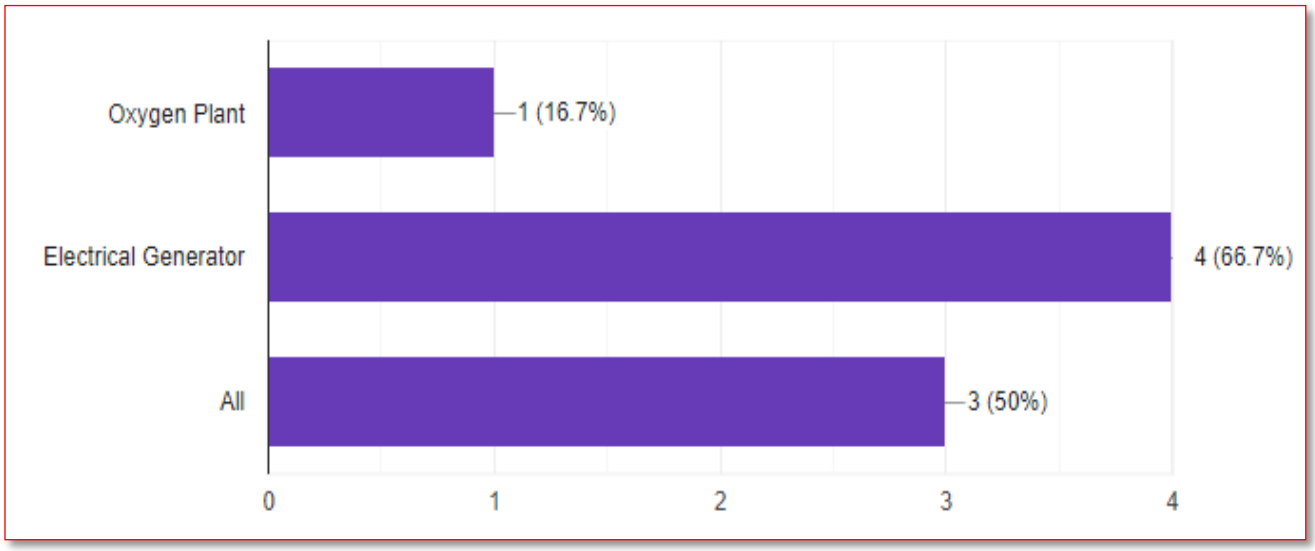

Figure 4.8: Types of facilities in different Hospitals

Figure 4.9 represents the respondents' views on doing Calibrations in different district Hospitals. Most of the respondents responded that they do calibration of their medical equipment.

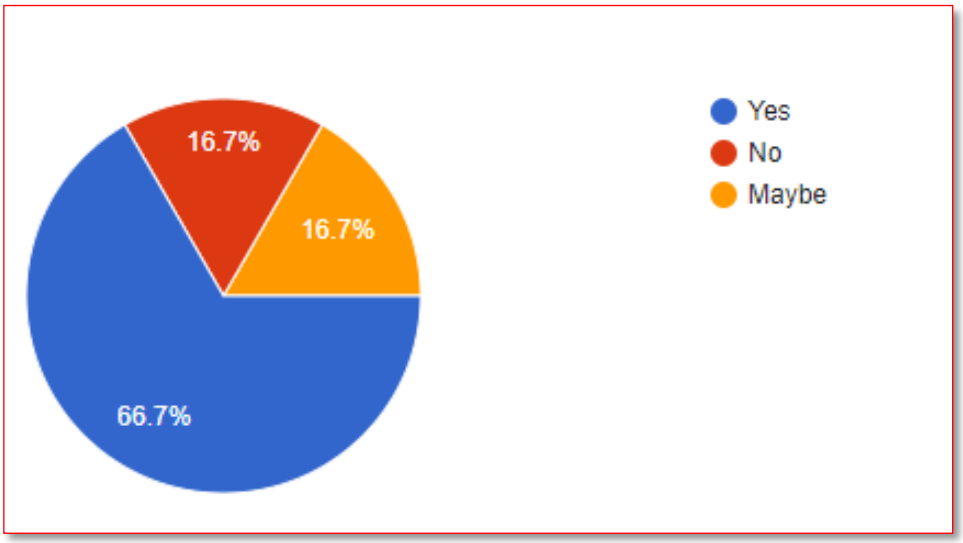

Figure 4.9: Status of doing Calibrations in different district Hospitals

Figure 4.10 represents the respondent view on Number of Engineers in different Hospitals. It was observed that some hospitals do not have Biomedical Engineers.

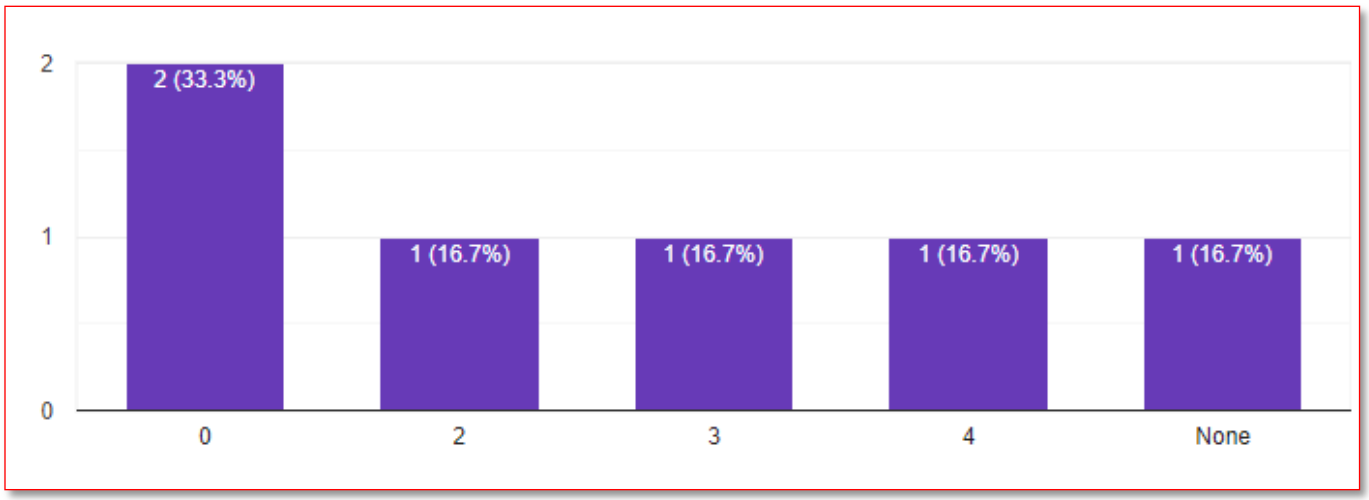

Figure 4.10: Status of Number of Engineers in different Hospitals

Figure 4.11 represents the respondents' views on Number of Technicians which are in different Hospitals.

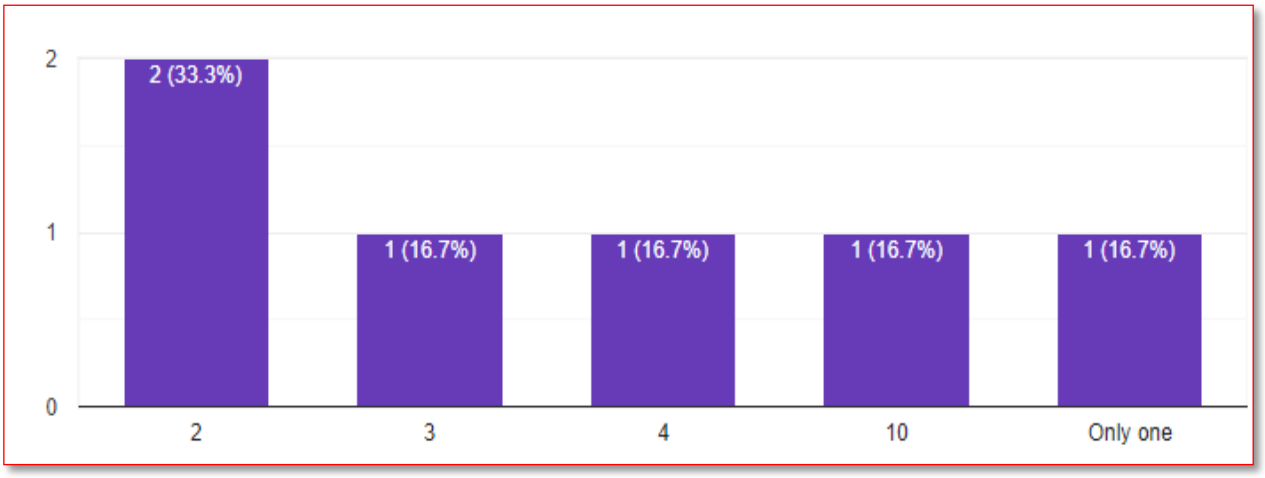

Figure 4.11: Status of Number of Technicians which are in different Hospitals

4.2.1.2 Presentation of Questionnaire (Part two).

The second questionnaire is composed of 2 sections. The first part comprises of personal identification of respondent. The second covers Hospital Information, staff performance, capacity building, capacity of your Hospital and facilities.

Figure 4.12 represents the respondents' Position (Questionnaire2). There are different positions like Data manager, Midwife, Nurses and specialists.

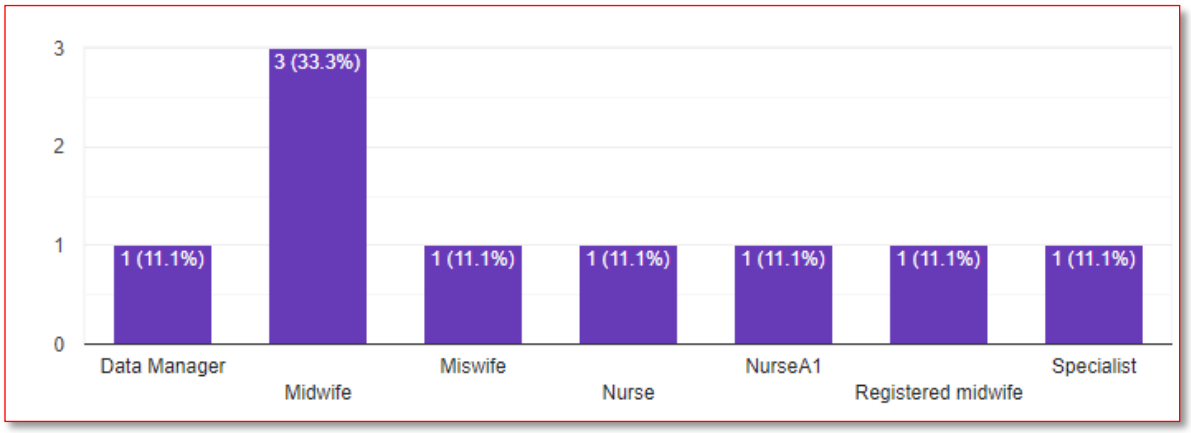

Figure 4.12: Respondent Position (Questionnaire2)

Figure 4.13 represents the respondents by their Gender. Percentage of Female was 77.8 % and male was 22.2%.

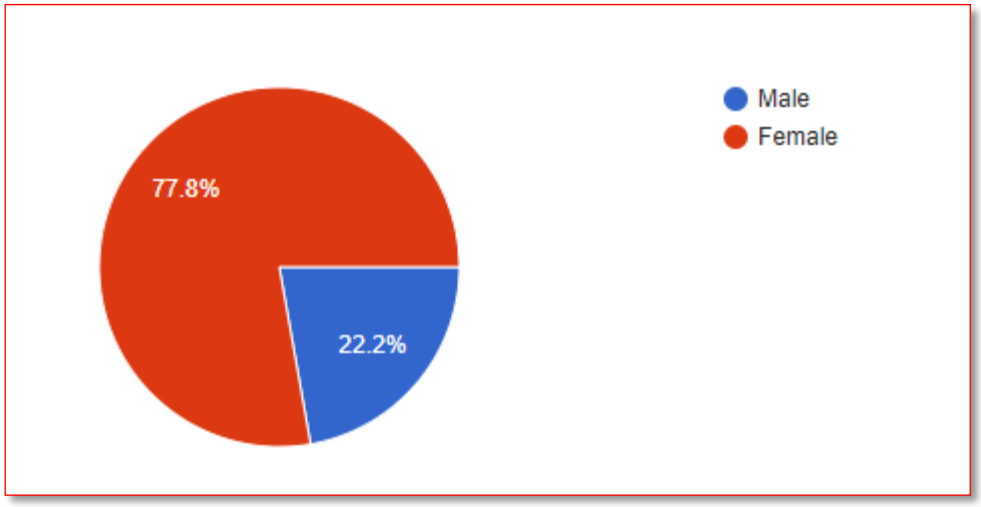

Figure 4.13: Respondent Gender

Figure 4.14 represents the respondents' qualifications. Most of them are advanced diploma.

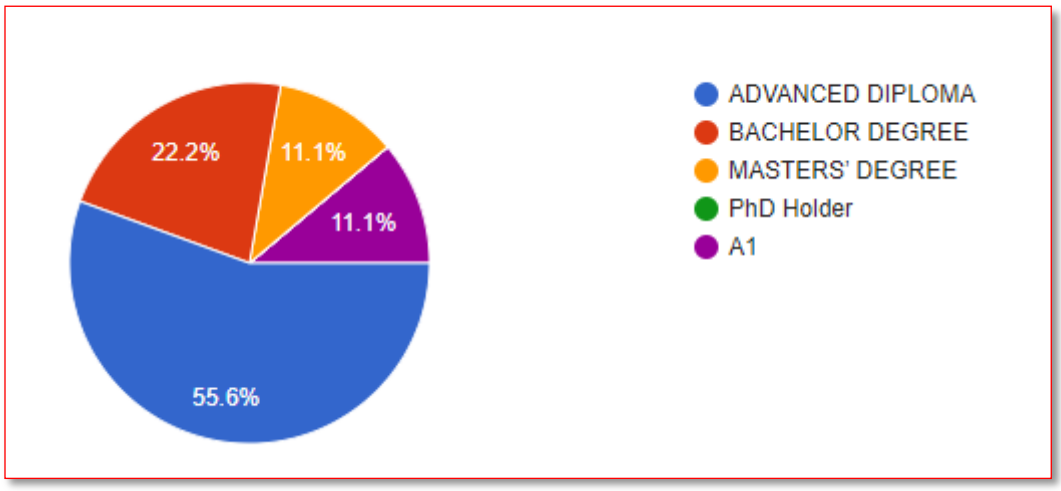

Figure 4.14: Respondents' qualifications

Figure 4.15 represents the respondents' Departments. There are clinical department and non clinical department. Most of the respondents are from clinical department.

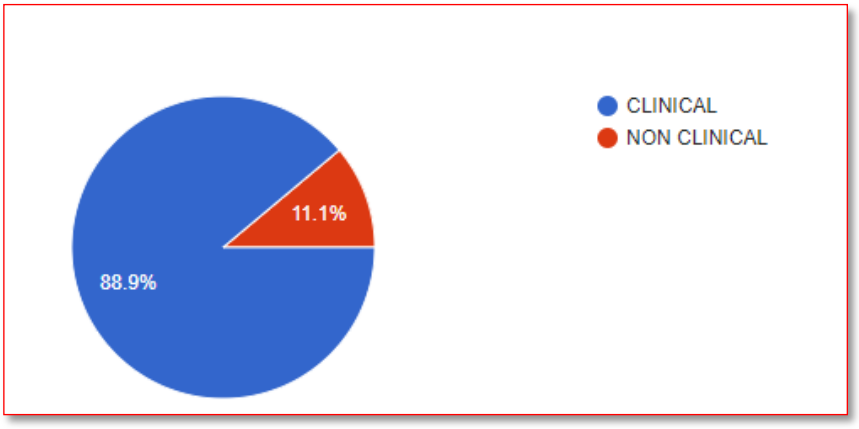

Figure 4.15: Respondents' Department

Figure 4.16 represents the number of clinical staff with doctorate Level in different Hospitals.

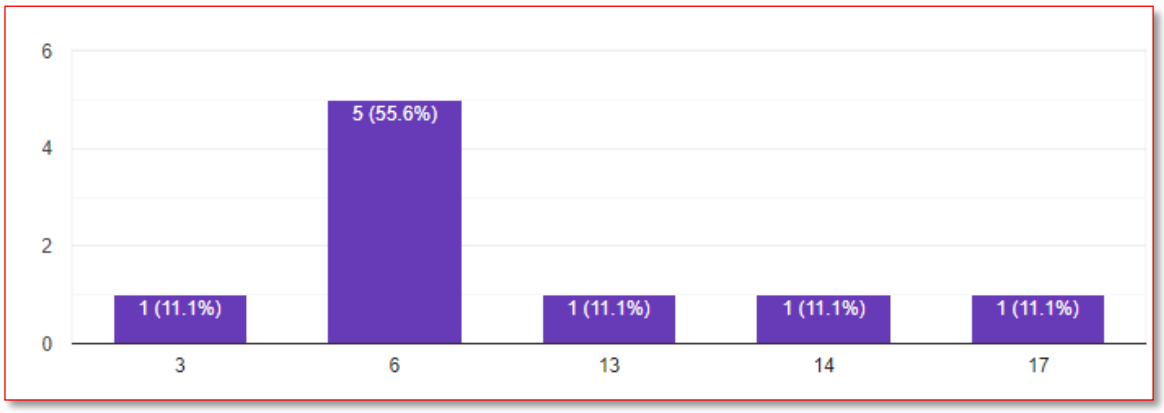

Figure 4.16: Number of clinical staff with doctorate Level in different Hospitals

Figure 4.17 represents the number of clinical staff who are at the technician level in different Hospitals.

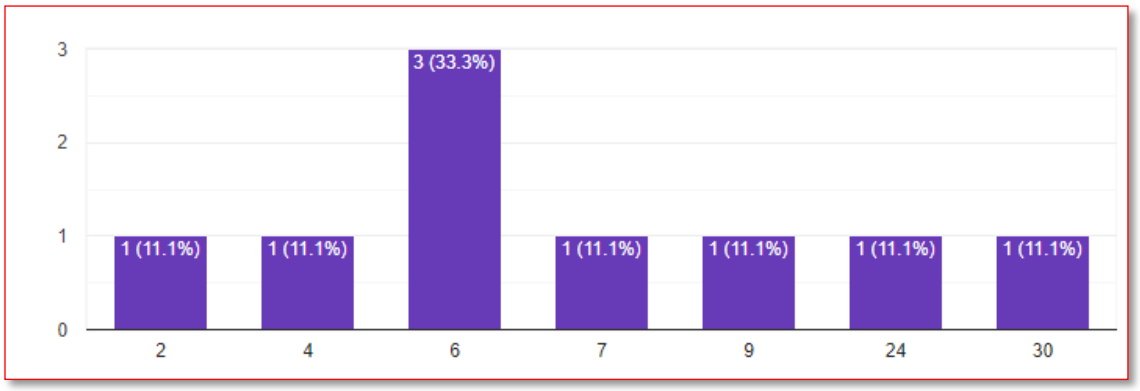

Figure 4.17: Clinical staff who are at Technicians Level in different Hospitals

Figure 4.18 represents the number of clinical staff who are at Nurses and Midwifery Levels in different Hospitals.

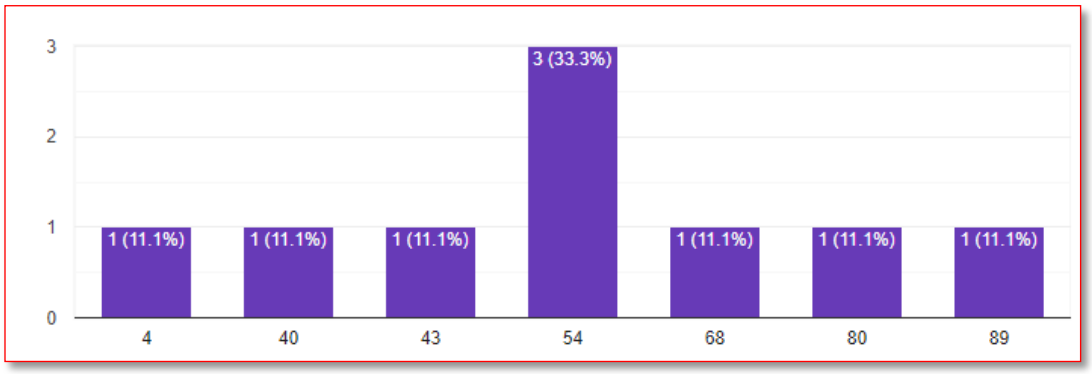

Figure 4.18: Clinical staff who are at Nurses and Midwifery Levels in different Hospitals

Figure 4.19 represents the respondent view on Capacity of Beds in different Hospitals. Most of hospitals have beds between 50and 200.

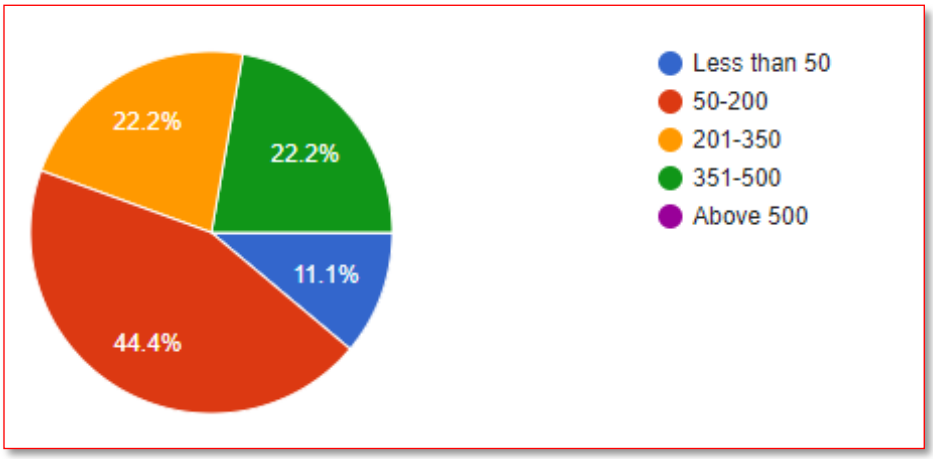

Figure 4.19: Capacity of Beds in different Hospital

Figure 4.20 represents the level of satisfaction for bed capacity in different Hospitals.

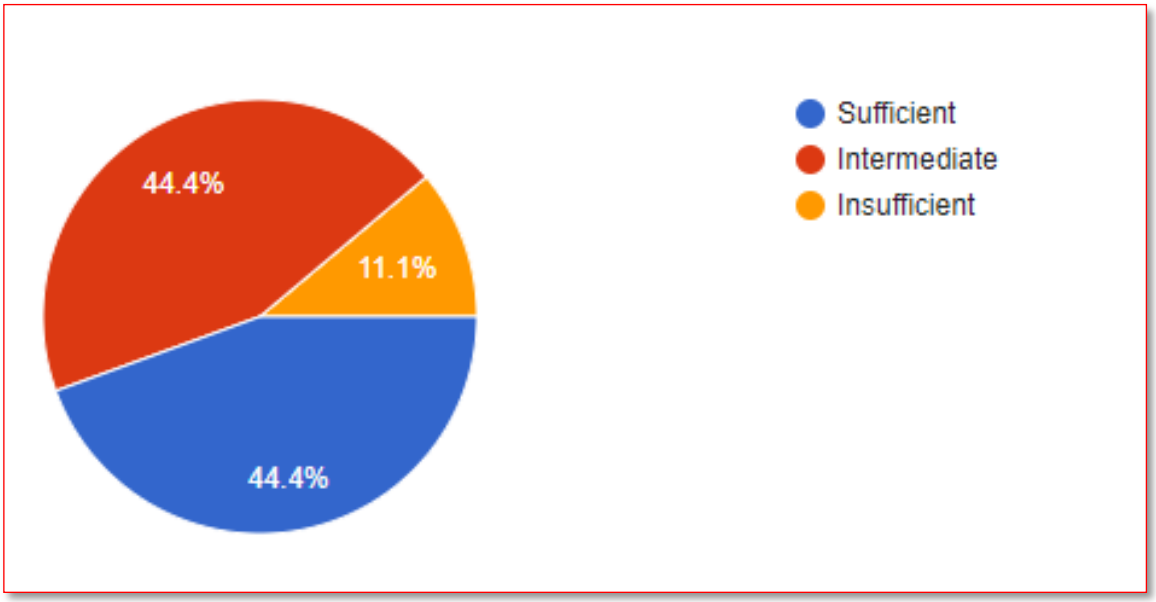

Figure 4.20: Level of Satisfaction for bed capacity in different Hospitals

Figure 4.21 represents the number of patient received per year in different hospitals. Most of hospitals receive more than 10,000 patients per year as presented by 77.8% of respondents.

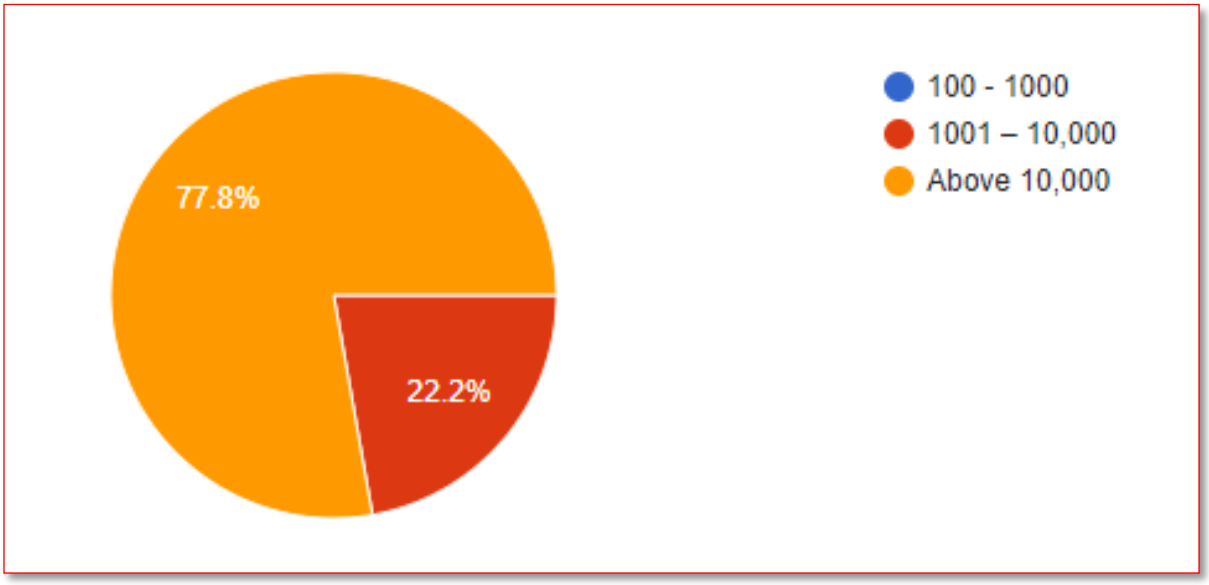

Figure 4.21: Number of Patient Received per Year in different hospitals

Figure 4.22 represents the number of patients received per month in different hospitals. Most hospitals receive more than 500 patients per month as presented by 77.8% of the respondents.

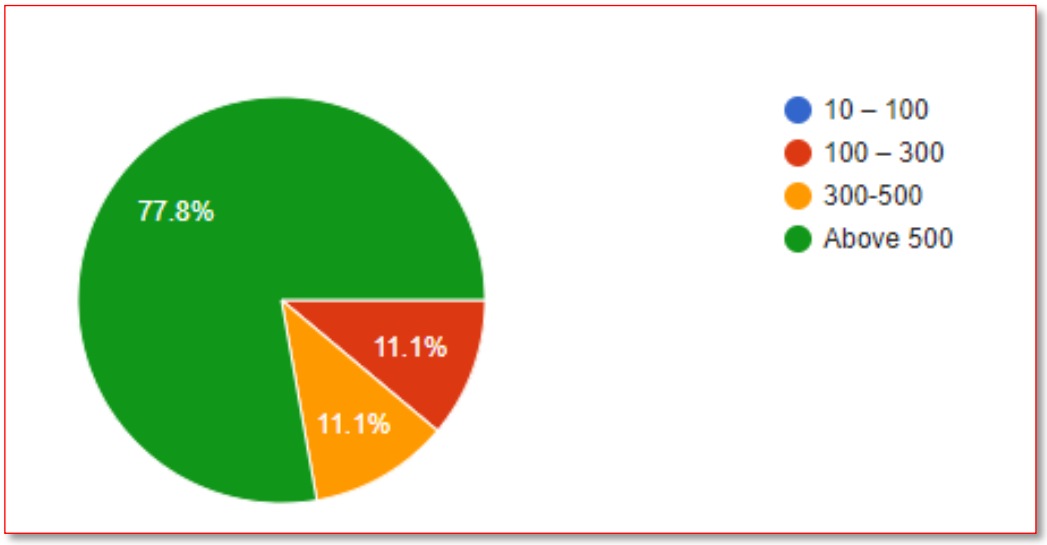

Figure 4.22: Number of patient received per month in different hospitals

Figure 4.23 represents the number of patient received per day in different hospitals. 88.9 % of responses indicated that most hospitals receive more than 100 patients per day.

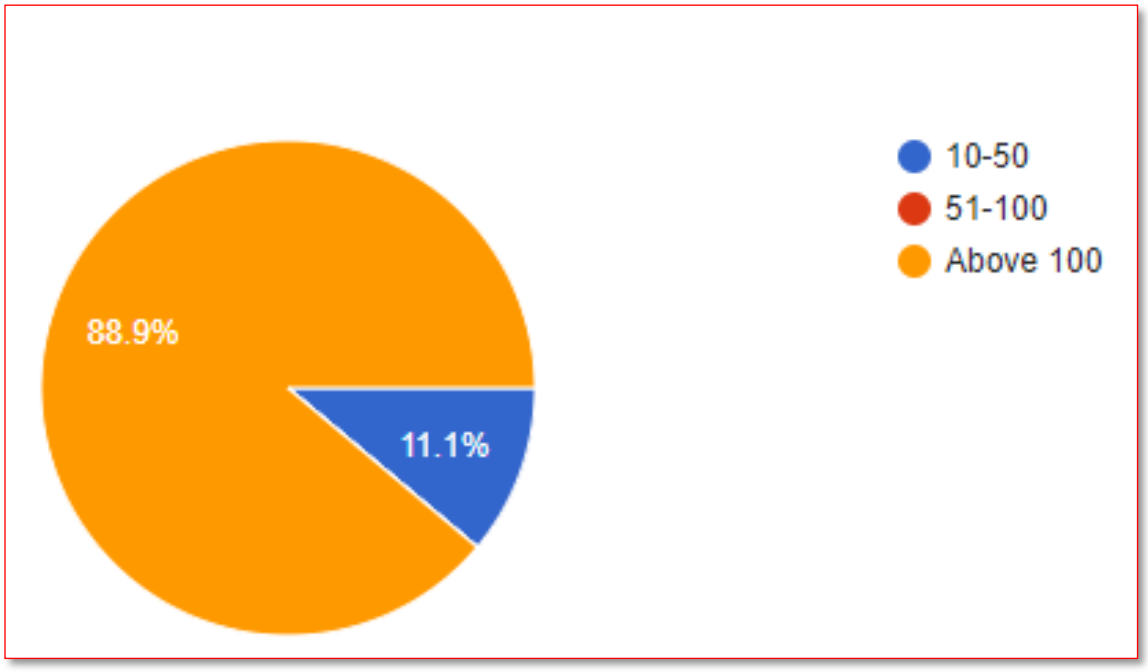

Figure 4.23: Number of Patient Received per day in different hospitals

Figure 4.24 represents the respondent view for the work performance of staff for the purpose of quality health care. Most of the staff are satisfied at the rate of 77.8%.

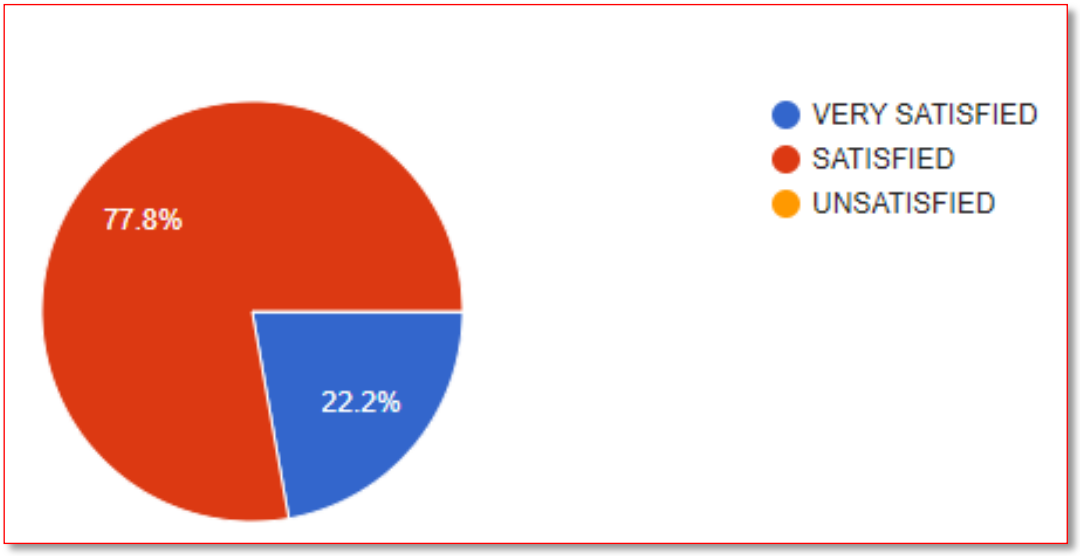

Figure 4.24: Work Performance of staff for the purpose of Quality Health Care

Figure 4.25 represents the respondents view on the requesting hospitals if they have equipment to be used for unexpected communicable diseases. All requested hospitals have the equipment tobe used.

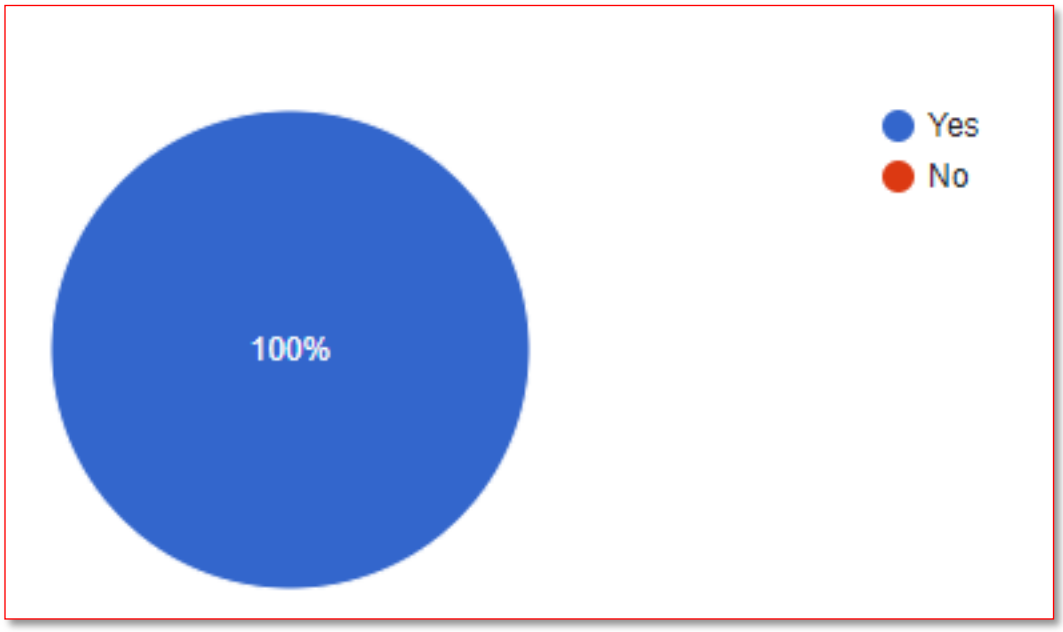

Figure 4.25: Status of equipment to be used for unexpected communicable diseases.

Figure 4.26 represents the respondents view on the material's types, modes and specifications used for unexpected communicable diseases in different hospitals.

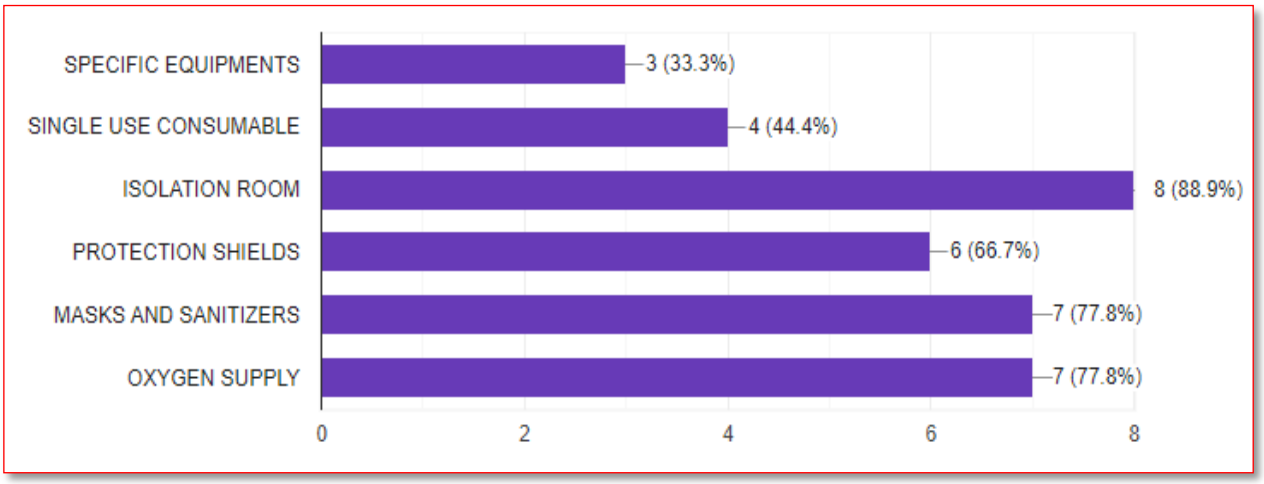

Figure 4.26: Material used for unexpected communicable diseases in different Hospitals.

Figure 4.27 represents the respondents view on the requesting hospitals if they do follow up on incidents. Most of the hospitals do follow up as indicated from respondents at 77.8%.

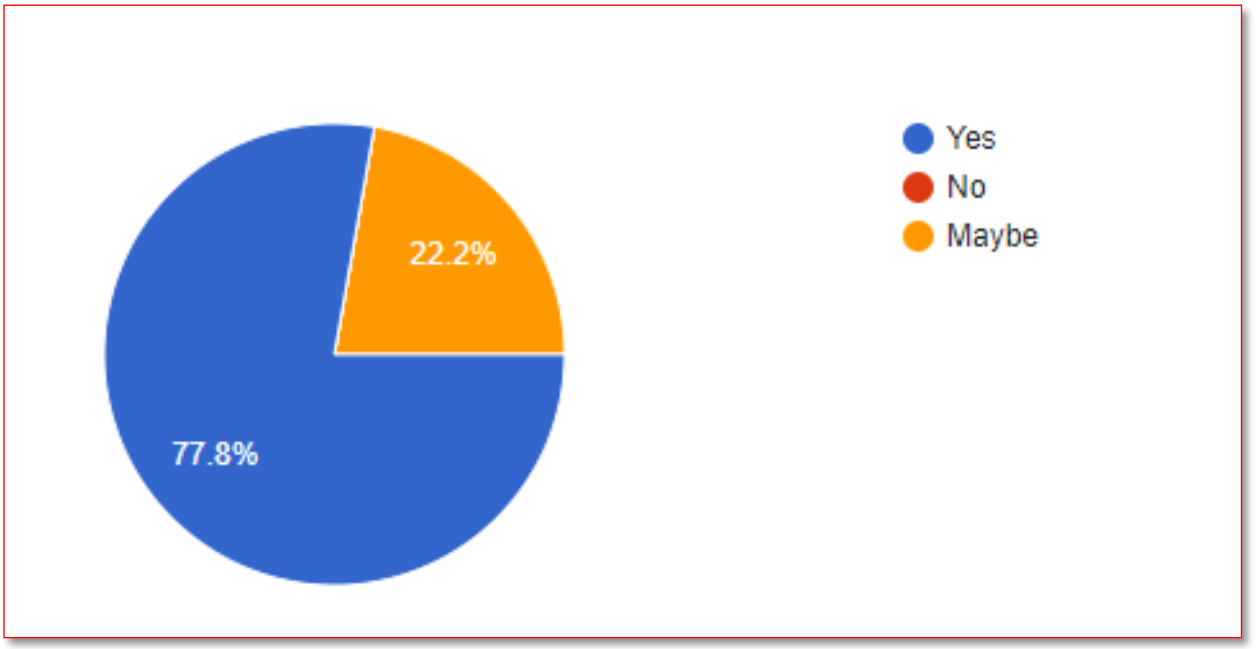

Figure 4.27: Responses of how hospitals make a follow up on incidents.

Figure 4.28 represents the respondents view on the measures taken by hospitals for persons who caused incidents. Most of the hospitals prepare the trainings.

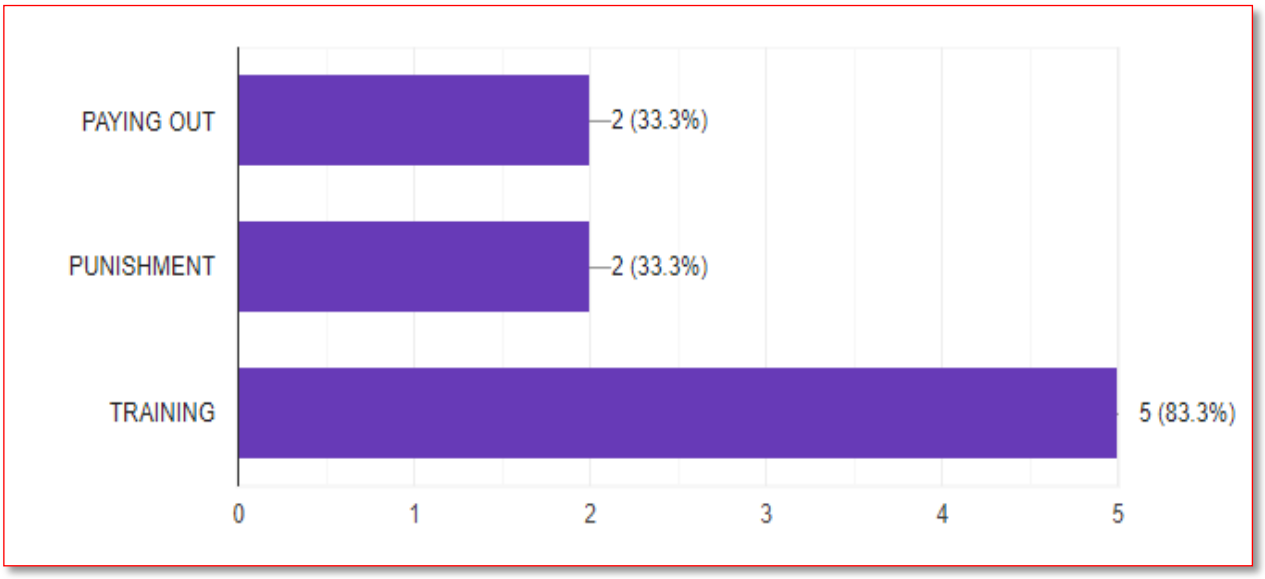

Figure 4.28: Responses for measures taken by hospitals for persons who caused incidents.

Figure 4.29 represents the respondents view on the method used by hospitals to repair equipment. Most of the hospitals use both internal staff and external consultancy.

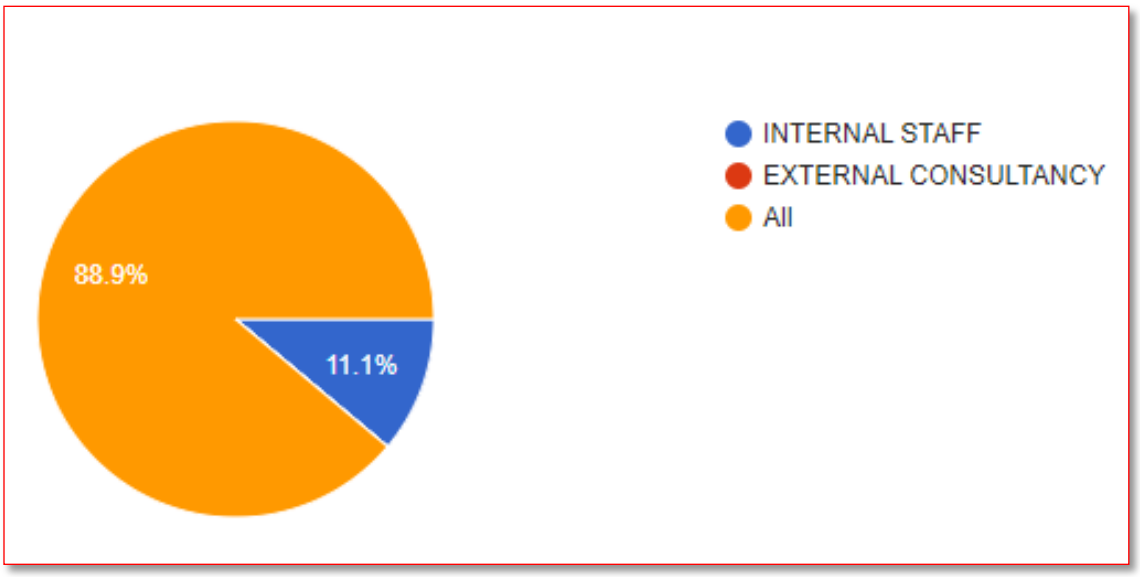

Figure 4.29: Responses on the method used by hospitals to repair equipment

Figure 4.30 represents the respondents view on the requesting hospitals if they have accreditation. Most of hospitals found to be accredited as indicated by 66.7%.

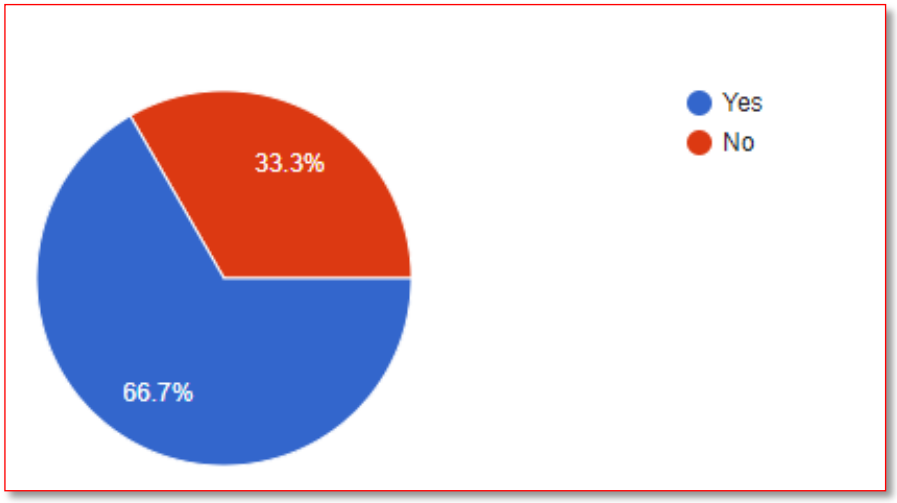

Figure 4.30: Hospitals which have accreditation.

Figure 4.31 represents the respondents view on the requesting hospitals what they miss to achieve because they do not have accreditation.

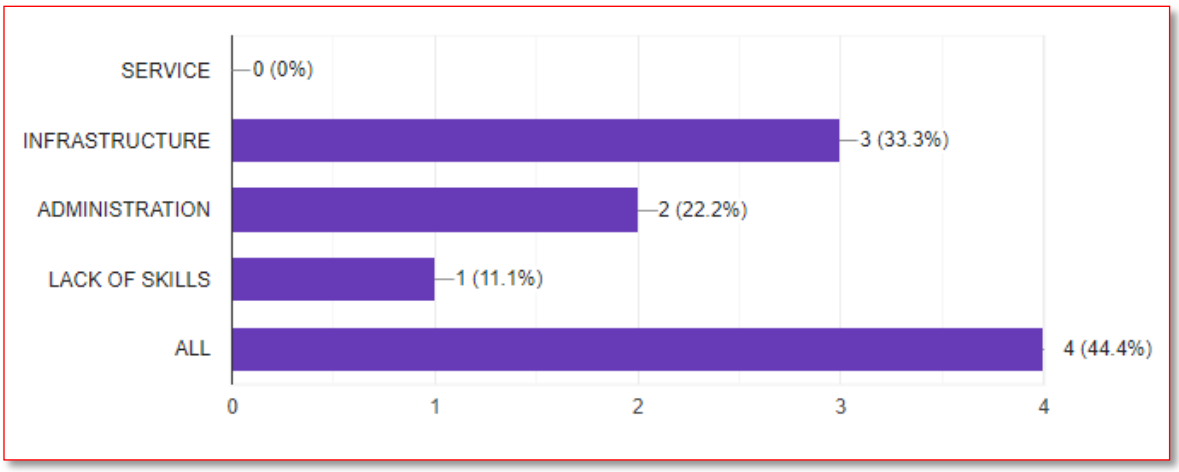

Figure 4.31: Percentages of what hospitals miss to achieve because they do not have accreditation.

Figure 4.32 represents the respondent's view on the requesting hospitals how they practice capacity building in their employees. Most of the respondents use trainings.

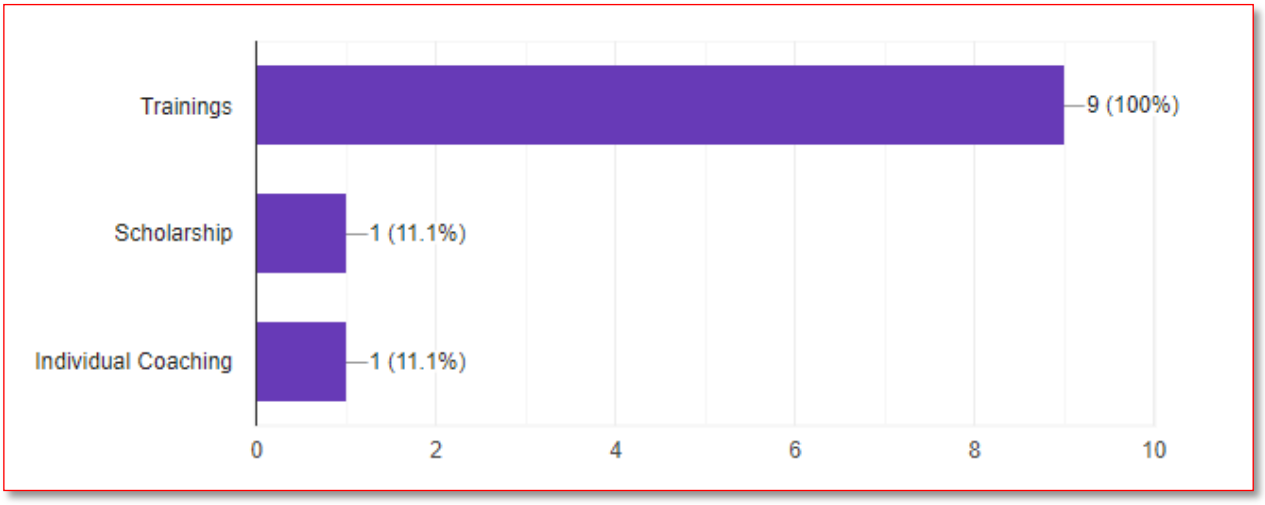

Figure 4.32: Hospitals and capacity building in their employees.

4.2.2 Statistical result

The following results are the results obtained after doing SPSS software analysis by using the statistical analysis method and showing the frequency and validity of the responses. There is also an interpretation of the statistical results that were discovered.

4.2.2.1. General Information about the Facility

Except for one private hospital, all of the hospitals evaluated are public. As regards access to electricity, all the hospitals can rely on the central supply; most of them have generators, and some do not have oxygen plants. *See Table 4.2* for further information.

Table 4.2: Sampling facilities that are applicable in the hospitals

		Frequency	Percent
Valid	All	2	33.3
	Electrical Generator	3	50.0
	Oxygen Plant	1	16.7
	Total	6	100.0

The result findings in *Figure 4.33* indicated number of beds in different district hospitals according to the percentages. The result findings mentioned in *Figure 4.33* means that many of the districthospitals have between 50 and 200 beds where they are represented by 44.4 % and those which have between 201 and 350 and those which have 351 and 500 have 22.2% respectively.

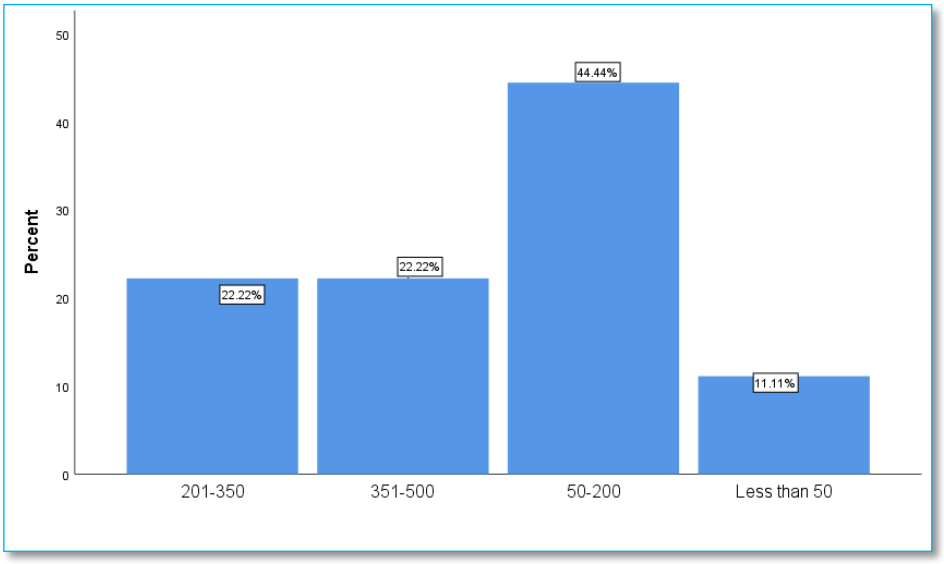

Figure 4.33: Distribution percentage of hospital with their capacity of the beds

The results presented in *table 4.3* shows valid percentage of beds capacity in the assessed hospitals where 44.4% of assessed hospitals have intermediate of beds; 44.4 % are sufficient and 11.1% show insufficient of bed.

Table 4.3: Percentage of beds capacity in the hospitals

Valid Percentage of beds capacity in the Hospitals			
		Frequency	Percent
	Insufficient	1	11.1
	Intermediate	4	44.4
	Sufficient	4	44.4
	Total	9	100.0

4.2.2.2 Human Resources

I. Staff strength

The maximum number of clinical staff with specialist level in all assessed hospitals is 12, and some DH (district hospitals) do not have any specialists; the maximum number of clinical staff with doctor level in all assessed hospitals is 17; the maximum number of clinical staff with technician level in all assessed hospitals is 30; and the maximum number of clinical staff with nurses and midwives level is 89. For more details in *table 4.4* here below.

Table 4.4: Descriptive statistics of clinical staff of the hospitals

Descriptive Statistics					
	No	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Clinical Staff With Specialist Level	9	0	12	4.11	3.408
Clinical Staff With Doctor Level	9	3	17	8.56	4.799
Clinical Staff With Technician Level	9	2	30	10.44	9.697
Clinical Staff With Nurses & Midwife Level	9	4	89	54.00	24.784

In all of the nine respondents from the six hospitals where the interview were conducted, Nurses Midwifes, and technicians are more dominant than other staff in the district hospitals with the mean values of 54 and 10.44, respectively. In the district hospitals, there were a few numbers of specialists and general medical practitioners with the mean values of 4.11 and 8.56, respectively. The reason why district hospitals are more likely to have a few number of specialists is that some of them are near either referral hospitals or provincial hospitals where they can transfer patients easily if it is an emergency case.

II. Patient Population

Table 4.5 shows the patient population to be managed in all assessed hospitals where 77.8% receive above 10,000 patients per year.

Table 4.5: Patients received per year

Patients	Frequency	Percent
1001 - 10,000	2	22.2
Above 10,000	7	77.8
Total	9	100.0

Table 4.6 shows the distribution percentage of patients received per month. 77.8 % of requested hospitals receive above 500 Patients.

Table 4.6: Distribution percentage of patients received per month

Distribution Percentage of Patients Received Per Month			
Patients		Frequency	Percent
Valid	100 - 300	1	11.1
	300 - 500	1	11.1
	Above 500	7	77.8
	Total	9	100.0

Table 4.7 shows the distribution percentage of patients received per month. 88.9 % of requested hospitals receive above 100 Patients.

Table 4.7: Distribution percentage of patients received per day

Distribution Percentage of Patients Received Per Day			
Patients		Frequency	Percent
Valid	18537	1	11.1
	Above 100	8	88.9
	Total	9	100.0

4.2.2.3. Medical Equipment and Management

Figure 4.34 shows the distribution of critical MDs within the six hospitals. Based on the clinical department available in the hospital, the medical equipment is available at a certain parcentage in the assessed hospitals.

- Imaging department: Mammographs, and CTscanners are rare find with a percentage of 33.33%, and 16.67% for MRI; X-ray machines and Echography are available at 83.33%.
- Surgery department: Anesthesia machines and Autoclave are available at 83.33%, suction machines available in all assessed hospitals.
- Emergency service: Ventilators are rare available at the percentage of 33.34% and Defibrillators are available at 88.33%
- Internal medicine services: dialysis machine are rare find at 33.34% and Endoscopy was also rare find at 50.01%

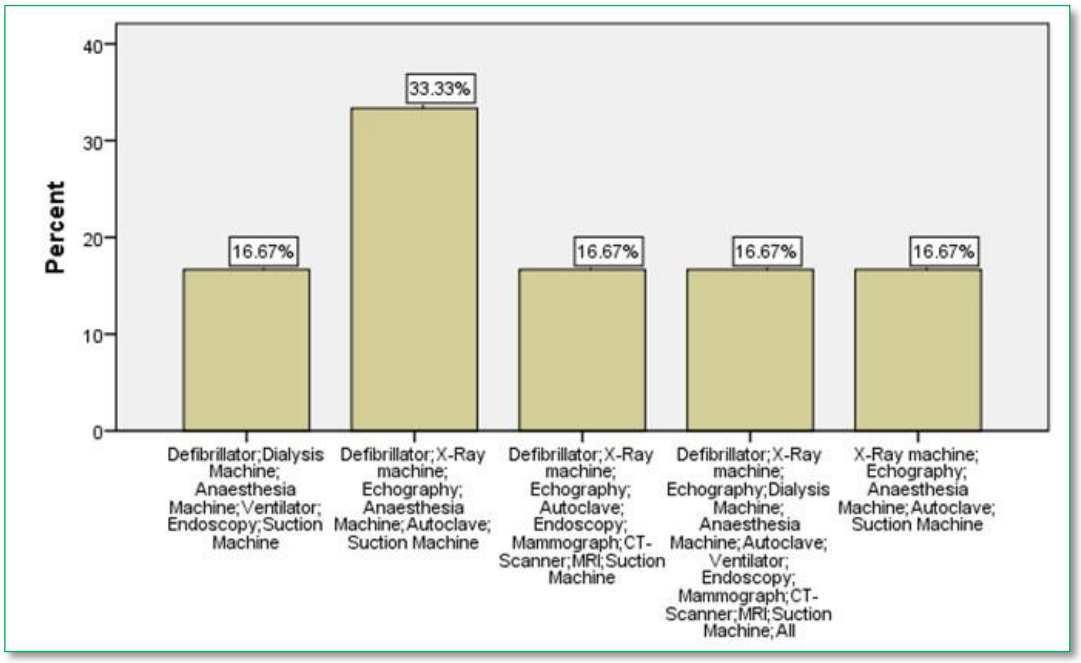

Figure 4.34: Distribution percent of the biomedical equipments which are available in the hospitals

All the assessed hospitals have a maintenance department. The approach to medical device maintenance varies depending on the facility. Most of the structures that have a maintenance department are in charge of preventive and corrective maintenance, with the exception of three hospitals that only follow corrective maintenance practices.

Table 4.8 presents that 50% of assessed hospitals do not have biomedical engineer other have at the maximum four engineers.

Table 4.8: Status of engineers in different hospitals

Status of Engineers in different Hospitals					
		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	0	3	50.0	50.0	50.0
	2	1	16.7	16.7	66.7
	3	1	16.7	16.7	83.3
	4	1	16.7	16.7	100.0

	Total	6	100.0	100.0	

The table 4.9, shows that the mean of biomedical engineers in Hospital is less than that of biomedical technician, that means that the number of biomedical engineers is lower that the number of the technician.

Table 4.9: Statistics of engineers and technicians in different hospitals

Statistics			
		How Many Engineers Do You Have In Your Hospital	How Many Technicians Do You Have In Your Hospital
N	Valid	6	6
	Missing	0	0
Mean		1.50	3.67
Median		1.00	2.50
Std. Deviation		1.761	3.266

As regards the management, all the hospitals have a form of inventory with different numbers of medical equipment see *table 4.10.*

Table 4.10: Cumulative counts of the equipment, which are available in the hospitals' inventories

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	1000+	1	16.7	16.7	16.7
	1003	1	16.7	16.7	33.3
	146	1	16.7	16.7	50.0
	189	1	16.7	16.7	66.7
	200	1	16.7	16.7	83.3
	273	1	16.7	16.7	100.0
	Total	6	100.0	100.0	

As it is seen in *table 4.11,* all assessed hospitals except two hospitals have calibration tools.

Table 4.11: Status of calibration of medical pieces of equipment in hospitals.

Calibration of Medical Equipment.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maybe	1	16.7	16.7	16.7

	No	1	16.7	16.7	33.3
	Yes	4	66.7	66.7	100.0
	Total	6	100.0	100.0	

4.3. Results discussion

This assessment was carried out to assess the medical equipment and facilities needed in different Rwandan hospitals to deliver effective healthcare. Quality in healthcare, according to Mosadeghrad AM in [29] is the result of collaboration between the patient and the healthcare provider in a supportive environment. Based on the WHO report about Rwanda [30], there is a shortage of skilled health professionals and an increased need for quality health products to ensure the appropriate delivery of health services.

In this research, the number of specialists and doctors is lower compared to the patients received in different hospitals because the maximum number of doctors is 17 and the patients received are more than 10,000 per year. The numbers of nurses and midwives are the biggest factor in the quality of service delivery in the Rwandan hospital, but based on the Rwanda official gazette special of September 1, 2020 [31]**,** the number of doctors, nurses, and midwives proposed for different district hospitals is not achieved; there is still a gap. Based on the Rwandan annual report 2017–2019 (13), the doctors per population ratio was 1/8,294 in 2019; the nurses per population ratio was 1/1420 in 2019; the midwives per population ratio was 1/2,889 in 2019, and the national target is one doctorper 7,000 in 2024, as set in HSSP IV. The gap is still there because WHO recommends having one doctor per 1000 people. Based on Rwanda accreditation standards/risk area 2 standard #6, staff must be sufficient to meet patient needs [32], because hospitals often function with fewer specialist staff and resources, making them unsuitable for the management of complex cases [33]**.**

The assessment has shown that all assessed hospitals have the necessary facilities like electricity and generators, but not all have an oxygen plant, which is more important in facilitating effective healthcare for patient with a respiratory problems. As we are in *the COVID-19* pandemic, it is better to have an oxygen plant in all district hospitals.

By comparing the capacity of the assessed hospitals with the number of patients received per year (***table 4.12***) and based on the responses from respondents, 11.1% represent insufficient beds in hospitals, 44.4 represent intermediate beds, and only 44.44% represent sufficient beds in the

assessed hospitals. There is also a lack of infrastructure, services, and skills, and all of them have an impact on good healthcare delivery and influence the lack of hospital accreditation.

Table 4.12: Relationship between patients received per year with the capacity of the hospital

Relationship between patients received per year with the capacity of beds hospital has						
		Capacity of Beds In The Hospital				Total
		201-350	351-500	50-200	Less than 50	
Patients Received Per Year	1001 - 10,000	0	0	1	1	1
	Above 10,000	2	2	3	0	7
Total		2	2	4	1	9

In this research, all assessed hospitals have an inventory document with clear information about the numbers and types of medical equipment they have, but they do not have all the necessary critical equipment according to the services they provide. Inpatient and outpatient surgery, laboratory services, gynecology and obstetric services, radiology services, mental health services, dental services, and eye services are available at all district hospitals. The medical equipment required in every service is based on the medical clinic equipment list [34] and the medicines and healthcare products regulatory agency [35] and other research is outlined in *table 4. 13.*

Biomedical technicians or engineers are the backbone of the biomedical department. Technical support for HTM ensures biomedical equipment is functioning according to regulatory and manufacturer specifications. Activities include but are not limited to preventative maintenance,calibration, and repair of medical devices; training clinicians on the devices; and maintaining all documentation relating to preventive maintenance and repairs. Gather information and provide the first response to adverse events involving biomedical equipment. Provide support in the assessment and selection of new devices [36]. According to this study, there is a shortage of biomedicalengineers or technicians in all of the hospitals studied, despite the large amount of equipment they must manage. 33.3% of assessed hospitals do not have any biomedical engineers and only 33.3% of assessed hospitals have two biomedical technicians. Based on the Rwanda Official Gazette 2020, theminimum number of biomedical engineers or technicians must be 2. They also have to do medical equipment calibration, which is the process of determining, checking, and rectifying the setting or graduation of equipment and defining the accuracy and quality of measurements recorded.

Based on *Table 4.11*, 80% of the assessed hospitals have calibration tools and they do calibration, but 20% not, which leads to the low accuracy of their medical equipment, especially for measurement devicesand affects the quality of services delivered.

Table 4.13: Guidelines on medical equipment required based on hospital services

Hospital services	Equipment required
OPD	Stethoscope BP machine Mobile lamp Otoscope X-ray view box Ophthalmoscope
Surgery	surgical light Surgical table Electrosurgical unit Anesthesia machine Suction machine Autoclave/sterilizer
Laboratories	Hematology analyser Biochemistry analyser Centrifuge
Gynecology/obstetric	Stethoscope BP machine Mobile lamp Fetoscope Ultrasound
Radiology	x-ray machine Ultrasound EKG/ECG Mammograph CT-scanner
Mental health	Stethoscope BP machine Mobile lamp

dental	dental chair OPG X-ray Sterilisation machine Cement Spatula
Eyes	Torch Retinoscope Direct ophthalmoscope A Scan keratometer

Summary

The collected and analyzed data are discussed in this chapter. The patient-to-health ratio recommended by the WHO was also presented in this chapter. The gap found in different district hospitals regarding medical equipment, facilities, and biomedical staff is presented and discussed. Guidelines on medical equipment required in every service to follow based on Rwandan accreditation standards, MOH standards, and international standards are also well presented.

Chapter 5: Conclusion and Recommendation

5.1 Conclusion

The research has the objective of assessing the medical equipment and facilities available in selected Rwandan hospitals. The assessment was done in six hospitals, and different responses were received from the respondents. It was discovered that, while medical equipment is readily available in some hospitals, it is not in others. In terms of medical equipment management, biomedical engineers and technicians are in short supply when compared to the number of pieces of equipment to manage, which necessitates the use of external maintenance support because biomedical is the backbone of healthcare services, resulting in a large number of outsourced medical equipment services.

All assessed hospitals have facilities such as electricity and generators but not all have oxygen plants. By comparing the capacity of the assessed hospital with the number of patients received per year and based on the responses from respondents, 11.1% represents insufficient beds in the hospital and 44.4 represent intermediate and only 44.44% represent sufficient beds in assessed hospitals. All district hospitals do not have accreditation because of a lack of adequate infrastructure, services, and skills. As there is currently a lack of guidelines developed that show all necessary medical equipment required for a hospital based on service delivery in Rwanda hospital, this thesis has developed guidelines that may guide the policy maker in the healthcare sector.

5.2 Recommendations

5.2.1 Ministry of Health in Rwanda

To improve health care delivery, based on the high quality of medical equipment, Ministry of Health recommended to increase the number of Biomedical Engineers and Technicians to be employed, trained, and deployed to the hospital.

The Ministry of Health is also recommended to align well with the rules and regulations found in the health sector at the standard level to increase medical equipment and facilities in hospitals. It is also important for the Ministry of Health to develop policies governing medical equipment requirements and management in hospitals based on services and patient population.

As the biomedical department is the backbone of healthcare delivery, it is recommended that MOH collaborate with polytechnics and UR (University of Rwanda) to increase the number of biomedical departments in their institutions to increase the number of biomedical technicians and engineers.

5.2.2 Rwandan Hospitals

Rwandan hospitals are recommended to facilitate university students and researchers in exploring different data and getting necessary information that can help improve the Rwandan health sector.

As the quality of healthcare services is influenced by the environment, district hospitals are recommended to improve their infrastructure.

5.2.3 Future Researchers

To improve this research, future researcher has to assess all Rwandan district hospitals to elaborate on all gaps related to medical equipment and their management and facilities needed to increase the quality of healthcare services in Rwanda.

Based on the volume of services, future researchers have to improve their research by indicating the number of every type of medical equipment required.

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Appendix

Questionaire Part I

This questionnaire is composed of two sections. Section 1 personal identification of respondent. Section2 covers Hospital Information, process to extend life of equipment and Medical Equipment and facilities.

No	Questions	Responses	
1	Respondent Position		
2	Respondent Sex	• Male • Female	▭ ▭
3	Respondent Qualification	• Diploma • Bachelor • Master's • PhD Holder • Other	▭ ▭ ▭ ▭ ▭
4	Respondent Department	• Clinical • Non-clinical	▭ ▭
5	Do you have an inventory in your hospital?	• Yes • No	▭ ▭
6	If yes, how much medical equipment do you have in your hospital ? (specify only the number)		
7	Specify which type of critical equipment you have in your hospital in the following	• Defibrillator • X-Ray Machine • Echography • Dialysis Machine • Anaesthesia Machine • Autoclave • Ventilator • Endoscopy • Mammography • CT-Scanner • MRI • Suction Machine • All	▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭ ▭
8	Which types of facilities do you have in your hospital?	• Oxygen plant • Electrical generator • All	▭ ▭ ▭
9	Do you do calibration of medical equipment?	• Yes • No • Maybe	▭ ▭ ▭

10	If yes, do you have calibration tools?	• Yes • No	☐ ☐
11	How many engineers do you have in your hospital?		
12	How many technician do you have in your hospital?		

Questionaire Part II

This questionnaire is composed with two sections. Section 1 personal identification of respondent. Section2 covers Hospital Information, staff performance, capacity building, capacity of yourHospitaland facilities.

No	**Questions**	**Responses**	
1	Respondent Position		
2	Respondent Sex	• Male • Female	☐ ☐
3	Respondent Qualification	• Diploma • Bachelor • Master's • PhD Holder • Other	☐ ☐ ☐ ☐ ☐
4	Respondent Department	• Clinical • Non-clinical	☐ ☐
5	How many clinical staff do you have in your hospital with Specialist level?		
6	How many clinical staff do you have in your hospital with Doctor level?		
7	How many clinical staff do you have in your hospital with technician level?		
8	How many clinical staff do you have in your hospital with nurses & midwife level?		

9	How many capacity of beds do you have in your hospital?	• Less than 50 • 50-200 • 201-350 • 351-500 • Above 500	
10	Which level of satisfaction of bed capacity in your hospital?	• Sufficient • Intermediate • Insufficient	
11	How many patients do you receive per year?	• 100-1000 • 1001-10000 • Above 10000	
12	How many patients do you receive per month?	• 10-100 • 100-300 • 300-500 • Above 500	
13	How many patient do you receive per day?	• 10-50 • 51-100 • Above 100	
14	How do your staff perform their work for the purpose of Quality healthcare?	• Very satisfied • Satisfied • Unsatisfied	
15	Does your hospital have equipment to be used for unexpected communicable diseases?	• Yes • No	
16	If yes, specify in the following	• Specific Equipment • Single use consumable • Isolation room • Protection shields • Masks and sanitizers • Oxygen supply	
17	Do you do follow up on incident?	• Yes • No	
18	If yes, which measures do you do for person causes incident?	• Paying out • Punishment • Training • Other	
19	What method do you use in equipment repairing?	• Internal Staff • External consultancy • All	
20	Do you have accreditation?	• Yes • No	
21	If no, what do you miss to achieve?	• Service • Infrastructure • Administration • Lack of skills • All	
22		• Training • Scholarship	

	How do you do capacity building in your employees?	• Individual Coaching • Other	