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‘‘PRACTICES AND FACTORS AFFECTING ON-SITE MEDICAL EQUIPMENT MAINTENANCE AT WAU TEACHING HOSPITAL, SOUTH SUDAN’’.

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DECLARATION:

I Natale Gon hereby declared that the thesis has been written by me without any external unauthorized help, that it has been neither presented to any institution for evaluation nor previously published in its entirely or in parts. Any papers, words or ideas of the thesis, however limited, which are quoted from or based on the other sources, have been acknowledge as such without exception.

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02/ October 2022

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DEDICATION:

I dedicate this study effort to both my mother and my uncle, who provided emotional and moral support to me while I was producing this work. Their presence provided me with the confidence and strength to keep on. God richly bless them.

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ABBREVATION AND ACRONYMS:

HIMP: Healthcare Instrument Maintenance Practice

HPF: Health Pooled Fund

MEMP: Medical Equipment Maintenance Practice

MOH: Ministry of Health

SMOH: State Ministry of Health

W.T.H: Wau Teaching Hospital

WHO: World Health Organization

Operational definition of terms

Corrective Maintenance: A means of restoring a device's durability, safety, and/or function after failure (WHO, 2016).

Health technology is the application of structured knowledge and talents as in shape of equipment, medications, immunizations, techniques, and procedures to treat a medical condition and enhance quality of care (WHO, 2016).

Medical Equipment: Medical devices that require calibration, service, restoration, user documentation, and decommissioning, which are frequently handled by medical architects (WHO, 2016).

Preventive repair is a series of activities done on a routine basis to allow equipment survive for longer period (WHO, 2016).

Stakeholders: They are the donor and implementing partners who are supporting health services delivery in a hospital (Health Pooled Fund and Cordaid International Organization).

ABSTRACT:

Background of the study

With advances in the clinical field, medical devices in hospitals are also becoming more sophisticated and need to function under ideal conditions. In this context, it is important for hospitals to focus on the effective and fast repair of life-saving equipment.

Objective: The objective of the research was to determine the practices and the influential factors that affect on-site medical equipment maintenance.

Methodology: This was a mixed method, concurrent triangulation. First data related to maintenance practices, factors affecting medical equipment and the root causes of equipment failure were collected using questionnaires and at the same time those maintenance practices, factors influencing medical devices and root causes of equipment failure were explored using semi-structure interviews with the qualified and experience healthcare workers. Questionnaires were analyzed using Statistical Package of Social Sciences (SPSS) version Twenty-Three. Content analysis inductive approach was used to analyze qualitative data in which themes and sub-themes were identified. Lastly the results were integrated for similarities or differences. Desk review and observation checklist were used.

Results: In this study, the maintenance practices documented was outsourcing a repair process to third-party logistic when a medical device broke down. There were lack of inspection, prevention, predictive and proactive maintenance practices, most areas of weakness were lack of a trained technician, biomedical engineering and there was no designated area to repair medical devices as equipment is being maintained in their places where they are situated in the hospital. There was scarcity of local, global and protocols in place. The study has found new medical device out-of-date lying down and that due lack expertise. The study also documented improper storage, inappropriate handling, lack of highly trained technicians, poor planning and management.

Conclusions: The findings showed that corrective maintenance and outsourcing were the main maintenance practices observed. Factors affecting medical equipment repair processes and the root causes of medical equipment maintenance failure were linked to Resources, education, information

bank, quality and testing, inspection and preventive maintenance, design and implementation and miss- appropriateness of medical equipment.

Recommendations: Biomedical engineering are needed at national and sub-national, avail resources for capacity building, equipment donation, procurement is to be based on the need and availability of the expertise and adoption of inspection and prevention strategy. Further study on medical equipment prioritization, human resource for medical equipment, financial implication on medical equipment maintenance practices.

Keywords: Medical. Equipment, Maintenance, Practices, Factors, Root Causes, Perception

"CHAPTER ONE INTRODUCTION"

1.1 Background of the study:

With progress in clinical advancement, medical equipment in hospitals is becoming increasingly advanced, so it is necessary to ensure that it is working under ideal conditions as clinical advancement progresses(1). A healthcare device is used for diagnosis, treatment, and follow-up on a patient's condition. Service delivery points must ensure that healthcare equipment is stored in a secure environment for both clients and workers. Improper repair of healthcare devices results in equipment breakdown, reduces the life cycle of the device's function, and wastes resources. In this context, hospitals must prioritize the effective and timely repair of more lifesaving equipment(2).

A study conducted in Iran(3), revealed seven main themes influencing medical device maintenance and management, such as physical resources, no dedicated area in the hospitals where maintenance processes can take place, limited trained human resources to handle the device operations and services, and inadequate funding for healthcare device maintenance processes. Moreover, the same study indicated that there were frequent medical equipment breakdowns due to an irregular power supply to the hospital, which affected the quality control of the devices. A computerized data system to keep records was not well implemented; no operation manuals necessary to assist the biomedical engineering units were available, and there were records of poor documentation for the maintenance of medical equipment. According to (4), information gathered through a case study from hospital managers and biomedical engineers in Kenya revealed factors that hampered device maintenance practices, including a lack of a preventive maintenance plan, which leads to frequent device failures; inadequate inventory documentation, which results in poor medical device selection and procurement; and a shortage of spare parts, which results in most devices not working. Based on a WHO survey (2006), approximately half of medical instruments in underdeveloped nations have been underutilized, improperly used, or inadequately maintained as a result of a lack of proper maintenance management processes (5).

As reported by the WHO, 70% of all medical devices introduced from advanced countries do not function well in lower-income countries, and more than 95% of the healthcare devices in the public sector are imported and of low quality, where 96% would not work well over 5 years after gift, and 39% did not function due to a lack of trained personnel, manufacturer manuals, or accessories. (6).

Constant maintenance ensures that each piece of equipment provides the required performance and has an estimated effective life cycle, which minimizes operating expenses for the hospital. Healthcare device repair processes have various categories ranging from inspection, preventive maintenance, and repair after the device has failed to operate(2).

WAU Teaching Hospital lacks records and information, which are key for every movement in equipment maintenance practices. There was no system to maintain data so that someone can successfully retrieve the information for efficient management. There was no biomedical engineering department and no biomedical engineering experts in the hospital, and most of the equipment observed was not functioning, and the reason behind that remained unclear.

The researcher was interested in understanding healthcare professionals' attitudes and the stakeholders' perspectives on medical equipment maintenance practices and factors affecting them. In conclusion, similar studies have been conducted in various countries, but up to this moment there was scarcity of information about factors that affect medical equipment maintenance practices in South Sudan. The fate of donated equipment was not clear; miss-management of medical equipment remained a great concern; the majority of the equipment were lying down and not functioning; there was no computer database to store the information about the equipment; there was a scarcity of bioengineers in the hospital, views of the stakeholders are very important in planning and procurement.

1.2 Problem Statement

out maintenance processes and the factors affecting them and to propose the best As reported by the WHO, 70% of all medical devices introduced from advanced countries do not function well in lower-income countries, and more than 95% of the healthcare devices in the public sector are imported and of low quality, where 96% would not work well over 5 years after gift, and 39% did not function due to a lack of trained personnel, manufacturer manuals, or accessories(6). Based on a WHO survey (2006), approximately half of medical instruments in underdeveloped nations had either been underutilized, improperly used, or inadequately maintained as a result of a lack of proper maintenance management processes (5). There was no of information provided on equipment maintenance practices and factors affecting them in South Sudan. WAU Teaching Hospital had no records and information, which are key challenges for every movement in equipment maintenance practices. It has been observed that, maintenance practices are outsourced to third-party logistic when the medical equipment broke. This had let the patients to invest more on the treatment by seeking further medical intervention at nearby countries. There was no system to maintain real-time data (a computer database) so that someone can retrieve the information successfully for efficient management. It has been observed that healthcare devices frequently break down, and some of the new equipment is lying around not being utilized. It has also been observed that calibration occurred once during equipment installation. Furthermore, there is no biomedical engineering department and no biomedical engineering experts in the hospital. It has been observed some of the donated equipment were lying un-utilized at the health facility, the study need to find out the position of the stakeholders, such as the donor and implementing partner, who are supporting health service delivery in the hospital. For those reasons, the researcher wanted to understand the opinions of healthcare workers and stakeholders on how hospital does carry the maintenance process, what factors that affect the repair process and to propose the best plan intervention for medical equipment maintenance practices in the hospital.

1.3 Purpose of the study:

The main purpose of the study was to determine what health care workers think about the elements that affect healthcare instrument maintenance practices (HIMP). The rationale of the research aimed

to provide a frame for HIMP to deepen and improve understanding of the elements that impact healthcare instrument maintenance practices at the hospital.

1.4 Objectives of the study

1.4.1 General Objective: -

The objective of the research was to determine the practices and the influential factors that affect on-site medical equipment maintenance.

1.4.2 Specific Objectives

i. To determine medical equipment maintenance practices in WAU Teaching Hospital

ii. To find out the factors that influence medical equipment maintenance practices.

iii. To identify major causes of medical equipment failure at WAU Teaching Hospital.

1.5 Research questions

i) How are medical equipment maintenance practices being implemented in WAU Teaching Hospital?

ii) What are the major factors affecting medical equipment maintenance practices in WAU Teaching Hospital?

iii) What are the major root causes of medical equipment failure at WAU Teaching Hospital?

1.6 The Significant of the study

The outcomes of this research provided a platform for the government and relevant stakeholders, such as funders, partners, and healthcare organization managers, to address medical equipment maintenance practices. Other scholars who desire to do comparable studies on this subject will find the study valuable as well.

1.7 Scope of the study: -

Wau County is one of the three counties that constitute Western Bahr El-Ghazal State, it has a projected population of 208,487 of 2008 census. It borders with Jur River to the East, Raja County to the West, Northern Bahr El-Ghazal State to the North and Western Equatoria State to the South. Most of the inhabitants depend on farming. The hospital has consultation, pediatric, medical, surgical, maternal, pharmaceutical departments, dental, ophthalmic, HIVAIDS, TB, mortuary and psychiatric units. The study was based at WAU Teaching Hospital. This is because it was the only regional referral hospital well equipped with sophisticated medical devices and the personnel who had knowledge and capacity to operate the devices compared to other states hospital.

1.8 Delimitation

The study was based at Wau Teaching Hospital. This is because it is the only public regional referral hospital serving four states. In addition, the hospital has sophisticated equipment and experienced healthcare workers who are knowledgeable so that they can provide a rich source of information to the researcher.

1.9 Limitation of the study: -

Some participants refused to cooperate out of fear of jeopardizing the confidentiality of the information they would provide. The investigator mitigated that by assuring the participants that the data will remain secure for the aim of the study, and the researcher did not identify any of them. Lack of access to full-texts of medical equipment maintenance practice articles published in South Sudan was noted, and the investigator dug into the global and regional settings in order to find the information relevant to the study. Most of the literatures in the area of study were more than five years, the investigator decided to cite them due to useful information they contained.

10. Organization of the Thesis

The research is organized into six chapters. Introduction, the study's background area, the problem statement, the study's purpose, basic research questions, the study's delimitation, the study's limitation, the study's significance, the scope of the study, the definition of terms, and organization of the study were included in chapter one. In the second chapter, the related literature to the study and conceptual framework was discussed. The third chapter contains the research design, study participants, data sources, data collection instruments, data collection procedures, and data analysis

methods. The fourth chapter presented the results and interpretation, fifth chapter had research discussions and Chapter Six had conclusions, recommendations, and future study suggestions.

"CHAPTER TWO: RELATED LITERATURE REVIEW"

2.1 Introduction

The section illustrates medical equipment maintenance practice at Wau Teaching Hospital, the major factors that affect medical equipment maintenance practice, the major root causes of medical equipment failure, and proposed better medical equipment maintenance planning interventions for medical equipment failure at Wau Teaching Hospital.

2.2 Theoretical literature review:

2.2.1 Maintenance practices:

Preventive Maintenance:

This is to assess and treat the equipment on the routine basis. The repair process on the regular interval will contribute in reducing an expected cost that may be spent during corrective repair.

Pro-active repair: This is the process of maintaining the exact part of the device that had fail to operate(8).

Corrective Maintenance is the process of restoring device back to its normal function after it failed to operate(8)

Predictive Repair: During assessment of the equipment, some of the devices may be found not working or malfunction, in such a situation the device needs to be repaired immediately(8).

Breakdown maintenance: This is a repair that incur huge cost due to its frequent breakdown.

A research carried out in Canada, found out that all the service delivery points were using their manufacturer's recommendation to maintain their medical instruments, and the hospital outsourced maintenance services to a third-party when the hospital lacked expert personnel (1).

Five maintenance practices were noted (preventive, pro-active, corrective, predictive and breakdown maintenance) in the health service delivery in Malaysia, it was found out that the first strategy adopted by the hospital managers was preventive maintenance and the last one was breakdown

repair. Preventive maintenance is an important approach since it extends the life cycle of the device and therefore reduces the cost (8). A research carried out in Iran, found out that, two maintenance practices were used in the hospital namely corrective and preventive maintenance. With corrective practice, device is maintained after its failed to operate while preventive maintenance was partially implemented due to limited knowledge about it (3). A study conducted by WHO, revealed that about 50% of the healthcare equipment in low and middle-income countries were used wrongly or were not adequately repaired due to ineffective managing policies. Moreover, these countries' ability to handle and repair healthcare remains limited (9). The repair of healthcare device is essential for lowering output costs and decreasing client frustration, treatment of client on time, and hence decreasing complication and mortality and danger during service delivery (10).

2.3. Factors affecting Medical Equipment Maintenance Practices

According to (4), the data was collected through a case study from hospital managers and biomedical engineers in Kenya, and the findings revealed factors that hampered device maintenance practices such as a lack of a preventive maintenance plan, which leads to frequent device failures; inadequate inventory documentation, which leads to poor medical device selection and procurement; and a shortage of spare parts, which results in most devices not working. According to (11), it was found that most of the factors that affected medical equipment maintenance practices were limited to qualified human resources, irregular device services, and workload on a few pieces of equipment in the health facilities that resulted in frequent equipment breakdown. It was also found out that 69.4% of actions taken to repair medical devices occurred when the equipment failed to operate. The study has documented that 93.9% of the maintenance program was accurate and 6.1% of the maintenance program was not in place. The study has classified the equipment into lifesaving and routine equipment such as incubators, resuscitators, suction machines, oxygen concentrators and BP, weighing scales, and thermometers, respectively. The study (12), revealed that factors that lead to effective performance of medical equipment are qualified candidates, inadequate infrastructure, knowledge about the device, routine supervision, and individual accountability. A study (3), revealed seven main themes of factors affecting healthcare device repair management such as physical resource, no dedicated area in the hospitals where maintenance process can take place, limited trained human resources to handle the devices operations and services, and inadequate financial resources for medical equipment maintenance. Moreover, the same study indicated that, there were

frequent medical equipment breakdown due to irregular power supply to the hospital, which affected the quality control of the devices, computerized data system to keep records was not well implemented, and no operation manuals necessary to assist the biomedical engineering units were available and there were records of poor documentations repair of healthcare device. On study conducted by World Health Organization, about 80% of healthcare instruments failures occurred due to preventable factors, 60% occurred due to inadequate repair and about 20% occurred due to inappropriate handling, environment stress and wear-out(13).

2.3.1 Root causes of medical equipment maintenance failure(13).

improper storage and transportation;
inappropriate treatment;
insufficient upkeep;
environmental adversity;
failure at random;
incorrect repair technique;
failure due to wear;
a lackluster maintenance culture;
a scarcity of highly skilled technicians;
insufficient upkeep of equipment;

2.4 Empirical literature Review on Medical Equipment Maintenance:

The maintenance of medical equipment is essential for reducing output costs, reducing patient dissatisfaction, treatment of patient on time, and reducing complication and mortality and risks during service delivery (9). According to WHO research, approximately half of the medical equipment in developing countries is used incorrectly or is not adequately maintained.

2.4.1 Medical Equipment Maintenance practices:

Maintenance practices look similar to each other across to all studies conducted, however in Canada, the hospital bioengineers look for company's manual to repair the equipment and the hospital outsource the third –party to do repair process when the technical experts are not in the hospital(1).

Reflecting that to South Sudan, there are limited number of bioengineers to do the repair process, and limited funding to outsource experts from outside. The researcher agreed that, inspection and schedule preventive maintenance are good approaches particular to resource limited setting.

2.4.2 Factors affecting Medical Equipment Maintenance Practices

A study (3), revealed seven main themes of factors affecting healthcare device repair management such as physical resource, no dedicated area in the hospitals where maintenance process can take place, limited trained human resources to handle the devices operations and services, and inadequate financial resources for medical equipment maintenance.

2.4.3 Best Practices for medical equipment maintenance planning interventions on medical equipment failures:

World Health Organization recommend the introduction of computerized maintenance management system software, which is very important in keeping an information about the devices, tracking previous records and it assist in scheduling inspection prevention maintenance dates(2). Equipment donation pulling process and in conformity to the country policy is the best practice to avoid equipment failure and damping(14).

Best practices also seen in Ghana Hospitals where effective maintenance records were established to track all maintenance activities(13).

The researcher also agreed with the five maintenance practices seen in Malaysia such as (preventive, pro-active, corrective, predictive and breakdown maintenance). These will enhance service delivery by prolonging the life of the equipment and save cost to the management.

Most of the literatures have identified seven themes as the main factors that affect medical equipment maintenance practices such as resources, information bank, quality control, documentation, education, service, inspection and preventive maintenance and design and implementation (3). Reflecting that to the setting where the researcher collected the data, the situation is similar and even need more attention compared to the previous studies conducted. In this setting, there was no physical resource where the maintenance processes can take place, there was no bioengineer who can repair the equipment, there was no computer database that can help to give

an information about the devices, there was no plan of inspection and preventive maintenance and there was limited funding to procure devices and outsourcing.

The previous studies did not clearly address the equipment donated, and that will be very important to ensure that all medical equipment brought to the country are in conformity with standard, and are safe to be used for the patients and the operators.

Miss- appropriateness of the medical equipment could be included as one of the theme that were not addressed by the previous studies. The studies done also did not get the views of the stakeholders such as donors or implementing partners who may be supporting health service delivery points. Their views are important to a sense that; the researcher tried to find out whether the devices donated to the hospital were in conformity with the country policy or any parallel policy.

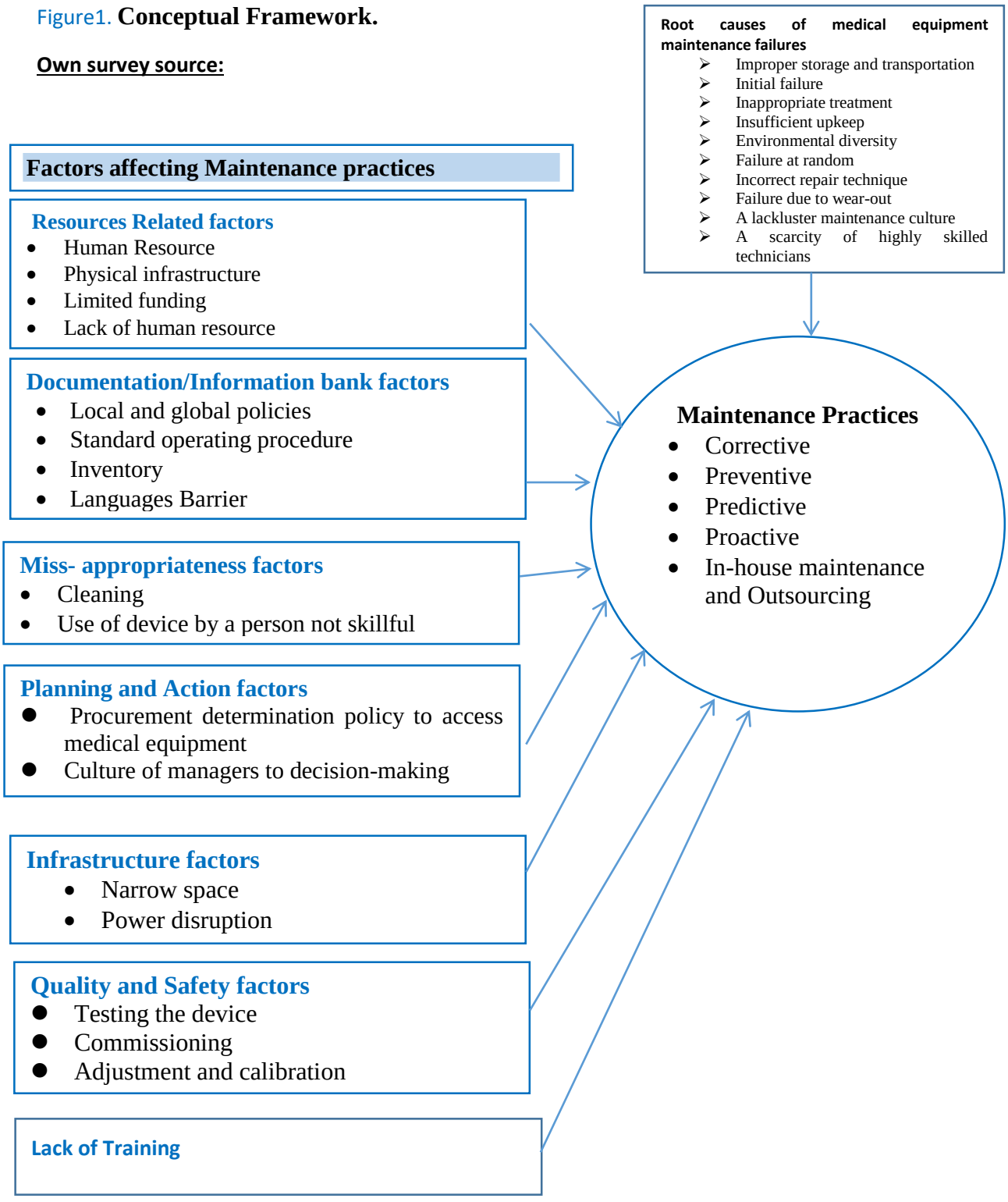
2.4.5 Summary of the Empirical Review:

In conclusion, similar studies have been conducted in various countries, up to this moment there was scarcity of information about maintenance practices, factors that affect medical equipment maintenance practices and root causes of medical equipment failure in South Sudan. Methodology used, Concurrent triangulation, data analysis method (average mean value computed and factor analysis) were rarely used in the previous study. The fate of donated equipment was not clear.

2.5 Conceptual Framework of the Study. The conceptual framework was the primary source of information generated in this study, in which the factors affecting medical equipment maintenance practices such as resources, information bank, planning, lack of training, infrastructure, and the root causes of medical equipment maintenance failure such as improper storage and transportation and inappropriate treatment of medical devices are considered independent variables, while maintenance practices such as inspection and preventive maintenance, corrective maintenance, predictive, proactive, in-house maintenance, and outsourcing are considered dependent variables. The relationship is shown in the figure 1 below.

Figure1. **Conceptual Framework.**

Own survey source:



"CHAPTER THREE: METHODS OF THE STUDY"

3.1 Introduction

The chapter described the method to collect and analyze data for the study. It covered research design and approach, target population sample size, sampling procedure, research instruments data collection procedure, pre-testing, data analysis and presentation.

3.2 Research Design and research approach:

Concurrent triangulation, a mixed method design was used in which a descriptive cross-sectional research design using quantitative to examined medical equipment maintenance practices, to find out factors that affect medical equipment maintenance practices and the major causes of medical equipment maintenance failure. A self-administer structured questionnaires were used to gather the information from the healthcare workers and stakeholders (Health Pooled Fund area coordinator and Cordaid International organization-logistician) who are knowledgeable and having ideas regarding medical equipment maintenance practices(15). At the same time, phenomenology study design using qualitative was used to investigate the perception of the respondents about maintenance practices, factors that affect healthcare instruments maintenance practices and major root causes medical equipment failure. Semi-structure interview was conducted with a purposive sampling of six (6) number of the respondents who were knowledgeable and had experiences with equipment maintenance process in the hospital.

3.3 Description of the study Area: -

The data were collected at WAU Teaching Hospital, a regional referral hospital serving the entire greater Bahr EL-Ghazal states namely: Aweil, Rumbek, Warrap and Western Bahr El Ghazal States. The site has been chosen due to it centrality, sophisticated medical equipment is found and more experienced and knowledgeable personnel can be found compared to other states hospital in the greater region.

3.4 Target and the study Population.

The target population were healthcare workers and stakeholders (Director General of Wau Teaching Hospital, Medical Director of Wau Teaching Hospital, Supply Chain Experts, Pediatrician, Obstetrician, Equipment Operators, Medical Doctors, Anesthetists, Theatre Attendance, Matrons, Nurses, Midwives, Storekeepers, donor and implementing partner who are supporting health service delivery in the hospital).

3.5 Inclusion and exclusion criteria

3.5.1 Inclusion criteria

Equipment operators, healthcare workers and stakeholders who have worked for over one year in the hospital.

3.5.2 Exclusion criteria

Non equipment operators, healthcare workers and the stakeholders who have no experiences and ideas about medical equipment maintenance exercise in the hospital.

3.6 Sampling

3.6.1 Sample size

For quantitative, the sample size was determined using Slovin's Formula size(16). With a population of 450 staff, a confidence level of 95% and a margin of error of 5%.

Slovin's Formula= N/ 1+ Ne^2, where: N is the population size and e is the margin of error

$450/1+ 450 (0.05)^2 = 450/1+450 (0.0025) = 450/1 + 1.125 = 450/2.125= 211.7= 212$

Thus, the sample size for quantitative was 212.

For qualitative study, According to Ellis (2016), the sample between 6-20 participants are enough for the study, or until data saturation is reached(11). The study has interviewed 6 people who were experienced and knowledgeable about medical equipment maintenance practices, major factors that

affect them and major causes of maintenance failure. The detail of respondents and their categories are shown in the **(Table1).**

3.6.2 Sampling technique

This study used a convenience sampling technique for quantitative where the respondents were chosen based on their working relationship. The participants from various departments were asked, if they would voluntarily sign a consent form and participate in the study. The researcher identified categories of respondents who agreed to participate in the study **(Table 1**). The majority of the respondents who participated were nurses and these were due to their present in all the department in the hospital. Questionnaires were distributed with the help of the recruited research assistants. A purposive sampling technique for qualitative was used to select participants who qualified, had the richest source of data and the knowledge on the subject matter(15).

3.6.3 Data collection instruments

The data collection tools were self-administered questionnaire, semi-structured interview, desk review and observation checklist.

3.6.4 Pre-Testing

According to Majenda and Majenda (2003), he stipulated that, the number of participants needed to participate in the pre-study should at least be 10% of the targeted sample size. Given the sample size of 212 respondents, the test has selected 22 participants to participate in the pre-study.

A small test was done at Wau Military Hospital before the real research data collection so as to examine the suitability of the data collection tool in term of reliability and validity.

3.7 Validity of Instruments

The extent to which data gathering tools measure what they are designed to measure is referred to as validity (Braun & Clarke, 2013). The validity of the instruments was determined by enlisting the assistance of several specialists in health systems management, with the supervisors being the primary individuals assisting in the determination of the validity of the instruments used in the study.

3.8 Reliability of Instrument

Research instruments are reliable when the instrument can consistently collect the needed information (Braun & Clarke, 2013). To find out the reliability of suggested data collection instruments, a pretest was conducted at Wau Military Hospital to study population who experiences and knowledgeable about medical equipment maintenance practices.

Analysis of the Scales' Reliability and Validity:

The reliability test and the internal consistency of data was measured using Cronbach's Alpha Coefficient method. The Coefficient was used to measure a scale of multiple questions frequency and the degree of compliance between Zero and One. When the coefficient comes nearer to One, Cronbach's Alpha is considered to be very high.

The following evaluations were done on the Cronbach alpha coefficient of researches in the social sciences:

<alpha< 0.40 the scale has no reliability. (Weak).

0.41 < alpha < 0.60 the scale's reliability is low. (Good).

0.61 < alpha < 0.80 the scale has acceptable reliability level. (Very good).

0.81 < alpha < 1.00 the scale's reliability is very high. (Perfect)

3.9 Data Collection Techniques:

For quantitative a self-administered questionnaires were distributed to the respondents at the time of data collection and qualitative, a semi-structured, with an interview guide that includes a series of questions for discussion[12]. Desk review and observation checklist was carried out with the head of the equipment operator.

3.10 Data management: Raw data collected were coded, edited, unwanted one omitted for accuracy and consistency.

3.11 Data analysis procedure:

Data were coded, cleaned, edited and data analysis used were the Statistical Package for Social Sciences (SPSS) version Twenty-Three (23) and content analysis (inductive). The descriptive statistical results were shown in tables and figure.

3.12 Data Integrations:

The researcher combined the findings from both the quantitative and qualitative and the similarities or differences were result noted.

3.13 Ethical Considerations:

Upon approval of the research proposal by the supervisor, it was presented to Ethical Review Committee/ Board and Ethical Clearance was given. Permission was taken from the director general of Wau Teaching Hospital and the respondents were requested to sign a consent form before interview. All data were treated with confidentiality.

"CHAPTER FOUR: DATA ANALYSIS AND THE RESULTS"

Introduction

The section illustrated the response rate, respondents' demographic profile, analysis of scale reliability and validity, descriptive statistics for medical equipment maintenance practice at Wau major factors that affect medical equipment maintenance practice and the major root causes of medical equipment failure, qualitative results, desk review and observation checklist.

4.1 Response Rate

The study had a total 212 distributed questionnaires, only 207 questionnaires were collected, 12 were found to be incompletes and 5 questionnaires were not retrieved**.** A total of 195 questionnaires scripts were analyzed using SPSS version Twenty-Three (23). Moreover, six respondents were interviewed for qualitative, and the recorded voices were transcript into a written text. Observation checklist and document review were used. The Five (5) Likert scale template was used for the data collection whereby the respondents were asked to tick an appropriate statement, strongly disagree, disagree, neutral, agree and strongly agree.

4.2. Demographic profile of the respondent

Based on this research, there were more females 108(55.4%) than males and study covered most of the age group ranging between 36- 40 years and above 41(21%), while observing their occupation the study indicated that most of the respondents who participated proficiently were nurses140 (72%) rather than any other professional (Table 1). The study showed, that most of respondents were in standard stage with good experiences. Thus, the study went further to educational background, and the finding were that, most of the respondents 88(45%) who participated were having a Diploma degree. With regard to marital status 150(77%), were married while on working

experience research specified that, most of the respondents had an experienced greater than 20 years, 72(40%).

Table 1: Demographic profile of the respondent

Demographic profile (N=195)	Items	Frequency	Percent
Gender	Male	87	44.6
	Female	108	55.4
Age of the respondents	21-25 years	12	6.2
	26-30 years	26	13.3
	31-35 years	37	19
	36-40 years	41	21
	Above 41 years	79	40.5
Occupation of the respondents	Medical Doctor	14	7.2
	Equipment Operator	10	5.1
	Storekeeper	3	1.5
	Nurse	140	71.8
	Mid-wife	14	7.2
	Health Pool Fund Area Coordinator	1	0.5
	Care International organization Area Coordinator	1	0.5
	Theatre Attendance	7	3.6
	Anaesthetist	5	2.6
Education Level	Basic level	3	1.5
	Secondary level	72	36.9
	Diploma level	88	45.1
	Bachelor Degree	29	14.9
	Master Degree	3	1.5
Marital Status	Married	150	76.9
	Single	26	13.3

	Divorced	4	2.1
	Widow/Widower	15	7.7
Working Experience	1-5 years	36	18.5
	6-10 years	27	13.8
	11-20 years	60	30.8
	Above 20 years	72	36.9

4.3 Analysis of Scales' Reliability and Validity:

This coefficient is used to measure a scale of multi-questions frequency and measure the degree of compliance between 0 and 1. As the coefficient draws nearer to 1 Cronbach's alpha is assumed to be very high.

Generally, the following evaluations are made on the Cronbach alpha coefficient of researches in the social sciences:

0.0 alpha< 0.40 the scale has no reliability. (Weak).

0.41 << alpha < 0.60 the scale's reliability is low. (Good).

0.61 < alpha < 0.80 the scale has acceptable reliability level. (Very good).

0.81 < alpha < 1.00 the scale's reliability is very high. (Perfect).

Table 2: Statistical reliability

Cronbach's Alpha	N of Items
.885	30

Primary source

The statistical reliability of the study done, and it is evaluated to be Perfect because it ranges between 0.81 < alpha < 1.00, and the scale's reliability is very high. (Perfect).

Factor Analysis Results:

An exploratory factor analysis was performed using a principal component analysis and varimax rotation for medical equipment maintenance practices. The minimal factor loading criterion was set to 0.5 [17]. Bartlett's test of sphericity measure (P=0.000), indicated that, the correlation matrix was significant (**Table 3**). The Kaiser-Meyer- Olkin measure of sample adequacy was 0.800, and this value indicated the appropriateness of the data for factor analysis. The communalities of the scale, which indicate the amount of variance in each dimension were assessed to ensure an acceptable level of explanation. The results showed that all the communalities were over 0.5, with the exception of one variable whose value was less than 0.5 and was deleted (**Table 4**). Finally, the factor solution derived from this analysis yielded 3 factors for the scale, which accounted for 55.010% of the variance in the data (**Table 5**).

Table 3. **KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.800
Bartlett's Test of Sphericity	Approx. Chi-Square	603.123
	df	66
	Sig.	.000

Table 4. **Communalities**

	Initial	Extraction
	Initial	Extraction
The Hospital has someone or in-house person mandated to repair the equipment	1.000	.571
This is an area in the hospital where the maintenance process can take place	1.000	.648
The hospital has the Bioengineer or technical person who can maintain the equipment	1.000	.647
There is a regular check up on medical equipment in the hospital	1.000	.577
There is a policy for the equipment practices in the hospital	1.000	.606
The hospital has the standard operating procedure	1.000	.618
The hospital repair the equipment by bringing an expert (Thirty-Party) from outside using outsourcing strategy	1.000	.587
The hospital procure in-house medical equipment maintenance practices	1.000	.576

Preventive Maintenance as it assess and treat the equipment on routine basis and repair process take place on the regular interval become the most preferred maintenance practices in Wau Teaching Hospital	1.000	.633
Corrective Maintenance as it a process of restoring device back to its normal function after it fails to operate, is the most preferred maintenance practice in Wau Teaching Hospital	1.000	.609
Predictive Maintenance is the most preferred maintenance practice in Wau Teaching Hospital	1.000	.728
Pro-active Maintenance being the process of maintaining the exact of the device that had failed to operate is the most preferred maintenance practices in Wau Teaching Hospital	1.000	.626
Resource related factors (such as lack of adequate human resource, physical infrastructure, limited funding) affects medical equipment maintenance practice	1.000	.651
Lacking of training to the equipment operators affects medical equipment maintenance practices	1.000	.718
Documentation/Information bank factors (such as local and global policies, standard operating procedure, lack of inventory and language barrier) affects medical equipment maintenance practices	1.000	.698
Miss- appropriateness factors (such as lack of frequent cleaning and use of device by a person not skillful) affects medical equipment maintenance practices	1.000	.637
Planning and Action factors (such as procurement determination policy to access medical equipment and culture of managers to decision-making) affects medical equipment maintenance practices	1.000	.675
Infrastructure factors(such as narrow space and power disruption affects medical equipment maintenance practices).	1.000	.630
Quality and Safety factors (such as testing the device commissioning, adjustment and calibration) affects medical equipment maintenance practices	1.000	.538
Improper storage and transportation are the major root causes for medical equipment maintenance failure	1.000	.610
Initial failure is the major root cause for medical equipment maintenance failure	1.000	.532
Inappropriate handling is the major cause for medical equipment maintenance failure	1.000	.691
Inadequate maintenance is the major root cause for medical equipment maintenance failure	1.000	.611
Environmental stress is the major root cause for medical equipment maintenance failure	1.000	.616
Random failure is the major root cause for medical equipment maintenance failure	1.000	.684
Inappropriate repair technic is the major root cause for medical equipment maintenance failure	1.000	.624
Wear-out failure is the major root cause for medical equipment maintenance failure	1.000	.743
Poor maintenance culture is the major root cause for medical equipment maintenance failure	1.000	.782
Lack of highly trained technicians are the major root causes for medical equipment maintenance failure	1.000	

Extraction Method: Principal Component Analysis.

Table 5.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.911	32.595	32.595	3.911	32.595	32.595	2.617	21.807	21.807
2	1.500	12.499	45.094	1.500	12.499	45.094	2.084	17.367	39.174
3	1.190	9.916	55.010	1.190	9.916	55.010	1.900	15.836	55.010
4	.968	8.063	63.073						
5	.891	7.424	70.497						
6	.700	5.835	76.332						
7	.650	5.420	81.752						
8	.567	4.727	86.479						
9	.470	3.918	90.397						
10	.432	3.599	93.996						
11	.396	3.303	97.299						
12	.324	2.701	100.000						

Extraction Method: Principal Component Analysis.

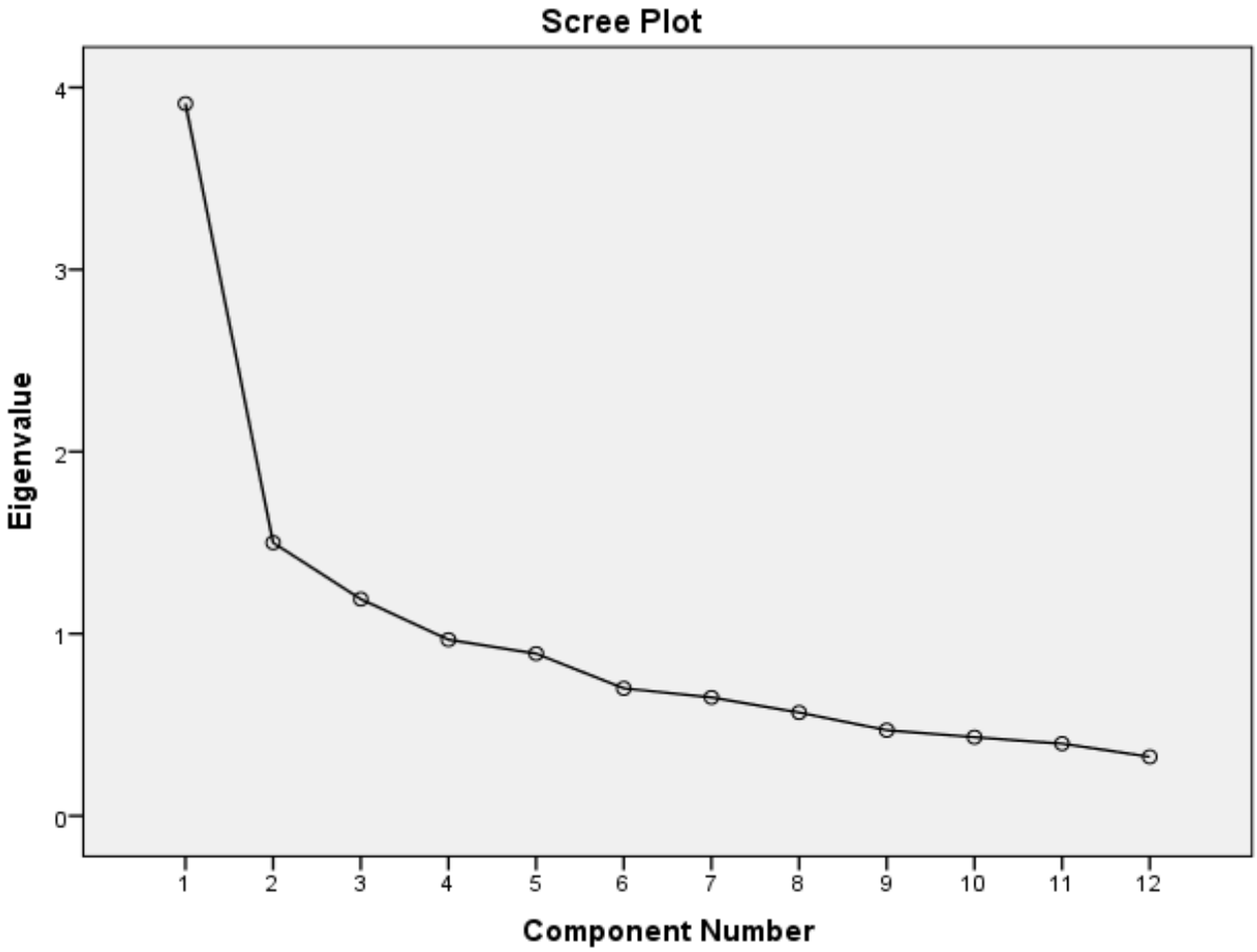


Fig 1. The three factors extracted.

Table 6: Rotated Component Matrix loaded together.

Types of practices	Component		
	1	2	3
Human Resource	.775		
	.736		
	.704		
	.696		
Policy and SOP		.723	
		.665	
		.636	
		.604	
Types of Maintenance Practices			.741
			.690
			.689
			.560

Table 6. This showed factors loading related to maintenance practices.

Factor 1: Indicates the expertise and infrastructure where the repair process can take place.

Factor 2: It loaded the policy and standard operating procedure together.

Factor 3: It loaded the types of maintenance practices.

Table 7. ***Medical equipment maintenance practice: Descriptive Statistics***

Item: Medical equipment maintenance practice	Scale[1]					Mean	Std. Dev.
	1	2	3	4	5		
The hospital has someone or in-house person mandated to repair the equipment	140	29	7	12	7	2.86	1.11
There is an area in the hospital where the maintenance process can take place	100	55	9	22	9	1.55	1.06
The hospital has the bioengineer or technical person who can maintain the equipment	120	44	17	11	3	1.90	1.19
There is a regular check up on medical equipment in the hospital	101	58	15	13	8	1.63	0.97
The hospital has regular electric power supply	92	52	15	22	14	1.82	1.10
There is a policy for the equipment maintenance practices in the hospital	94	56	20	17	7	2.05	1.29
The hospital has the standard operating procedure	90	51	17	25	12	1.90	1.12
The hospital repair the equipment by bringing an expert (Third Party) from outside using outsourcing strategy	74	43	15	44	19	2.07	1.27

[1] ***Where 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4=Agree 5=Strongly Agree***

The hospital procures in-house medical equipment maintenance practices	94	58	28	8	7	2.44	1.43
Preventive maintenance as it assess and treat the equipment on the routine basis and repair process take place on the regular interval become the most preferred maintenance practice in WAU teaching hospital	81	47	24	25	18	1.85	1.05
Corrective maintenance as it is a process of restoring device back to its normal function after it fails to operate is the most preferred maintenance practice in WAU teaching hospital	45	55	13	25	57	2.24	1.35
Predictive maintenance is the most preferred maintenance practice in WAU teaching hospital	77	56	24	22	16	2.97	1.59
pro-active maintenance being the process of maintaining the exact part of the device that had failed to operate is the most preferred maintenance practice in WAU teaching hospital	77	53	18	33	14	2.20	1.29
Grand mean for Medical equipment maintenance practice						2.113	

Table (7) shows Descriptive Statistics under Objective 1, Medical Equipment Maintenance Practice, and the overall grand mean value of Medical Equipment Maintenance Practice was **2.11**, which can be interpreted as weakly practiced (the practices are uninfluential), as the weighted average mean value falls between a mean range of **1.80 and 2.59.**

In the descriptive data analysis, mean values were calculated for each construct in the Likert scales, from Strongly Disagree=1 to Strongly Agree=5, and the associated standard deviation was also calculated. The mean responses given for each construct of variables under investigation were averaged to obtain the composite mean for variables. For objective interpretation and comparison of the results, the composite mean was interpreted by dividing the distances between the scale values (4) by the number of values (which is 5 on a 5-point Likert scale). Thus the distance is 4/5 =

0.80, which is used to calculate the weighted averages (1+0.8= 1.8, 1.8+08= 2.6, 2.6+0.8=3.4, 3.4+0.8=4.2, 4.2+0.8=5). The weighted average categories (mean score) were interpreted with the level of agreement for each factor calculated, and its interpretation was aligned with an equal level of degree to explain the objectives. A weighted average between 1.00-1.79 interpreted as "very low/very weak", 1.80-2.59 as low, 2.60-3.39 as neutral/do not know, 3.40-4.19 as moderate, and 4.20-5.00 as a high level of practice or performance or effect.

Table 8. Weighted average values for 5 point Likert scales

Weighted Average	Result	Result interpretation
1.00-1.79	Strongly disagree	Very uninfluential
1.80-2.59	disagree	uninfluential
2.60-3.39	neutral	Neutral/do not know
3.40-4.19	agree	influential
4.20-5.00	Strongly agree	Very influential

Table 9. The Hospital has someone or in-house person mandated to repair the equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	140	71.8	71.8	71.8
	Disagree	29	14.9	14.9	86.7
	Neutral	7	3.6	3.6	90.3
	Agree	12	6.2	6.2	96.4
	Strongly Agree	7	3.6	3.6	100.0
	Total	195	100.0	100.0	

Primary source

Table (9) offered the details of the repair of medical devices equipment; where strongly disagree got 72%, disagree got 15%, neutral got 3%, agree got 6% and strongly agree got 4%. These show that

most respondents have disagree on the issue of the hospital having someone or in-house person mandated to repair the equipment**.**

Table 10. There is an area in the hospital where the maintenance process can take place

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	100	51.3	51.3	51.3
	Disagree	55	28.2	28.2	79.5
	Neutral	9	4.6	4.6	84.1
	Agree	22	11.3	11.3	95.4
	Strongly Agree	9	4.6	4.6	100.0
	Total	195	100.0	100.0	

Primary source

Table (10) gave the details of an area for maintenance; where strongly disagree got 51%, disagree got 28%, neutral got 5%, agree got 11%, and strongly agree got 5%. These shows that most respondents have disagreed that there is no an area in the hospital where the maintenance process can take place.

Table 11. The hospital has the Bioengineer or technical person who can maintain the equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	120	61.5	61.5	61.5
	Disagree	44	22.6	22.6	84.1
	Neutral	17	8.7	8.7	92.8
	Agree	11	5.6	5.6	98.5
	Strongly Agree	3	1.5	1.5	100.0
	Total	195	100.0	100.0	

Primary source

Table (11) gave details the technical or biomedical engineered; where strongly disagree got 61%, disagree got 23%, neutral got 9%, agree got 6% and strongly agree got 1%. These show that most respondents have disagree that the hospital has no the bioengineer or technical person who can maintain the equipment.

Table 12. There is a regular check up on medical equipment in the hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	101	51.8	51.8	51.8
	Disagree	58	29.7	29.7	81.5
	Neutral	15	7.7	7.7	89.2
	Agree	13	6.7	6.7	95.9
	Strongly Agree	8	4.1	4.1	100.0
	Total	195	100.0	100.0	

Primary source

Table (12) gave details of regular checkup on medical devices**;** where strongly disagree got 52%, disagree got 30%, neutral got 8%, and agree got 6%. And strongly agree got 4%. These show that most respondents have disagreed that there is no regular check up on medical equipment in the hospital.

Table 13.The hospital has a regular electric power supply

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	92	47.2	47.2	47.2
	Disagree	52	26.7	26.7	73.8
	Neutral	15	7.7	7.7	81.5
	Agree	22	11.3	11.3	92.8
	Strongly Agree	14	7.2	7.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (13) gave the details of power supply in the hospital, where strongly disagree got 47%, disagree got 27%, neutral got 8%, and agree got 11%, and strongly agree got 7%. These show that most respondents have disagreed that the hospital has no regular electric power supply.

Table 14. There is a policy for the equipment practices in the hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	94	48.2	48.5	48.5
	Disagree	56	28.7	28.9	77.3
	Neutral	20	10.3	10.3	87.6
	Agree	17	8.7	8.8	96.4
	Strongly Agree	7	3.6	3.6	100.0
	Total	194	99.5	100.0	
Missing	System	1	.5		
Total		195	100.0		

Primary source

The table (14) gave details of policy for the equipment practices; where strongly disagree got 48%, disagree got 29%, neutral got 10%, and agree got 9%, and strongly agree got 4%. These show that most respondents have disagreed that there is no policy for the equipment practices in the hospital.

Table 15. The hospital has the standard operating procedure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	90	46.2	46.2	46.2
	Disagree	51	26.2	26.2	72.3
	Neutral	17	8.7	8.7	81.0
	Agree	25	12.8	12.8	93.8
	Strongly Agree	12	6.2	6.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (15) gave the details of standard operating procedure; where strongly disagree got 46%, disagree got 26%, neutral got 9%, and agree got 13%, and strongly agree got 6%. These show that most participants have disagreed that the hospital has no standard operating procedure.

Table 16. The hospital repair the equipment by bringing an expert (Thirty-Party) from outside using outsourcing strategy.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	74	37.9	37.9	37.9
	Disagree	43	22.1	22.1	60.0
	Neutral	15	7.7	7.7	67.7
	Agree	44	22.6	22.6	90.3
	Strongly Agree	19	9.7	9.7	100.0
	Total	195	100.0	100.0	

Primary source

Table (16) illustrated details of the Third- Party Logistic; where strongly disagreed got 38%, disagree got 22%, neutral got 8%, and agree got 22%, and strongly agree got 10%. These show that most of the respondents have disagreed that the hospital does not repair the equipment by bringing an expert (Thirty-Party) from outside using outsourcing strategy.

Table 17. The hospital procure in-house medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	94	48.2	48.2	48.2
	Disagree	58	29.7	29.7	77.9
	Neutral	28	14.4	14.4	92.3
	Agree	8	4.1	4.1	96.4
	Strongly Agree	7	3.6	3.6	100.0
	Total	195	100.0	100.0	

Primary source

Table (17) demonstrates in-house procurement of medical equipment; where strongly disagree got 48%, disagree got 30%, neutral got 14%, and agree got 4%, and strongly agree got 4%. These illustrate that most respondents have disagreed that the hospital is not procuring in-house medical equipment maintenance practices.

Table 18. Preventive Maintenance as it assess and treat the equipment on routine basis and repair process take place on the regular interval become the most preferred maintenance practices in Wau Teaching Hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	81	41.5	41.5	41.5
	Disagree	47	24.1	24.1	65.6
	Neutral	24	12.3	12.3	77.9
	Agree	25	12.8	12.8	90.8
	Strongly agree	18	9.2	9.2	100.0
	Total	195	100.0	100.0	

Primary source

Primary source

Table (18) showed the details of Preventive Maintenance practices; where strongly disagree got 42%, disagree got 24%, neutral got 12%, and agree got 13% and strongly agree got 9%. These illustrate that most respondents have disagreed that Preventive Maintenance as it assesses and treat the equipment on routine basis and repair process is not take place on the regular interval is not the most preferred maintenance practices in Wau Teaching Hospital.

Table 19. Corrective Maintenance as it a process of restoring device back to its normal function after it fails to operate, is the most preferred maintenance practice in Wau Teaching Hospital.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	45	23.1	23.1	23.1
	Disagree	55	28.2	28.2	51.3
	Neutral	13	6.7	6.7	57.9
	Agree	25	12.8	12.8	70.8
	Strongly Agree	57	29.2	29.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (19) summarized the details of the Corrective Maintenance practice activity in the hospital; where strongly disagree got 23%, disagree got 28%, neutral got 7%, and agree got 13% and strongly agree got 29%. These illustrate that most respondents have agreed that Corrective Maintenance as it is a process of restoring device back to its normal function after it fails to operate, is the most preferred maintenance practice in Wau Teaching Hospital**.**

Table 20. Predictive Maintenance is the most preferred maintenance practice in Wau Teaching Hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	77	39.5	39.5	39.5
	Disagree	56	28.7	28.7	68.2
	Neutral	24	12.3	12.3	80.5
	Agree	22	11.3	11.3	91.8
	Strongly Agree	16	8.2	8.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (20) showed the details of the Predictive Maintenance; where strongly disagree got 40%, disagree got 29%, neutral got 12%, and agree got 11%, and strongly agree got 8%. These illustrate that most respondents have disagreed that Predictive Maintenance is not the most preferred maintenance practice in Wau Teaching Hospital.

Table 21. Pro-active Maintenance being the process of maintaining the exact of the device that had failed to operate is the most preferred maintenance practices in Wau Teaching Hospital.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	77	39.5	39.5	39.5
	Disagree	53	27.2	27.2	66.7
	Neutral	18	9.2	9.2	75.9
	Agree	33	16.9	16.9	92.8
	Strongly Agree	14	7.2	7.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (21) showed the details of Pro-active Maintenance; where strongly disagree got 40%, disagree got 27%, neutral got 9%, and agree got 17% and strongly agree got 7%. These illustrate that most respondents have disagreed that Pro-active Maintenance being the process of maintaining the exact of the device that had failed to operate is not the most preferred maintenance practices in Wau Teaching Hospital.

Factors influencing medical equipment maintenance practices

Table 22. Factors influencing medical equipment maintenance practices: Descriptive Statistics

Item: Factors influencing medical equipment maintenance practices	Scale[2]					Mean	**Std. Dev.**
	1	2	3	4	5		
Resources Related factors (such as lack of adequate human resource, Physical infrastructure) affects medical equipment maintenance practices	41	14	14	54	72	3.52	1.55
Lack of training to the equipment operators affects medical equipment maintenance practices	31	22	12	55	75	3.62	1.48
Documentation/Information bank factors (such as Local and global policies, Standard operating procedure, Lack of inventory and Languages Barrier) affects medical equipment maintenance practices	23	27	13	56	76	3.53	1.48
Miss- appropriateness factors (such as Lack of frequent cleaning and Use of device by a person not skilful) affects medical equipment maintenance practices	32	22	22	48	71	3.69	1.41
Planning and Action factors (such as Procurement determination policy to access medical equipment and Culture of managers to decision-making) affects medical equipment maintenance practices	32	22	22	48	71	3.57	1.42
Infrastructure factors (such as Narrow space and Power disruption) affects medical equipment maintenance practices	30	16	26	58	65	3.71	1.43
Quality and Safety factors (such as Testing the device commissioning and Adjustment and calibration) affects medical equipment maintenance practices	26	24	8	60	77	3.68	1.34
Grand mean of factors influencing medical equipment maintenance practices						3.61	

Source: Own survey, 2022

[2] *Where 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4=Agree 5=Strongly Agree*

The overall grand mean value of factors influencing medical equipment maintenance practices secured a gran mean of 3.61 and it can be interpreted as all the identified factors found to be influential factors as the weighted average mean value as well the individual factor mean value falls between a mean ranges of 3.40-4.19

Table 23. Resources related factors (such as lack of adequate human resource, physical infrastructure, limited funding) affects medical equipment maintenance practice.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	41	21.0	21.0	21.0
	Disagree	14	7.2	7.2	28.2
	Neutral	14	7.2	7.2	35.4
	Agree	54	27.7	27.7	63.1
	Strongly Agree	72	36.9	36.9	100.0
	Total	195	100.0	100.0	

Primary source

Table (23) indicated the Resources related factors; where strongly disagree got 21%, disagree got 7%, neutral got 7%, and agree got 28%, and strongly agree got 37%. These illustrate that most respondents have agreed that Resources related factors (such as lack of adequate human resource, physical infrastructure, limited funding) affects medical equipment maintenance practice.

Table 24. Lack of training to the equipment operators affects medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	31	15.9	15.9	15.9
	Disagree	22	11.3	11.3	27.2
	Neutral	12	6.2	6.2	33.3
	Agree	55	28.2	28.2	61.5
	Strongly Agree	75	38.5	38.5	100.0
	Total	195	100.0	100.0	

Primary source

Table (24) narrated the details of the lack of training to equipment operators; where strongly disagree got 16%, disagree got 11%, neutral got 6%, and agree got 28%, and strongly agree got 39%. These illustrate that most respondents have agreed that there is a Lack of training to the equipment operators and that do affects medical equipment maintenance practices.

Table 25.´Miss- appropriateness factors (such as lack of frequent cleaning and use of device by a person not skillful) affects medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	23	11.8	11.8	11.8
	Disagree	27	13.8	13.8	25.6
	Neutral	13	6.7	6.7	32.3
	Agree	56	28.7	28.7	61.0
	Strongly Agree	76	39.0	39.0	100.0
	Total	195	100.0	100.0	

Primary source

Table (25) demonstrated the details of miss- appropriateness factors; where strongly disagree got 12%, disagree got 14%, neutral got 6%, and agree got 29%, and strongly agree got 39%. These illustrate that most respondents have agreed that there are mal-practices and they do medical equipment repair practices in the hospital.

Table 26. Documentation/Information bank factors (such as local and global policies, standard operating procedure, lack of inventory and language barrier) affects medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	32	16.4	16.4	16.4
	Disagree	22	11.3	11.3	27.7
	Neutral	22	11.3	11.3	39.0
	Agree	48	24.6	24.6	63.6

	Strongly Agree	71	36.4	36.4	100.0
	Total	195	100.0	100.0	

Primary source

Table (26) illustrated the details of the Documentation/Information bank factors; where strongly disagree got 17%, disagree got 11%, neutral got 11%, and agree got 25%, and strongly agree got 36%. These illustrate that most respondents have agreed that Documentation/Information bank factors (such as local and global policies, standard operating procedure, lack of inventory and language barrier) do affects medical equipment maintenance practices.

Table 27. Planning and Action factors (such as procurement determination policy to access medical equipment and culture of managers to decision-making) affects medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	30	15.4	15.4	15.4
	Disagree	16	8.2	8.2	23.6
	Neutral	26	13.3	13.3	36.9
	Agree	58	29.7	29.7	66.7
	Strongly Agree	65	33.3	33.3	100.0
	Total	195	100.0	100.0	

Primary source

Table (27) showed the details of Planning and Action factors; where strongly disagree got 16%, disagree got 8%, neutral got 13%, and agree got 30%, and strongly agree got 33%. These illustrate that most respondents have agreed that Planning and Action factors (such as procurement determination policy to access medical equipment and culture of managers to decision-making) do affects medical equipment maintenance practices.

Table 28. Infrastructure factors(such as narrow space and power disruption affects medical equipment maintenance practices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	26	13.3	13.3	13.3
	Disagree	24	12.3	12.3	25.6
	Neutral	8	4.1	4.1	29.7

	Agree	60	30.8	30.8	60.5
	Strongly agree	77	39.5	39.5	100.0
	Total	195	100.0	100.0	

Primary source

Table (28) gave the details of Infrastructure factors; where strongly disagree got 13%, disagree got 12%, neutral got 4%, and agree got 31% and strongly agree got 40%. These illustrate that most participants have agreed that Infrastructure factors (such as narrow space and power disruption) do affects medical equipment maintenance practices.

Table 29. Quality and Safety factors (such as testing the device commissioning, adjustment and calibration) affects medical equipment maintenance practices.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	22	11.3	11.3	11.3
	Disagree	20	10.3	10.3	21.5
	Neutral	23	11.8	11.8	33.3
	Agree	64	32.8	32.8	66.2
	Strongly Agree	66	33.8	33.8	100.0
	Total	195	100.0	100.0	

Primary source

Table (29) demonstrated the details of Quality and Safety factors where strongly disagree got 11%, disagree got 10%, neutral got 12%, and agree got 33% and strongly agree got 34%. These illustrate that Quality and Safety factors (such as testing the device, commissioning, adjustment and calibration) do affect medical equipment maintenance practices.

Root causes of medical equipment maintenance failures

Table 30: Root causes of medical equipment maintenance failures: Descriptive Statistics

Item: Root causes of medical equipment maintenance failures	Scale[3]					Mean	Std. Dev.
	1	2	3	4	5		

[3] ***Where 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4=Agree 5=Strongly Agree***

Improper storage and transportation is major root cause for medical equipment maintenance failures	29	21	15	62	68	3.61	1.43
Initial failure is major root cause for medical equipment maintenance failures	29	22	20	71	53	3.50	1.39
Inappropriate handling is major root cause for medical equipment maintenance failures	29	16	13	69	68	3.67	1.41
Inadequate maintenance is major root cause for medical equipment maintenance failures	27	16	10	69	73	3.74	1.39
Environmental stress is major root cause for medical equipment maintenance failures	35	25	19	58	58	3.41	1.48
Random failure is major root cause for medical equipment maintenance failures	27	20	25	60	63	3.57	1.39
Inappropriate repair technique is major root cause for medical equipment maintenance failures	31	12	16	69	67	3.66	1.41
Wear-out failure is major root cause for medical equipment maintenance failures	35	20	24	58	58	3.43	1.46
poor maintenance culture is major root cause for medical equipment maintenance failures	42	16	13	54	70	3.48	1.56
lack of highly trained technicians is major root cause for medical equipment maintenance failures	41	16	11	43	84	3.58	1.59
Grand mean of Root causes of medical equipment maintenance failures						3.565	

Source: Own survey, 2022

The overall grand mean value of root causes of medical equipment maintenance failures secured a grand mean of 3.565 and it can be interpreted as identified factors found to be influential factors as the weighted average mean value falls between a mean ranges of 3.40-4.19.

Table 31. Improper storage and transportation are the major root causes for medical equipment maintenance failure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	29	14.9	14.9	14.9
	Disagree	21	10.8	10.8	25.6
	Neutral	15	7.7	7.7	33.3
	Agree	62	31.8	31.8	65.1
	Strongly Agree	68	34.9	34.9	100.0
	Total	195	100.0	100.0	

Primary source

Table (31) gave details Improper storage and transportation; where strongly disagree got 15%, disagree got 11%, neutral got 7%, and agree got 32% and strongly agree got 35%. These demonstrate that improper storage and transportation are the major root causes for medical equipment maintenance failure.

Table 32. Initial failure is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	29	14.9	14.9	14.9
	Disagree	22	11.3	11.3	26.2
	Neutral	20	10.3	10.3	36.4
	Agree	71	36.4	36.4	72.8
	Strongly Agree	53	27.2	27.2	100.0
	Total	195	100.0	100.0	

Primary source

Table (32) showed the details of Initial failure; where strongly disagree got 15%, disagree got 11%, neutral got 10%, and agree got 37% and strongly agree got 27%. These demonstrate that Initial failure is the major root cause for medical equipment maintenance failure.

Table 33. Inappropriate handling is the major cause for medical equipment maintenance failure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	29	14.9	14.9	14.9
	Disagree	16	8.2	8.2	23.1
	Neutral	13	6.7	6.7	29.7
	Agree	69	35.4	35.4	65.1
	Strongly Agree	68	34.9	34.9	100.0
	Total	195	100.0	100.0	

Primary source

Table (33) illustrated the details of inappropriate handling; where strongly disagree got 15%, disagree got 8%, neutral got 7%, and agree got 35% and strongly agree got 35%. These demonstrate that inappropriate handling of medical device is the major cause for medical equipment maintenance failure.

Table 34. Inadequate maintenance is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	27	13.8	13.8	13.8
	Disagree	16	8.2	8.2	22.1
	Neutral	10	5.1	5.1	27.2
	Agree	69	35.4	35.4	62.6
	Strongly Agree	73	37.4	37.4	100.0
	Total	195	100.0	100.0	

Primary source

Table (34) showed the details of inadequate maintenance, where strongly disagree got 14%, disagree got 8%, neutral got 5%, and agree got 35% and strongly agree got 38%. These demonstrate that inadequate maintenance is the major root cause for medical equipment maintenance failure.

Table 35. Environmental stress is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	35	17.9	17.9	17.9
	Disagree	25	12.8	12.8	30.8
	Neutral	19	9.7	9.7	40.5
	Agree	58	29.7	29.7	70.3
	Strongly Agree	58	29.7	29.7	100.0
	Total	195	100.0	100.0	

Primary source

Table (35) gave the details of environmental stress; where strongly disagree got 18%, disagree got 13%, neutral got 9%, and agree got 30% and strongly agree got 30%. These demonstrate that environmental stress is the major root cause for medical equipment maintenance failure.

Table 36. Random failure is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	27	13.8	13.8	13.8
	Disagree	20	10.3	10.3	24.1
	Neutral	25	12.8	12.8	36.9
	Agree	60	30.8	30.8	67.7
	Strongly Agree	63	32.3	32.3	100.0
	Total	195	100.0	100.0	

Primary source

Table (36) demonstrated the details of random failure; where strongly disagree got 14%, disagree got 10%, neutral got 13%, and agree got 31% and strongly agree got 32%. These demonstrate that random failure is the major root cause for medical equipment maintenance failure.

Table 37. Inappropriate repair technic is the major root cause for medical equipment maintenance failure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	31	15.9	15.9	15.9
	Disagree	12	6.2	6.2	22.1
	Neutral	16	8.2	8.2	30.3
	Agree	69	35.4	35.4	65.6
	Strongly Agree	67	34.4	34.4	100.0
	Total	195	100.0	100.0	

Primary source

Table (37) provided the details of inappropriate repairing technical; where strongly disagree got 16%, disagree got 6%, neutral got 8%, and agree got 36% and strongly agree got 34%. These demonstrate that inappropriate repairing technical is the major root cause for medical equipment maintenance failure.

Table 38. Wear-out failure is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	35	17.9	17.9	17.9
	Disagree	20	10.3	10.3	28.2
	Neutral	24	12.3	12.3	40.5
	Agree	58	29.7	29.7	70.3
	Strongly Agree	58	29.7	29.7	100.0
	Total	195	100.0	100.0	

Primary source

Table (38) revealed the details of Wear-out failure; where strongly disagree got 18%, disagree got 10%, neutral got 12%, and agree got 30% and strongly agree got 30%. These validate that Wear-out failure is the major root cause for medical equipment maintenance failure.

Table 39. Poor maintenance culture is the major root cause for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	42	21.5	21.5	21.5
	Disagree	16	8.2	8.2	29.7
	Neutral	13	6.7	6.7	36.4
	Agree	54	27.7	27.7	64.1
	Strongly Agree	70	35.9	35.9	100.0
	Total	195	100.0	100.0	

Primary source

Table (39) offered the details of poor maintenance culture; where strongly disagree got 21%, disagree got 8%, neutral got 7%, and agree got 28% and strongly agree got 36%. These proved that poor maintenance culture is the major root cause for medical equipment maintenance failure.

Table 40. Lack of highly trained technicians are the major root causes for medical equipment maintenance failure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	41	21.0	21.0	21.0
	Disagree	16	8.2	8.2	29.2
	Neutral	11	5.6	5.6	34.9
	Agree	43	22.1	22.1	56.9
	Strongly Agree	84	43.1	43.1	100.0
	Total	195	100.0	100.0	

Primary source

Table (40) provided the details of lack of highly trained technicians; where strongly disagree got 21%, disagree got 8%, neutral got 6%, and agree got 22% and strongly agree got 43%. These demonstrate that Lack of highly trained technicians are the major root causes for medical equipment maintenance failure.

Results for qualitative study:

Data were obtained from the field note and audio recorded that were transcript into a written text. Data were cleaned, coded, edited till the 8 themes and 16 subthemes were obtained from the respondents. Table below summarized the themes and sub-themes pointed out by the respondents.

Table 41. Themes and Sub-Themes.

Themes	Sub-themes
Resources	Financial resource
	Human resource
	Physical resource
Documentation	Operator guiding manual
	National and global protocols
Inspection and Preventive repair	Routine checkup of the equipment
Quality safety	Safety of the operator, patient and equipment
Education and Services	Users training
	Installation
	Decommissioning
	Corrective repair
	Outsourcing
Design and Implementation	Planning for repair activities in the hospital
	Setting up and define local policies
Miss- Appropriateness of the Medical devices	Medical device being handle by un-skill personnel
	Un-hygiene of the Medical equipment

Theme1: Resources:

This was made up of three types, financial, Physical and human resources. Resources is fundamental for effectiveness performance of the medical equipment maintenance practices in Wau Teaching Hospital**.** All the respondents mentioned that, Wau Teaching Hospital lack resources to build on.

Financial Resource:

Financial resource is to ensure hospital has the funding opportunity to assist in procuring medical devices, purchasing the spare parts and repairing the equipment. Majority of respondents have

narrated that; funding is of a great concern, since it facilitates to procure medical equipment, spare parts, and repair the medical devices on time; but the hospital has no budget designated for medical equipment.

Human Resource: The present of highly trained technicians and the biomedical engineered are very important in planning, and implementation of medical equipment maintenance practices.

All the respondents have pointed out that, the most area of weakness in the hospital is lack of a trained technician and biomedical engineered in the hospital. One of the participants mentioned that, when medical device breakdown, it is only the organization who supported the hospital will hire and bring the biomedical engineered to come and repair the medical device when it breaks down.

Another respondent narrated that, equipment procured depend on the availability of the expertise hired by the organization and when the project ended, no one is capable to operate the devices such as infant and bay incubators.

Physical resource: The majority of the participants have mentioned that, a separate area to maintain equipment, is paramount to the institution. Well ventilated area, present of spare parts, good storage practices will have a long life span for the devices.

One of the participant said and I quote: There is no designated area to repair medical devices in the hospital rather an equipment is being maintain in their places where they are situated. The majority of the participants pointed out that, the building of the hospital is an old design, and have contributed to poor hygiene of medical devices in the hospital. Another participant mentioned that, most of the equipment donated do not have spare parts, he added nowadays, most of the equipment operating in the modern world are using software and that software need to be updated and it incur huge financial cost. In this study it was found that wear-out failure was attributed to donated equipment to the hospital where the capability to operate those sophisticated devices is rarely available. Language barrier was documented from one of the participant when he said and I quote, some of the equipment do come with the foreign language and it is so difficult to the equipment operators to understand or follow the company instruction

Theme 2 Documentation:

Documentation will ensure all the information about the equipment is available on the desk when needed. The majority of the respondents have mentioned that, when it comes to information about the devices, protocol and guidelines and I quote from the director general of Wau Teaching Hospital, he said, there are scarcity of local, global and protocols in place, lack computer data base designated to store the information system about the devices, documentation is paper base activity.

Theme3: Inspection and Preventive repair.

The theme came up from lack of regular checkup of medical devices in the hospital. Majority of Participants agreed that; assessing medical devices on the regular bases will help to find out any fault and will allow the hospital management to plan whether to device need to be repair or plan to procure new medical device.

One of the respondent mentioned that; lack of biomedical expert in the hospital is one factor that affected the planning and repair process in the hospital. The equipment operators have limited knowledge in dealing with devices. The participants also mentioned that; some of sophisticated equipment are lying down un- used.

Theme 4: Quality safety.

This theme emerged from the safety of the equipment operators, patients and equipment itself.

The participants stated that; safety is paramount in any implementation process. One of the participants said that some of health care instrument is hazardous such as X- Ray machine if not handle properly. Majority agreed that irregular power supply do affect service delivery and can easily harm a patient. The participants also pointed out equipment are being donated and it not in conformity to the need of the institution like anesthetic machine brought no one has used it, so, it became very difficult to test the safety of medical device, and this is due to a fact that there is no biomedical expert in the hospital.

Theme 5: Education.

All the participants have mentioned that training is very important to the equipment operators, and that is due to fact that some of the medical devices are so sophisticated and it require someone to be

train so as to handle the device safely for the operator and the patient. All the respondents stated that the highly specialized equipment donated by the implementing partner who support the hospital are being brought together by a hired consultant mandated to operate the machine, and when the project ended up in the hospital, there is no one who can operate the device and some are lying down un-use. This document a rare training being conducted to the equipment operators.

Theme 6: Services.

This theme emerged from sub-themes such fixing the device, scraping equipment, breakdown repair and bring a biomedical engineered to repair the device.

Installation: Is the process of fixing the new medical device for it to operates in an effective manner.

All the respondents stated that the installation process is being done by the hired expertise and rarely the involvement of the equipment users.

Decommissioning: Is the process of scraping medical device of no longer use in the hospital.

The participants mentioned that expired medical equipment are being damp either in an open space in the hospital or in the hall. The study has found new medical device outdated lying down, and this is a waste of the resource.

Corrective repair: Is the process of repairing medical device when it breaks down. All the participants mentioned that breakdown repair is the only maintenance practices seen in the hospital.

One of the participant stated that when equipment failed to operate, the hospital management raised the concern to the implementing partner who does support the hospital. The supporting organization outsource a Third- Party Logistic to come and do the repair of the equipment. Another respondent mentioned that, bring an expert from outside to repair medical device incur a huge cost on the hospital.

Outsourcing: Outsourcing is to give a contract to a Third-Party Logistic to do the work on behalf of the institution. The interviewers stated that outsourcing is the main practice observed in the hospital where an expertise is being brought to repair medical devices after they failed to operate.

One of the participant mentioned that outsourcing take long time for the equipment to be repair on time and it incurs a huge cost on the hospital.

Theme 7: Design and Implementation.

This theme came up from subthemes narrated by the respondents that, there is lack defining policies and protocols to guide the maintenance activities in the hospital. Lack of planning process to repair medical devices in the hospital. One of the participant mentioned, due to poor planning, oxygen cylinders were brought to the hospital and oxygen regulators mismatch and that have contributed to waste of the resource. The study also documents non-availability of planning activities.

Theme 8: Miss- Appropriateness of the Medical devices.

This came out from handling the medical equipment by un-skilled personnel, un-hygienic of medical equipment and inappropriate storage of medical equipment. One of the interviewer mentioned there is intentional miss-appropriateness of medical devices in the hospital, I quote his statement; some of medical equipment brought for first time are lying in the hall and under the verandah un-protected. He added that there is a poor planning and management observed in the institution.

Quantitative and qualitative results integration:

Majority of the respondents from both the studies have agreed that corrective maintenance was the only practice seen in the hospital, there was no biomedical engineered, scarcity of funding support, lack of training to the equipment operators, lack of documentation/information (local and global policies, standard operating procedure, weak inventory and language barrier), miss- appropriateness of medical devices (by un-skilled personnel , un-hygiene of medical devices and improper storage), lack of planning and action by the top management, lack of place designated to maintain equipment, irregular power, inadequate quality and safety practices such as testing, calibrating and lack of computer data to store and retrieve information about the equipment maintenance practices were the major growing factors affecting medical equipment maintenance practices at Wau Teaching hospital.

The point of contrast was around Third-Party Logistic where majority of the respondents in quantitative study have disagreed that hospital was not contracting a company to come and repair the medical devices while in qualitative study the supply chain experts pointed out the maintenance practices were contracted to a third party logistic since the hospital lack biomedical engineered.

In view of this, majority of the respondents are not well familiar with the term Third-Party Logistics and that reflect their poor understanding in regard to maintenance practices at the hospital.

Desk Review:

In the current study, there were non-availability of the plan paper base in regard to medical devices maintenance process, there were scarcity of local, global policies and protocols.

Table 42. Observation Checklist: The table showed three types of score. If the element met the standard it scores 2, in case of half-done, one score and in case of incompatibility, it scores zero.

Maintenance Practices	Standards	Data Collection Method	Data Collection Source	Score		
				0	1	2
Inspection and Preventive	To assess and treat the equipment on the routine basis.	Observation and record review	Head Equipment operator	0		
Corrective	To restore device back to its normal function after it fail to operate.	Observation and Record Review	Head Equipment operator		1	
Predictive	A forecasting technique to determine the rate of failure of certain types of replaceable component, and	Record Review	Head Equipment operator	0		

	then the interval is set to repair the device					
Proactive	The process of maintaining the exact part of the device that had fail to operate.	Record Review	Head Equipment operator	0		
In-house	Staff do maintain the device in the health facility	Observation & Interview	Head Equipment operator	0		
Outsourcing	Third Party logistic contracted to repair the equipment	Record Review	Head Equipment operator	2		

"CHAPTER FIVE DISCUSSION"

Introduction

The section showed the demographic profile of the respondents who have participated in the researched intern of their sex, age, occupation, education background and experiences. The discussion under four objectives namely; healthcare apparatus repair exercise, factors influencing medical equipment maintenance practices, the major root causes medical equipment maintenance failures and the best practices for medical equipment planning intervention.

1. Respondent's demographic profile:

Based on this research, there were more females 108(55.4%) than males and study covered most of the age group ranging between 36- 40 years and above 41(21%), while observing their occupation the study indicated that most of the respondents who participated proficiently were nurses140 (72%) rather than any other professional (**Table 1**). The study showed, that most of respondents were in standard stage with good experiences. Thus, the study went further to educational background, and the finding were that, most of the respondents 88(45%) who participated were having a Diploma degree. With regard to marital status 150(77%), were married while on working experience research specified that, most of the respondents had an experienced greater than 20 years, 72(40%).

2. Health Care apparatus repairs exercise:

A study conducted in Canada, almost the services delivery unit were using their manufacturers' guiding manual to maintain their medical instruments and the hospital do outsource maintenance services to a Third- Party Logistic(1).

In this present study, it was found that, maintenance practices are outsourced to Thirty-Party Logistic, and the corrective maintenance is the main practices observed when medical equipment breakdown.

In Malaysia, five maintenance practices were noted (Preventive, Proactive, Corrective, Predictive and Breakdown maintenance), and the most used practices were preventive and breakdown maintenance(8). In the current study, majority of the respondents have mentioned that preventive, predictive and proactive maintenance practices are rarely being implemented in the hospital and that

is due to a complete lack biomedical engineering, highly trained technicians and there is not designated area to repair medical devices, rather that medical equipment is being maintain where they located. This have really shown that, Wau Teaching hospital is still far behind.

Study conducted in Iran, it was found out that two practices corrective and preventive maintenance were used(3). In this present study, corrective maintenance is the only repair practices seen in the hospital. Majority of the respondents pointed out that, for effective maintenance practices, there should be a guiding policy, standard operating procedure, adequate space and biomedical engineered, in actual fact these are not being observed in the hospital. World Health Organization has revealed that, 50% of the healthcare instrument in Low and Middle income countries is used wrongly or is not adequate repair due to ineffective managing policies(9). In this study, the situation is of great concern since no single document was seen during desk review.

3. Factors influencing medical equipment maintenance practice:

A study conducted in Kenya, it was found out that, most of the factors that affect medical equipment maintenance practices were lack of preventive maintenance plan, inadequate inventory documentation and shortage of spare parts(4).

One of the study have shown that, most of the factors affect medical equipment maintenance practice were limited to qualifies human resource, irregularity in servicing the medical devices and workload on a limited number of equipment(11).

A study revealed that, factors that lead to ineffective performance of medical equipment maintenance practices were linked to qualified candidates to operate the machine, inadequate infrastructure, limited knowledge about the devices and lack of individual accountability(12).

In the current study, the majority of respondents strongly agreed that lack of biomedical engineered, scarcity of funding support, lack of training to the equipment operators, lack of documentation/information (local and global policies, standard operating procedure, weak inventory and language barrier), miss- appropriateness of medical devices (by un-skilled personnel and un-hygiene of medical devices) lack of planning and action by the top management, lack of place

designated to maintain equipment, lack of quality and safety practices such as testing, calibrating are the major growing factors affecting medical equipment maintenance practices in Wau Teaching hospital. The study also documented most of the donated equipment to hospital were lying un-used and that due to a fact that, the implementing partner supporting the hospital do hired consultant to operate the devices, and upon completion of the project the equipment remains un-used. Comparing these results to the other world, there were some corners stones where they are building on, in the current study, the situation is of great concern, since there is no foundation yet observed to deal with medical device maintenance practices in the hospital, and that called for backward in the modernization era.

4. Root causes of medical equipment maintenance failures:

Study carried out by WHO, it revealed that 80% of health care instrument failure happened due to preventable factors, 60% occurred due to inadequate repair and about 20% occurred due to inappropriate handling(13).

In Ghana, it was found out that, the causes of the health care instrument were attributed to improper storage, transportation, insufficient upkeep of the devices, environmental diversity failure at random, incorrect repair process, failure due to wear out of the devices and limited number of highly trained skilled personnel(13).

In the current study, the situation is more complex compared to the study carried out in Ghana, all the roots cause of medical equipment maintenance failures looked the same but there are limited number of skilled personnel seen in study conducted in Ghana, on the other hand, there is no single biomedical engineered seen in Wau Teaching Hospital and that have raise an alarming situation of great need in Wau Teaching Hospital compared to the study conducted in Ghana.

5. Best Practices for Medical equipment maintenance planning interventions on medical equipment failures:

World Health Organization recommend the introduction of Computerized Maintenance Management System software. The software is very important in keeping an information about the devices, tracking previous records and it assist in scheduling inspection prevention maintenance

dates(2). Equipment donation pulling process and in conformity to the country policy is the best practice to avoid equipment failure and damping(14).

Best practiced also seen in Ghana Hospitals where effective maintenance records were established to track all maintenance activities(13). The researcher also agreed with the five maintenance practices seen in Malaysia such as (preventive, pro-active, corrective, predictive and breakdown maintenance). These will enhance service delivery by prolonging the life of the equipment and save cost to the management.

In the current study since the hospital did not own the maintenance practices on the ground, rather depend on the donor's expertise to repair the medical devices, it is of great concern that availing the resources such as biomedical engineered who will be concerned for equipment, infrastructure to ensure adequate space and ventilation, financing and adopting local and global policies and protocols. At the current level of Wau Teaching Hospital, inspection-preventive and corrective maintenance should be adopted as the best practices.

"CHAPTER: SIX CONCLUSION AND RECOMMENDATIONS"

6.1 Conclusion

With advances in the clinical field, medical equipment in hospitals is becoming increasingly advanced, so it is necessary to ensure that it is working under ideal conditions as clinical advancements progress. Improper repair of healthcare devices results in equipment breakdown, reduces their function, and wastes of resources.

6.2 Health Care apparatus repairs practices in Wau Teaching Hospital:

In the present study, it was found that, maintenance practices are outsourced to Thirty-Party Logistic, and the corrective maintenance is the main practices observed when medical equipment broke down. There were lack of inspection, prevention, predictive and proactive maintenance practices and there was no designated area to repair medical devices rather an equipment is being maintain in their places where they are situated in the hospital. The study also documented scarcity of local, global and protocols in place, lack of computer data base designated to store the information system about the devices, there was irregularity in power supply, most of the medical equipment were donated by the implementing partner and it is not based on the need of hospital. The study has found new medical device out-of-date lying down, and that was a waste of the resource.

6.3 Factors influencing medical equipment maintenance practice:

In the current study, the majority of respondents strongly agreed that lack of biomedical engineered, scarcity of funding support, lack of training to the equipment operators, lack of documentation/information, miss- appropriateness of medical devices ,lack of planning and action by the top management, lack of place designated to maintain equipment, lack of quality and safety practices such as testing, calibrating are the major growing factors affecting medical equipment maintenance practices in Wau Teaching hospital. The study also documented most of the donated equipment to hospital were lying un-used and that due to a fact that, the implementing partner supporting the hospital do hired consultant to operate the devices, and upon completion of the project the equipment remains un-used.

6.4 Root causes of medical equipment maintenance failures:

In the current study, the situation was more complex compared to the study carried out in Ghana, all the roots cause of medical equipment maintenance failures looked the same but there were limited number of skilled personnel seen in study conducted in Ghana, on the other hand, there was no single biomedical engineered seen in Wau Teaching Hospital and that had raise an alarming situation of great need to have biomedical engineering in Wau Teaching Hospital compared to the study conducted in Ghana.

6.5 Recommendations:

For the effective and smooth implementation of medical equipment maintenance practices rely on the resources such human expertise, funding, infrastructure, proper documentation, capacity building and education, routine checkup of medical devices, proper forecasting and implementation.

Medical equipment maintenance practice:

In the present study, it was found that, maintenance practices were outsourced to Thirty-Party Logistic when medical equipment breakdown. There were lacks of inspection and preventive, predictive and proactive maintenance practices being implemented in the hospital.

For effective maintenance practices, ministry of health, donors and hospital have to avail resources particular biomedical engineered, financial allocation and establishment of an infrastructure mandated to repair the medical equipment, long and short term capacity building in the field of biomedical engineering. Treating institution has to adopt the best practices of inspection and prevention maintenance and that will allow the managers to detect any defect and that will allow the institution to plan early for repair or replacement of the device and the practices will lead into long life span of the equipment.

Factors influencing medical equipment maintenance practice:

In the current study, the influencing factors affecting medical equipment maintenance practices were link to lack of biomedical engineered, scarcity of funding support, lack of training to the equipment operators, lack of documentation/information, lack of planning and action by the top managers, lack of place designated to maintain equipment, lack of quality and safety practices such as testing, calibration.

It is recommended that Ministry of Health has to planning, forecasting and procuring of medical equipment and that should be based on the need and expertise in the treating institution. Ministry of Health has to formulate policy, protocol and standard operating procedure in the area of equipment maintenance process and to cascade them down as a guiding principles to the tiers. Ministry of Health to introduce computer data base and that will help the managers to store and retrieve information quickly about medical devices. Moreover, resources are of the growing concern need to be address.

Root causes of medical equipment maintenance failures:

In the current study, the results demonstrated that, root causes of medical equipment maintenance failure were linked to improper storage, inappropriate handling, inappropriate maintenance and repair technic and lack of biomedical engineered remain the growing concern at Wau Teaching Hospital.

It is recommended that MOH has to allocate funding for the establishment of adequate infrastructure, introduction of biomedical engineering department, long term capacity building of health staff designated in the field of bioengineering.

6.6 Best Practices for Medical equipment maintenance planning interventions on medical equipment failures:

In the current study since the hospital did not own the maintenance practices on the ground, rather it depends on the donor's expertise to repair the medical devices, it is of a great concern to avail a human resource. At the moment, since Wau Teaching Hospital did not yet have foundation to handle equipment maintenance practices by their own, it is advisable to adopt inspection- prevention maintenance, and it will allow fault detection and quick management decision to either repair and replace the device. Hospital has to adopt WHO recommendation to introduce computer data base for storing and easy retrieving information about medical equipment maintenance practices.

6.7 Study Limitation and Future Research Study

Scarcity of an access to full-texts of medical equipment maintenance practice articles published in South Sudan. Some participants refused to cooperate because they feared jeopardizing the confidentiality of the information they provided. English language became a barrier to some of the health staff, and study have used google translator to translate the questionnaires. It important to dig more in the areas of financial implication on medical equipment maintenance practices, maintenance

management of medical device, human resource for medical equipment, availability and gaps and medical equipment prioritization in the health facility.

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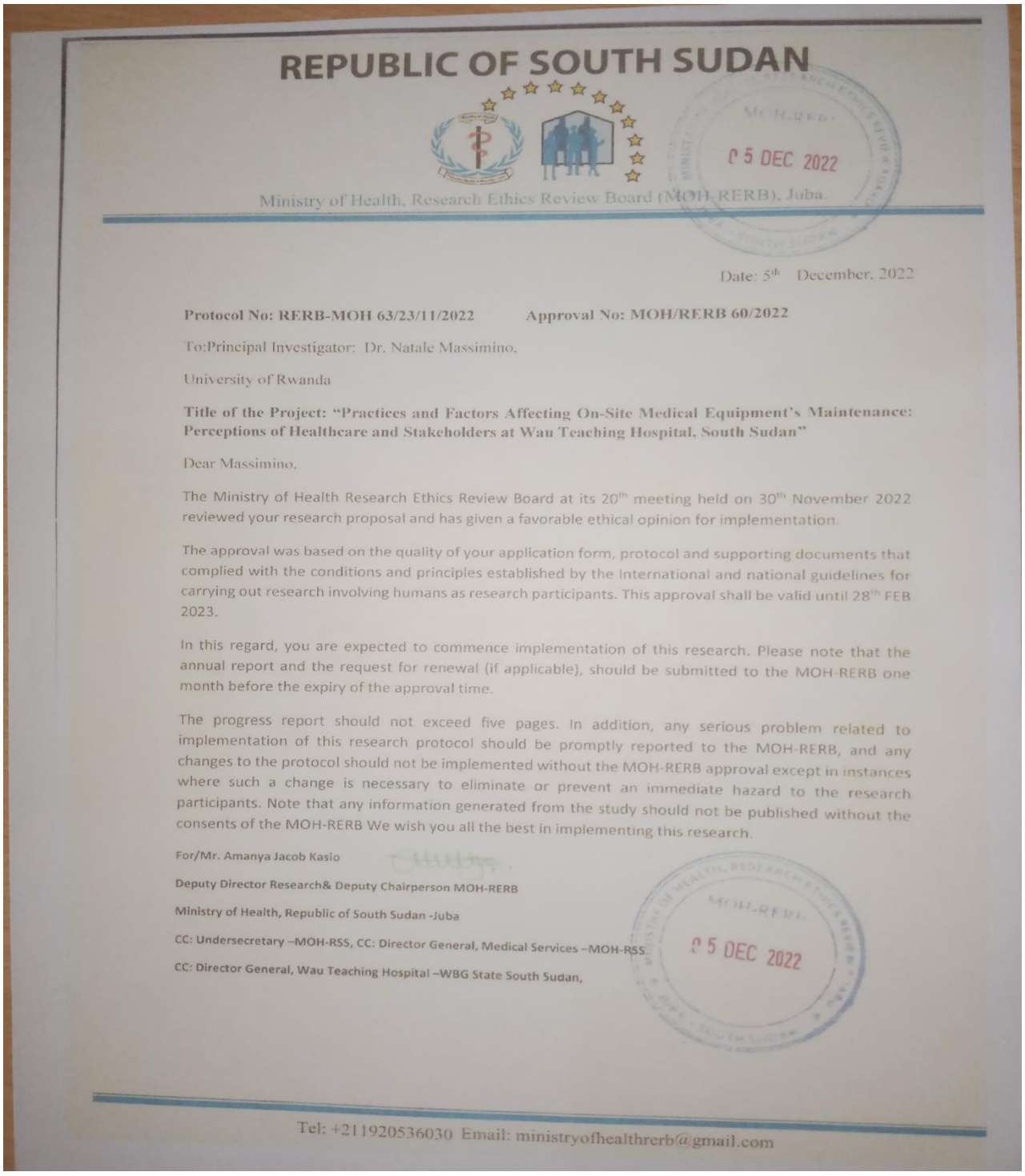
Appendix (1) Ethical Approval



REPUBLIC OF SOUTH SUDAN

Ministry of Health, Research Ethics Review Board (MOH-RERB), Juba.

05 DEC 2022

Date: 5th December, 2022

Protocol No: RERB-MOH 63/23/11/2022 **Approval No: MOH/RERB 60/2022**

To:Principal Investigator: Dr. Natale Massimino,

University of Rwanda

Title of the Project: "Practices and Factors Affecting On-Site Medical Equipment's Maintenance: Perceptions of Healthcare and Stakeholders at Wau Teaching Hospital, South Sudan"

Dear Massimino,

The Ministry of Health Research Ethics Review Board at its 20th meeting held on 30th November 2022 reviewed your research proposal and has given a favorable ethical opinion for implementation.

The approval was based on the quality of your application form, protocol and supporting documents that complied with the conditions and principles established by the International and national guidelines for carrying out research involving humans as research participants. This approval shall be valid until 28th FEB 2023.

In this regard, you are expected to commence implementation of this research. Please note that the annual report and the request for renewal (if applicable), should be submitted to the MOH-RERB one month before the expiry of the approval time.

The progress report should not exceed five pages. In addition, any serious problem related to implementation of this research protocol should be promptly reported to the MOH-RERB, and any changes to the protocol should not be implemented without the MOH-RERB approval except in instances where such a change is necessary to eliminate or prevent an immediate hazard to the research participants. Note that any information generated from the study should not be published without the consents of the MOH-RERB We wish you all the best in implementing this research.

For/Mr. Amanya Jacob Kasio

Deputy Director Research& Deputy Chairperson MOH-RERB

Ministry of Health, Republic of South Sudan -Juba

CC: Undersecretary –MOH-RSS, CC: Director General, Medical Services –MOH-RSS

CC: Director General, Wau Teaching Hospital –WBG State South Sudan,

05 DEC 2022

Tel: +211920536030 Email: ministryofhealthrerb@gmail.com

Appendix (II): Consent form

PRACTICES AND FACTORS AFFECTING ON-SITE MEDICAL EQUIPMENT MAINTENANCE, PERCEPTIONS OF HEALTHCARE AND STAKEHOLDERS AT WAU TEACHING HOSPITAL, SOUTH SUDAN

Consent to take part in research

• I..... willingly accept to engage in this research project.

• I realize that even if I agree to participate now, I can withdraw at any moment or refuse to answer any question without penalty.

• I may revoke consent to use data from my interview within two weeks of the interview, in which case the content will be erased.

• I was given written explanations of the study's objective and nature, as well as the opportunity to ask questions about it.

• I understand that participating in this research will not directly benefit me.

• I accept interview to be audio-recorded

• I am aware that any information I disclose for this study will be kept strictly confidential.

• I knowledgeable that understand that original audio recordings will be retained in a secure place.

• I am aware that under freedom of information legalization I can be able to get the information I have provided at any time while it is in storage as specified above.

• I accept that I am free to contact any of the research participants for additional clarity and information.

• I understand that all information I provide for this study will be treated confidentially.

• I am aware that the results of this research, my identity will remain disclose.

.

- I am aware that at any time I can call the researcher to seek I am free to contact any explanation and information.

Names, degrees, affiliations and contact details of researchers (and academic supervisors when relevant).

Signature of research's Participant Date

---------- ----------

Signature of researcher

I believe the participant is giving informed consent to participate in this study

---------- ----------

Signature of researcher Date

Appendix (III): Questionnaires

PRACTICES AND FACTORS AFFECTING ON-SITE MEDICAL EQUIPMENT MAINTENANCE, PERCEPTIONS OF HEALTHCARE AND STAKEHOLDERS AT WAU TEACHING HOSPITAL, SOUTH SUDAN.

The main purpose is to find out what health care workers think about the elements that affect health care instrument maintenance practices (MEMP). The purpose of the research is also to provide a framework for MEMP to deepen and improve understanding of the elements that impact healthcare instrument maintenance practices at WAU Teaching Hospital. The research will capture the indicators that impact maintenance practices at the hospital.

Your response is highly paramount and will be kept confidential for the purpose of the study.

Thank You
Natale Gon
Email: natalegon9@gmail.com

Instruction:

- Please use a **"√"** Mark to select the options that best represent your response for parts I, and use a **"√"** Mark for part II to indicate your level of agreement using a five-point liker scale from strongly disagree to strongly agree.

Part One: Demographic profile of the respondent

Respondent code (Name): _____

Email (ID)_____

Q1. What is your Age?

18-25years□ 26-30 years □ 31-35 year □ 36-40 years □ 41 and above □

Q2. What is your Gender? Male □ Female □

Q3. Designation/Occupation: _____

Q4. What is your Education levels?

Basic □ Secondary□ Diploma □ Bachelor degree□ Master degree and above □

Q5. What is your Marital Status?

Married□ Single □ Divorced□ Widow/Widower □

Q6. Working Experience:

1-5 Years□ 6-10 Years□ 11-20 Years □ 20 Years and above □

Objective 1-3: Please Fill your answers by putting a tick mark (" √") using a five-point liker scale by indicating your level of agreement where 1=Strongly disagree; 2= Disagree; 3= Neutral 4= Agree; 5= Strongly agree.

S.No	Item	Scale				
Obj.1	Medical equipment maintenance practice	1	2	3	4	5
1	The hospital has someone or in-house person mandated to repair the equipment					
2	There is an area in the hospital where the maintenance process can take place					
3	The hospital has the bioengineer or technical person who can maintain the equipment					
4	There is a regular check up on medical equipment in the hospital					
5	The hospital has regular electric power supply					
6	There is a policy for the equipment maintenance practices in the hospital					
7	The hospital has the standard operating procedure					
8	The hospital repair the equipment by bringing an expert (Third Party) from outside using outsourcing strategy					
9	The hospital procures in-house medical equipment maintenance practices					

10	Preventive maintenance as it assess and treat the equipment on the routine basis and repair process take place on the regular interval become the most preferred maintenance practice in WAU teaching hospital					
11	Corrective maintenance as it is a process of restoring device back to its normal function after it fails to operate is the most preferred maintenance practice in WAU teaching hospital					
12	Predictive maintenance is the most preferred maintenance practice in WAU teaching hospital					
13	pro-active maintenance being the process of maintaining the exact part of the device that had failed to operate is the most preferred maintenance practice in WAU teaching hospital					
Obj.2	Factors influencing medical equipment maintenance practices	1	2	3	4	5
14	Resources Related factors (such as lack of adequate human resource, Physical infrastructure, Limited funding, Lack of human resource) affects medical equipment maintenance practices					
15	Lack of training to the equipment operators affects medical equipment maintenance practices					
16	Documentation/Information bank factors (such as Local and global policies, Standard operating procedure, Lack of inventory and Languages Barrier) affects medical equipment maintenance practices					
17	Miss- appropriateness factors (such as Lack of frequent cleaning and Use of device by a person not skillful) affects medical equipment maintenance practices					
18	Planning and Action factors (such as Procurement determination policy to access medical equipment and Culture of managers to decision-making) affects medical equipment maintenance practices					
19	Infrastructure factors (such as Narrow space and Power disruption) affects medical equipment maintenance practices					
20	Quality and Safety factors (such as Testing the device Commissioning and Adjustment and calibration) affects medical equipment maintenance practices					
Obj.3	Root causes of medical equipment maintenance failures	1	2	3	4	5
21	Improper storage and transportation is major root cause for medical equipment maintenance failures					
22	Initial failure is major root cause for medical equipment maintenance failures					
23	Inappropriate handling is major root cause for medical equipment maintenance failures					
24	Inadequate maintenance is major root cause for medical equipment maintenance failures					
25	Environmental stress is major root cause for medical equipment maintenance failures					
26	Random failure is major root cause for medical equipment maintenance failures					
27	Inappropriate repair technique is major root cause for medical equipment maintenance failures					
28	Wear-out failure is major root cause for medical equipment maintenance failures					

29	poor maintenance culture is major root cause for medical equipment maintenance failures
30	lack of highly trained technicians is major root cause for medical equipment maintenance failures

Objective 4: Best practices for Medical equipment maintenance planning intervention on medical equipment failures.

31. What best practice would you suggest as best Medical equipment maintenance planning interventions on medical equipment failures?

_____

_____

_____

Appendix (IV) Translated questionnaires for the purpose of better understanding.

استبيانات الممارسات والعوامل التي تؤثر على صيانة المعدات الطبية في الموقع ، وتصورات الرعاية الصحيةوأصحاب المصلحة في مستشفى واو التعليمي ، جنوب السودان. الغرض الرئيسي هو معرفة ما يفكر فيه العاملون في مجال الرعاية الصحية حول العناصر التي تؤثر على ممارسات صيانة أدوات الرعاية الصحية (MEMP). الغرض من البحث لتعميق وتحسين فهم العناصر التي تؤثر على ممارسات صيانة أدوات الرعاية الصحية في MEMPهو أيضًا توفير إطار عمل لـ التعليمي. سوف يلتقط البحث المؤشرات التي تؤثر على ممارسات الصيانة في المستشفى. إن إجابتك ذات أهمية WAUمستشفى ¬ تعليمات: natalegon9@gmail.comقصوى وستظل سرية لغرض الدراسة. شكرًا لك ناتالي جون البريد الإلكتروني: الرجاء استخدام علامة "√" لتحديد الخيارات التي تمثل إجابتك بشكل أفضل للأجزاء الأولى ، واستخدم العلامة "√" للجزء الثاني للإشارة إلى مستوى موافقتك باستخدام مقياس من خمس نقاط من عدم الموافقة بشدة إلى الموافقة بشدة . الجزء الأول: الملف الديموغرافي للمستفتى رمز المستجيب (الاسم): _____ عنوان الايميل)_____

س 1. ما هو عمرك؟ 18-25 سنة، 26-30 سنة ، 31-35 سنة ، 36-40 سنة ، 41 سنة وما فوق

س 2. ما هو جنسك؟ ذكر □ انثى □

س 3. الوظيفة / الوظيفة: _____

س 4. ما هي مستوياتك التعليمية؟ أساسي ثانوي دبلوم بكالوريوس ماجستير وما فوق

س 5. ما هو وضعك العائلي؟ متزوج أعزب مطلق أرمل / أرمل

س 6. خبرة العمل: 1-5 سنوات 6-10 سنوات 11-20 سنة 20 سنة فما فوق □

الهدف 1-3: يرجى ملء إجاباتك بوضع علامة ("√") باستخدام مقياس مماثل من خمس نقاط بالإشارة إلى مستوى موافقتك حيث 1 = لا أوافق بشدة ؛ 2 = لا أوافق ؛ 3 = محايد 4 = موافق ؛ 5 = موافق بشدة. .

لا بند مقياس الهدف

1 ممارسة صيانة المعدات الطبية 1 2 3 4 5 1 يوجد بالمستشفى شخص أو شخص في المنزل مكلف بإصلاح المعدات

2 هناك منطقة في المستشفى يمكن أن تتم فيها عملية الصيانة

3 يوجد بالمستشفى مهندس حيوي أو فني يمكنه صيانة المعدات

4 هناك فحص منتظم للمعدات الطبية في المستشفى

5 يوجد بالمستشفى مصدر طاقة كهربائية منتظم

6 توجد سياسة خاصة بممارسات صيانة المعدات في المستشفى

7 المستشفى لديها إجراءات التشغيل القياسية

8 تقوم المستشفى بإصلاح المعدات عن طريق إحضار خبير (طرف ثالث) من الخارج باستخدام استراتيجية الاستعانة بمصادر خارجية

9 يقوم المستشفى بشراء ممارسات صيانة المعدات الطبية في المنزل

10- أصبحت الصيانة الوقائية ، حيث إنها تقيم وتعالج المعدات على أساس روتيني وتتم عملية الإصلاح على فترات منتظمة ، أكثر ممارسات الصيانة المفضلة في مستشفى WAU التعليمي

11 الصيانة التصحيحية ، حيث إنها عملية استعادة الجهاز إلى وظيفته العادية بعد فشل تشغيله ، هي ممارسة الصيانة الأكثر تفضيلاً في مستشفى WAU التعليمي

12 الصيانة التنبؤية هي ممارسة الصيانة الأكثر تفضيلاً في مستشفى WAU التعليمي

13 الصيانة الاستباقية هي عملية صيانة الجزء الدقيق من الجهاز الذي فشل في العمل ، وهي ممارسة الصيانة الأكثر تفضيلاً في مستشفى WAU التعليمي الهدف 2 العوامل المؤثرة في ممارسات صيانة المعدات الطبية 1 2 3 4 5

14 العوامل ذات الصلة بالموارد (مثل نقص الموارد البشرية الكافية ، والبنية التحتية المادية ، والتمويل المحدود ، ونقص الموارد البشرية) تؤثر على ممارسات صيانة المعدات الطبية

15 يؤثر نقص تدريب مشغلي المعدات على ممارسات صيانة المعدات الطبية

16 عوامل بنك المعلومات / التوثيق (مثل السياسات المحلية والعالمية وإجراءات التشغيل القياسية ونقص المخزون وحاجز اللغات) تؤثر على ممارسات صيانة المعدات الطبية

17- عوامل عدم الملاءمة (مثل قلة التنظيف المتكرر واستخدام الجهاز من قبل شخص غير ماهر) تؤثر على ممارسات صيانة المعدات الطبية

18 عوامل التخطيط والعمل (مثل سياسة تحديد المشتريات للوصول إلى المعدات الطبية وثقافة المديرين لاتخاذ القرار) تؤثر على ممارسات صيانة المعدات الطبية

19 عوامل البنية التحتية (مثل المساحة الضيقة وانقطاع التيار الكهربائي) تؤثر على ممارسات صيانة المعدات الطبية

20 عوامل الجودة والسلامة (مثل اختبار تشغيل الجهاز وضبطه ومعايرته) تؤثر على ممارسات صيانة المعدات الطبية الهدف 3 الأسباب الجذرية لفشل صيانة المعدات الطبية 1 2 3 4 5

21 التخزين والنقل غير المناسبين هو السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

22 يعتبر الفشل الأولي سببًا جذريًا رئيسيًا لفشل صيانة المعدات الطبية

23 يعتبر التعامل غير المناسب سببًا جذريًا رئيسيًا لفشل صيانة المعدات الطبية

24السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

25 الإجهاد البيئي هو السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

26 يعتبر الفشل العشوائي سببًا جذريًا رئيسيًا لفشل صيانة المعدات الطبية

إن أسلوب الإصلاح غير المناسب هو السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

28 يعتبر فشل التآكل سببًا جذريًا رئيسيًا لفشل صيانة المعدات الطبية

29 ثقافة الصيانة السيئة هي السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

30 من الفنيين المدربين تدريباً عالياً هو السبب الجذري الرئيسي لفشل صيانة المعدات الطبية

الهدف 4: أفضل الممارسات للتدخل في تخطيط صيانة المعدات الطبية بشأن أعطال المعدات الطبية.

31. ما هي أفضل الممارسات التي تقترحها كأفضل تدخلات لتخطيط صيانة المعدات الطبية بشأن أعطال المعدات الطبية؟

Appendix (V): Semi-structure Questionnaires.

PRACTICES AND FACTORS AFFECTING ON-SITE MEDICAL EQUIPMENT MAINTENANCE, PERCEPTIONS OF HEALTHCARE AND STAKEHOLDERS AT WAU TEACHING HOSPITAL, SOUTH SUDAN.

The main purpose is to find out what health care workers think about the elements that affect health care instrument maintenance practices (MEMP). The purpose of the research is also to provide a framework for MEMP to deepen and improve understanding of the elements that impact healthcare instrument maintenance practices at WAU Teaching Hospital. The research will capture the indicators that impact maintenance practices at the hospital.

Your response is highly paramount and will be kept confidential for the purpose of the study.

Thank You
Natale Gon
Email: natalegon9@gmail.com

Part One: Demographic profile of the respondent

Respondent code (Name): _____

Email (ID)_____

Q1. What is your Age?

18-25years□ 26-30 years □ 31-35 year □ 36-40 years □ 41 and above □

Q2. What is your Gender? Male □ Female □

Q3. Designation/Occupation: _____

Q4. What is your Education levels?

Basic □ Secondary□ Diploma □ Bachelor degree□ Master degree and above □

Q5. What is your Marital Status?

Married□ Single □ Divorced□ Widow/Widower □

Q6. Working Experience:

1-5 Years□ 6-10 Years□ 11-20 Years □ 20 Years and above □

1. Introduction

The researcher begins by:

• Welcomes the respondent

• Introduce himself and his profession.

• Provide the respondent with information about the research and its goal.

2. Clause of Confidentiality

The researcher assures the respondents that, all information gathered during this interview will be kept secure and confidential.

3. Study identifiers

Your name or any other identifying information, as well as everything you say, will be used solely for research reasons.

4. Interview Instructions

i. How are you today, and are you prepared for the interview?

ii. Interview with a health-care worker:

-A series of questions will be presented one by one.

i. Please introduce yourself and briefly describe your work experience.

ii. Please explain your general perception about medical equipment maintenance practices.

iii. Where is the healthcare instrument repair practice taking place?

iii. How are maintenance practices do takes place in the hospital?

iv. What do you know about the most important activities and responsibilities related to medical equipment?

v. What factors to your opinion do affect the medical devices repair practices in

hospitals?

vi. What are the major root causes of medical equipment maintenance failure in the hospital?

viii. Do the equipment users have the necessary training in the area of equipment handling?

ix. Do you have an idea for equipment donation and procurement policies?

x. Describe the role of the stakeholders who are supporting the hospital when it comes to equipment procurement or donation?

xi. What are the hurdles and roadblocks to implementing medical equipment maintenance in health centers and special hospitals?

xii. What suggestions do you have for enhancing healthcare instrument repair practice?

xiii. Would you need to mention any concern regarding healthcare instrument repairing processes?

Thank you for taking part in the interview; may we contact you again if I have any additional questions or require clarification?

Appendix VI: categories of participants

S/N	Category of the Participants	Numbers of the Participants
	Quantitative Study	
1	Medical Doctors	15
2	Equipment operators	10
3	Theatre Attendance	8
4	Store-keepers	3
5	Nurses	144
6	Mid-wives	16
7	Matron	8
8	Anesthetist	5
9	Health Pool Fund Field Coordinator (Donor)	1
10	Cordaid International Organization (Implementing partner)	1
Qualitative Study		
1	Supply Chain Expert	2 people
2	Pediatrician	1
3	Obstetrician	1
4	Director General	1
5	Medical Director	1

Appendix VII: Research Timetable

S/N	ACTIVITIES	July	August	September	October	November
1	Proposal draft Start	3 week				
2	Ethical clearness	4 week				
3	Data collection training		1 week			
4	Data testing		2 Week			
5	Data Collection		3 & 4 Week			
6	Data Cleaning and Analysis			1 2, 3 & 4 Weeks		
	Data Analysis				1,2,and 3 weeks	1week
7	Report writing					2 and 3 weeks
8	Submission of dissertation and draft Manuscript					4 week
9	Defense					4 week

Appendix VIII: Activities and Budget Allocation

S/N	Activity	Description	Unit Cost (USD)	Frequency	Total cost	Remarks
1	Travel expenses		$100	2	$200	To get Ethical clearance
2	Two days training for research assistants and one day of pretesting the tools	Allowances	$50	3	$150	
3	Venue hiring		$30	2	$60	
4	Refreshments		$5	3	$15	
5	Data collection	Allowances	$11	7	$ 77	
6	Transport for research assistants during data collection		$11	7	$77	
7	Stationery and supplies					
	Writing pads		$3	1	$3	
	A4Rims		$60	1	$60	
	Clear bags		$2	3	$6	
	Pens		$ 1	12	$12	
	Marker pens		$ 1.5	12	$18	
	Flip charts		$7	1	$7	
	Photocopy and binding (Proposal,questionnaire and reports)		$50	1	$50	
	Grand Total				**735 USD**	

Appendix (IX) Proposed Observation Checklist.

Maintenance Practices	Standards	Data Collection Method	Data Collection Source	Score 0	1	2
Inspection and Preventive	To assess and treat the equipment on the routine basis.	Observation and record review	Head Equipment operator			
Corrective	To restore device back to its normal function after it fail to operate.	Observation and Record Review	Head Equipment operator			
Predictive	A forecasting technique to determine the rate of failure of certain types of replaceable component, and then the interval is set to repair the device	Record Review	Head Equipment operator			
Proactive	The process of maintaining the exact part of the device that had fail to operate.	Record Review	Head Equipment operator			

In-house Outsourcing	Staff do maintain the device in the health facility Third Party logistic contracted to repair the equipment	Observation & Interview Record Review	Head Equipment operator Head Equipment operator			