

# An Assessment of the Effectiveness of Equipment Maintenance Practices in Public Hospitals.

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## ABSTRACT

*In the move towards world-class service delivery, many institutions are realizing a need for the use of proper maintenance of operation facilities and equipments. Health-care institutions, machines and equipment are becoming technologically more advanced and at the same time more complex and difficult to control. The purpose of the paper was to assess the effectiveness of the maintenance practices used in the maintenance of equipments at three public hospitals. The researchers set objectives which were to determine the different maintenance practices used to maintain the hospital equipment, challenges of these maintenance practices and the effect of maintenance practices on health-care service delivery. Purposive sampling was used in the distribution of 55 questionnaires among the operators and the workers. The results reviewed a high rate of equipment unavailability attributed by high failure rates due to unreliable schedule systems for equipment, high equipment breakdowns and shortage of manpower. As a result of these challenges, only 24% of the respondents agreed the health service delivery was good, while 76% agreed it was not good. 84% of the respondents in the maintenance department agreed the maintenance practices used in the maintenance of the equipment were giving a lot of challenges while 16% were not sure. As a result of these findings, the researchers grouped the different hospital equipments into different categories based on the level of criticality and designed an effective maintenance model based on reliability centered maintenance (RCM) for the purpose of improving the availability and reliability of the hospital equipment in order to add value to the health-care service.*

**Keywords:** Effectiveness, Maintenance, Hospital, Value addition

## 1. Introduction

Great changes in technology have brought about many changes in the type of machines and equipments needed for the treatment of patients in hospitals. As a result of these changes, equipment maintenance requirements have also changed and advanced. According to [1], with many developments coming to light every day, health care facilities must be prepared to accommodate whatever the future holds.

According to [2], all health service providers want the best service to be provided and delivered and to enable them to do so; they need to actively manage health service assets by ensuring that they are used effectively and optimally. The health service's most valuable assets are the human resource and physical assets such as facilities and healthcare equipments. Assessing the effectiveness of the maintenance practices used in the maintenance of hospital valuable assets was relevant as a hospital is an institution which renders health care services. According to [3], a hospital is not a mere building, but a complex social institution that handles the dynamics of life and death situations during the process of rendering health care.

Maintenance is defined as a combination of all technical and associated administrative activities required to keep equipments, installations and other physical assets in the desired operating condition or restore them to their condition [4, 5, 6]. While [7] defines it as an activity involved in keeping equipments in good working conditions by increasing reliability and availability whilst reducing failure rate. In the context of a hospital, making sure equipment is available and reliable is one factor that adds value to the health care services provided by a hospital. Therefore, effective and appropriate maintenance practices on the hospital equipments contributes to improved efficiency within the health sector resulting in improved and increased health outcomes, and a more sustainable health service.

Over the past few years, the population of Zambia has increased resulting in a direct effect on the health care services provided. The fact that the existing hospital facilities and valuable equipments have not changed to cater for the increase in population, this has resulted in an increase in the number of equipment failure rates. According to [8], installed health facilities are as old as the hospitals themselves and some of the medical equipment are unserviceable and need outright

replacement. In this research, the effectiveness of equipment maintenance practices plays a dominant role in modern health service provision. Making sure equipment maintenance practices are effective results in increased equipment availability and reliability thus a plus to the value of health service provided. The principal proposition of this research was to assess the existing maintenance practices at three public hospitals in the Copperbelt province of Zambia and in the process identify appropriate maintenance strategies for the identified equipments.

## **2. Methodology**

In order to achieve the objectives of the research, a descriptive research design was used in order to trace the relationship among the facts obtained and observed in order to gain a deeper understanding of the patterns regarding the maintenance practices. Purposive sampling was used in the distribution of questionnaires at three hospitals; Kitwe Central Hospital, Nchanga North Hospital and Ronald Ross Hospital. Purposive sampling was used because the ownership of these Public Hospitals is vested in the government, and their administrative arrangements and management are similar as they are guided by the same policies and thus the researchers considered the institutions as possessing the same characteristics. The data obtained from the questionnaires, structured interviews and direct observations was analyzed quantitatively and qualitatively. Under quantitative analysis, SPSS and Microsoft excel were used.

### **2.1 Structured Questionnaires**

The questionnaire was designed in a way that captured the different views of management and the maintenance personnel as well as the equipment end users. The questionnaire comprised of closed-ended and open-ended questions. Questions pertaining to equipment availability, maintenance strategies and service delivery were asked. They were distributed to all the departments in each of the hospitals involved and to the maintenance teams as well.

### **2.2 Interviews**

Interviews were conducted in order to get clarification and in-depth understanding of the subject area under study. These personal interviews were conducted with the head of maintenance department and the maintenance employees in order to obtain data pertaining to the following;

- Number of equipments found in specific departments and their criticality
- General failure rate of the specified equipment
- Maintenance Strategies used to handle these failures
- Methods used to notify maintenance department on equipment failures.
- Maintenance respond time to failure reports
- Number of employees in the departments as well as their trades, skills and experience
- Availability of the spares in department

### **2.3 Observations**

Observations were used to obtain an understanding of the hospitals environment with regard to the maintenance practices and the conditions of the equipments utilized in the provision of health care service. The researchers were able to obtain data that was not given by the respondents in the questionnaire and the personal interviews.

## **3. Results**

A total of 40 questionnaires were distributed among the maintenance personnel and equipment operators and only 39 were retrieved while only 10 out of 15 questionnaires were retrieved from workers. Therefore, a total number of 55 questionnaires were distributed and 49 collected. Table 1 depicts questionnaire distribution among the three hospitals.

Table 1: Questionnaire Distribution among three Hospitals

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	Frequency	Percent	Valid Percent	Cumulative Percent
KITWE C.	18	36.7	36.7	36.7
NCHANGA N	17	34.7	34.7	71.4
RONALD ROSS	14	28.6	28.6	100.0
Total	49	100.0	100.0	

**3.1 Service Delivery**

Service delivery can be affected by the type of maintenance practices. Therefore the researchers also assessed service delivery offered by the hospitals. Figure 1 show how the service delivery is rated in the three hospitals.

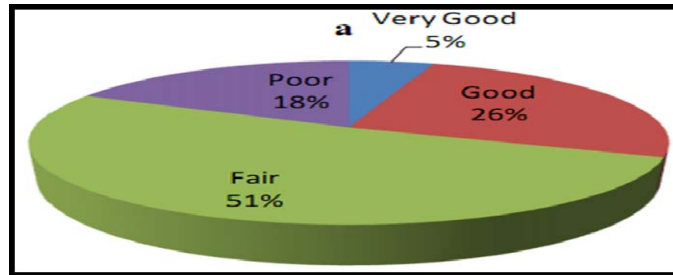


Figure 1: Service Delivery Rating

Further analysis of data, the respondents indicated the following activities to be the major problems faced by the three hospitals. These problems have also affected service delivery.

- Inadequate equipment
- Shortage of manpower
- Machines not serviced as per schedule
- Absolute material and equipments
- Equipment breakdown and high equipment unavailability
- Shortage in drugs

**3.2 Maintenance Program**

Table 2 summaries the response to the questionnaire to questions related to the hospitals' having a maintenance program to attend to equipment break downs. The table shows that 93.9% agreed a maintenance program was in place while 6.1% did not agree.

Table 2: Maintenance Program

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid YES	46	93.9	93.9	93.9
Valid NO	3	6.1	6.1	100.0
Total	49	100.0	100.0	

Further analysis of the results, the researchers deduced breakdown maintenance strategy to be the most used strategy in the maintenance of equipment. Table 3 shows that 69.4% of the respondents stated that the action on the equipments was only taken after failure had occurred. Preventive maintenance programs do exist in the maintenance department but they are not adhered to.

Table 3: Maintenance Carried Out

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	Frequency	Percent	Valid Percent	Cumulative Percent
MONTHLY	6	12.2	13.0	13.0
WEEKLY	3	6.1	6.5	19.6
DAILY	2	4.1	4.3	23.9
AFTER BREAKDOWN	34	69.4	73.9	97.8
SEMI ANNUALLY	1	2.0	2.2	100.0
Total	46	93.9	100.0	
Missing System	3	6.1		
Total	49	100.0		

**3.3 Strategy Operation Challenges**

The researchers assessed whether breakdown maintenance caused any operation challenges in the hospital. Figure 2 shows how this maintenance strategy affected equipment availability and reliability as responded to by the respondents. 57% of the respondents indicated the system gave challenges while 18% believed it did not and 25% did not respond to the question.

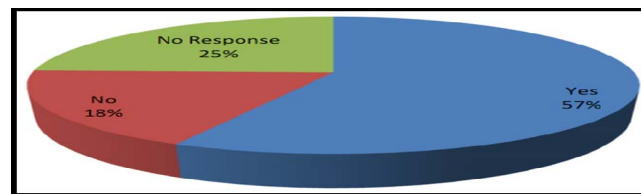


Figure 2: Strategy Operation challenges

**3.4 Hospital Equipments Categorization**

Using structured interviews and hospital records, the researchers identified the type of equipments found in the hospital. The equipments were then grouped into medical and non-medical equipment. These two groups were further categorized into critical and ordinary equipments. Critical equipments are special kind of equipment used to attend to patients with special and rare medical cases. The following are the critical equipments; incubators, resuscitators, auto clef, suction machines, oxygen concentrators and cylinders, boilers, cold rooms etc. These medical equipment require a short MTTR. The following are ordinary equipments i.e., BP machines, weighing scales, thermometers and physiotherapy equipments,

The researchers also assessed the frequency of these equipment breakdowns at the three hospitals. Table 4 shows the overall frequency of the equipment breakdowns at the three hospitals. 32.7% indicated monthly breakdowns, 13% indicated weekly breakdowns, and 9% indicated daily breakdowns and 10% semi annually.

Table 4: overall frequency of the equipment breakdowns at the three hospitals

	Frequency	Percent	Valid Percent	Cumulative Percent
MONTHLY	16	32.7	33.3	33.3
WEEKLY	13	26.5	27.1	60.4
DAILY	9	18.4	18.8	79.2
SEMI ANNUALLY	10	20.4	20.8	100.0
Total	48	98.0	100.0	
Missing System	1	2.0		
Total	49	100.0		

**3.5 Maintenance Staff**

Table 5 summarizes the responses to questions related to number of skilled and unskilled maintenance staff at each of the three hospitals in the maintenance department. At the three hospitals, the following trades and skills were found; electricians, auto mechanics, plumbers, welders, painters, boiler attendants while biomedical technicians, mechanical fitters and air-conditioning technicians are only found at Kitwe Central Hospital. Further analysis of the data shows that the number of equipment failures reported on a daily basis was not proportional to the workforce. Therefore, MTTR is increased and this is not acceptable in a public hospital.

Table 5: Number of Skilled and Unskilled Maintenance staff at each Hospital

	Skilled workers	Unskilled workers
Kitwe Central	10	5
Nchanga North	4	2
Ronald Ross	6	2

### 3.6 Spare Parts

Data regarding spare parts inventory was not accessible from the three hospitals, therefore it was difficult to determine whether a proper inventory system existed. Interviews conducted with the maintenance personnel confirmed that spare parts are usually bought when a breakdown occurs.

## 4. Discussion

After the analysis of the questionnaires and structures interviews, it was found that breakdown maintenance is the most practiced strategy at three hospitals. This maintenance strategy was indicated to be giving challenges of 57% by the respondents. Though 93.9% of the respondents indicated that the hospitals had maintenance programs, 64.3% indicated that equipments are only maintained after a breakdown. Most of the equipments in the hospitals are very old and this has also contributed to high rates of breakdowns. Poor maintenance documentation has also contributed to poor tracking of equipments previous worked on. Job request forms are the only forms used for record keeping and these forms do not indicate the jobs done per department or per machine.

The fact that, these are government institutions relaying on grants from the government, supplies for maintenance take long to be purchased resulting in maintenance tasks piling up thus increased MTTR. Management commitment to maintenance issues always affects institutions and unfortunately hospitals are not exempted. Lack of training of maintenance staff on new trends in maintenance and especially when new equipments are bought contributes to reduced Mean time between failures (MTBF).

Figure 3 shows the relationship which was established among the variables. Equipments unavailability was mainly due to equipment failure, maintenance methods and manpower challenges. The high failure rate were caused by little or poor maintenance activities. It clearly shows that, service delivery is affected by manpower availability and equipment availability and reliability. It was therefore imperative for the researchers to develop an appropriate maintenance system based on reliability centered maintenance (RCM). The basis of this RCM decision model was to add value to the maintenance system and in so doing, add value to the services delivered at these three hospitals. Figure 4 shows the RCM decision model designed.

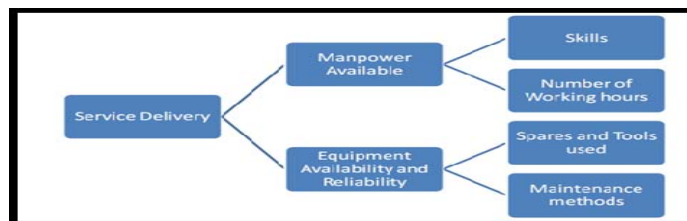


Figure 3: Interaction of variables

### 4.1 RCM Model

The RCM model (figure 4) was developed to suit the nature of the hospital equipments. RCM combines different maintenance systems and uses them to attend to different equipment based on their failure model and level of criticality. Using the data collected on the types of equipments in the hospitals, the researchers categorized these equipments into medical and non- medical equipments. These two groups were further categorized into critical and ordinary equipments. The RCM model developed was based on the reviewed RCM model [8]. The model was recommended to the three hospitals on the basis of the hospital having enough information on MTBF and MTTR of the different equipments the hospitals have. Although the researchers did not determine the MTTR and MTBF, availability of the equipments is expected to improve if the RCM model proposed is taken into consideration. This model focuses on assigning equipments to specific maintenance strategies based on their level of criticality, model of failure, MTTR and MTBF. In order for the model to be successful, full cooperation from the equipments operators and maintenance staff will be required. Proper documentation of the equipment and recording of failures will be necessary. This model will work with the current sys-

tem of reporting complaints mainly done using work requests forms, telephones and physical reporting. Using the specific maintenance strategies under which each equipment has been placed, the operators will need to carefully monitor the equipment. The hospital equipments were not placed in the model as the researchers did not have information on the MTTR and MTBF for the equipments.

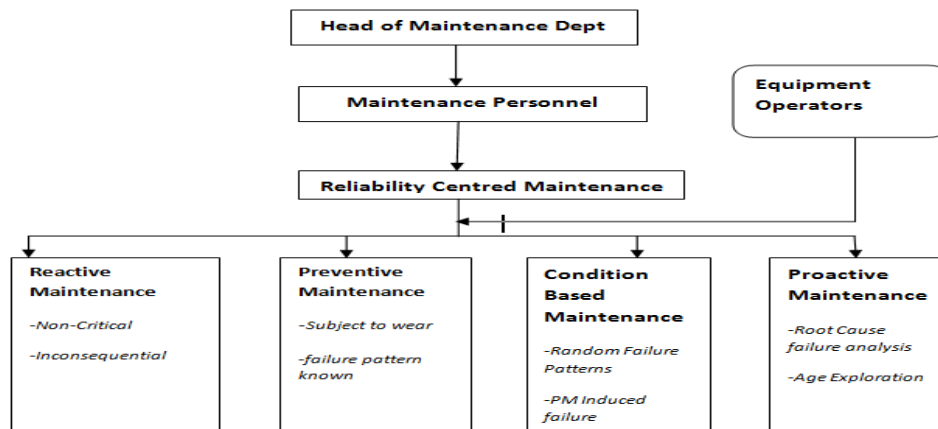


Figure 4: Proposed RCM Decision Model

## 5. Conclusion

The researchers concluded that the maintenance practices at the three hospitals are not effective. This was concluded on the basis of lack of work order system to capture all work in order to manage labour, no skill training programs and poor spare inventory and purchasing system. The service delivery rated at 26% and one of the factors contributing to this low rating is poor maintenance practices. It was therefore relevant to conclude that poor maintenance practices affected service delivery.

Reliability Centered Maintenance should be used in order to achieve a good rate of equipment availability. The decision model proposed takes into account the different types of equipments categorized as either critical or ordinary equipment. Management commitment to the proposed model will facilitate the achievement of high equipment availability. Additional maintenance personnel and training on new trends in maintenance is important for the success of the proposed RCM model. Implementing this model will improve the service delivery of the three hospitals if the following recommendations are taken into consideration by the hospitals.

- Team-work among equipment operators and maintenance workers in order to facilitate fast response to equipment breakdowns.
- Management commitment to training of employees regarding new trends in maintenance and new equipment operation.
- Improvement of the maintenance task documentation system and scheduling.

In conclusion, the maintenance practices currently practiced are not effective for the hospital. In order to provide valuable health care services, proper maintenance practices will need to be implemented.

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