

## Original Research Article

# A comprehensive study on the maintenance of medical equipment at tertiary care hospital in India

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### ABSTRACT

**Background:** It is essential for any health-care facility, regardless of its size, to implement a maintenance programme for medical equipment. The maintenance not only has a positive impact on the safety and effectiveness of healthcare technology, but also increases the lifetime of equipment and thus helps to save scarce investment resources. It also enhances the demand for health services. Demand for services availability is crucial of functioning healthcare technology.

**Methods:** A comprehensive descriptive study of the maintenance of equipment at a tertiary care corporate hospital in India from January 2012 to May 2012. A convenient sampling method was used to capture data from Key Participants which included two categories of staff viz technicians and managers/administrators. There were 40 technicians and 10 managers who responded to the questionnaire. Both the primary and secondary sources of data were used.

**Results:** Breakdown data analysis showed that the major cause of breakdown was human errors. About 40% of breakdown that occurred in the hospital was mainly because of manual errors followed by electrical and mechanical issues. Average down time for the time period of 5 months came to around 19 hours, which was quite high. Analysis of KAP questionnaire showed that about 55% technicians were not having the educational qualification required for handling the medical equipment, about 15% were not given training at the time of purchase of the equipment. Similarly, few managers were not aware about maintenance practices and importance of maintenance management for smooth and efficient functioning.

**Conclusions:** Good and effective maintenance practices can reduce the cost of maintenance of equipment that arises due to breakdown. The training of equipment users and maintenance managers reduces the equipment downtime. To reduce the possibility of equipment malfunction following service or repair, all personnel involved in maintaining and servicing equipment should be trained.

**Keywords:** Biomedical engineering, Equipment maintenance, Equipment breakdown, Maintenance contract

### INTRODUCTION

The term “maintenance” means to keep the equipment in operational condition or repair it to its operational mode. Main objective of the maintenance is to have increased availability of production systems, with increased safety and

optimized cost.<sup>1</sup> Medical technology includes medical equipment used by health organizations for diagnosis, therapy, monitoring, rehabilitation, and care. Medical technology management plays a key role in health care services. An effective medical device management is required to ensure high-quality patient care.<sup>2,3</sup>

A maintenance program generated through the consideration of characteristics and failures of medical equipment play an important role in technology management.<sup>4</sup>

The maintenance department is one of the greatest levers of profitability that any capital-intensive organization has. Medical equipment contribute to almost 40-50% of costs in a tertiary hospital setup, the medical equipment though cutting edge at the time of purchase poses the threat of inevitable obsolescence within 6-7 years of installation.<sup>5</sup> An average of 40-50% of a capital intensive industries operating budget is consumed by maintenance expenditure. With the availability of advanced technology related to maintenance, this figure can be greatly reduced. As such maintenance is often an organizations largest single controllable expense.<sup>6</sup>

It is imperative that hospitals look at how they can reduce and better manage their maintenance costs.<sup>7</sup> As per a study done by National Health Systems Resource Center, the dysfunctional rate in equipment could be as high as 60% in many areas of the world with dysfunctional rate in equipment averaging about 20%-30% even in areas with a fair medical equipment industry presence.<sup>8</sup>

The maintenance not only has a positive impact on the safety and effectiveness of healthcare technology, but also increases the lifetime of equipment and thus helps to save scarce investment resources. It also enhances the demand for health services. Demand for services availability is crucial of functioning healthcare technology.<sup>9</sup>

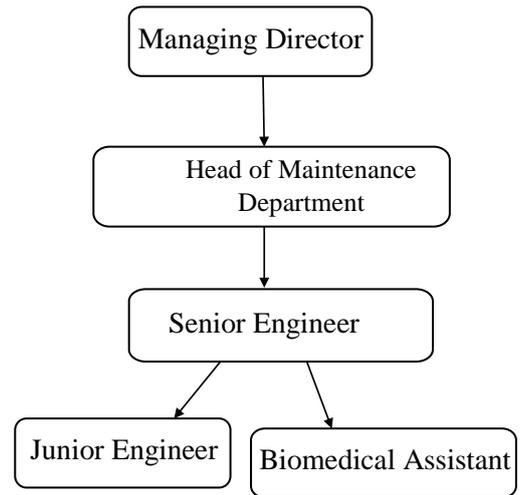
**METHODS**

A comprehensive descriptive study of the maintenance of equipment at a tertiary care corporate hospital in India from January 2012 to May 2012. A convenient sampling method was used to capture data from Key Participants which included two categories of staff viz technicians and managers/administrators. There were 40 technicians and 10 managers who responded to the questionnaire. Whole population of technicians and managers was considered so no inclusion and exclusion criteria were applicable. They were interviewed according to their availability and convenience. Both primary and secondary sources of data were used.

The primary data was collected through structured interviews with the technicians and the managers. Secondary data was collected from the biomedical record such as complaint book, maintenance book, breakdown register and contract files. The detailed data about the number of equipment, breakdown and downtime was collected. The data was also collected about the role and responsibilities of the staff of maintenance department and biomedical engineering department. The data collected during the period of study was analyzed with the help of MS Office Suite.

**RESULTS**

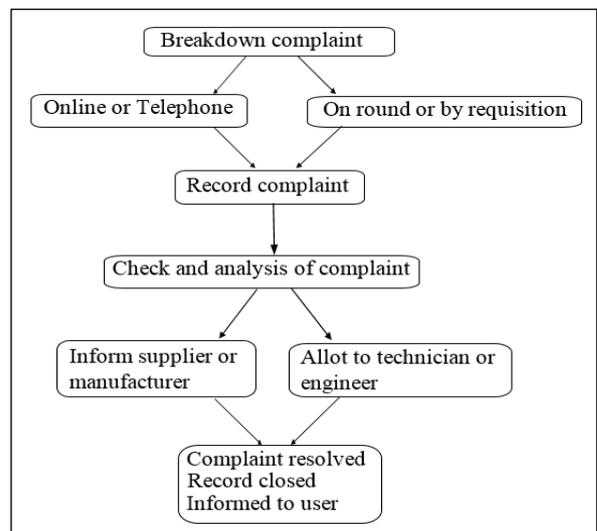
In the hospital under study, the maintenance of medical equipment was carried out by the biomedical engineering department. This department played a very significant role in medical equipment planning starting from procurement to the condemnation of the medical devices. The biomedical engineering department was responsible for the equipment's technical evaluation during procurement process, installation, maintenance, repair, calibration etc.



**Figure 1: Organizational structure.**

**Table 1: Category of staff.**

Sr.no	Staff	No
1	Head of the Department	1
2	Senior Engineer	1
3	Junior Engineer	3
4	Assistant	2
Total		7



**Figure 2: Workflow analysis in case of breakdown.**

**Interdepartmental linkage**

The maintenance of medical equipment is important function so, biomedical department in the hospital was inter-connected to various departments in the hospital. Hospital had good intranet and internal telephonic accessibility. The emergency calls were attended by biomedical personnel on priority basis.

**Data analysis**

*Breakdown analysis*

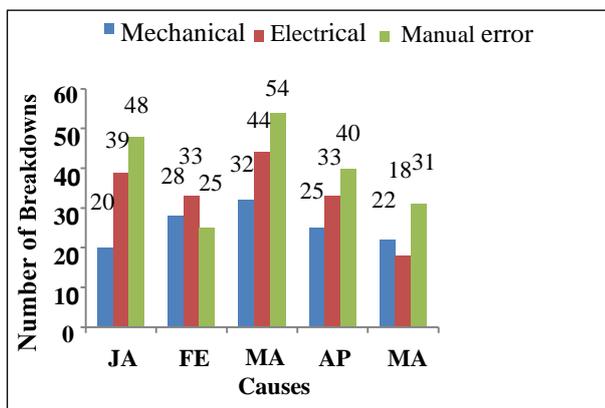
*According the type of error*

The data of breakdown of medical equipment was collected for the period of five months from the January to May. The analysis was done according to type of errors that caused breakdown of medical devices (Table 2) and (Figure 3).

**Table 2: breakdown analysis according to type of error.**

Month	Mechanical	Electrical	Manual Error	Total Break Down
Jan	20	39	48	103
Feb	28	33	25	91
Mar	32	44	54	112
Apr	25	33	40	82
May	22	18	31	79
	127	167	198	492

The data showed that in the time span of 5 months, total breakdowns that occurred were 492. The highest breakdowns were in the month of March i.e.112. The breakdowns that occurred due to Manual errors and wrong handling contributed the most i.e.198.



**Figure 3: Breakdown analysis.**

The data showed that about 40.24% errors occurred due to manual errors followed by electrical and mechanical i.e. 33.94% and 25.81% respectively. These types of errors

occurred due to lack of awareness and education. Manual errors were followed by the electrical errors. Electrical errors happened due to electrical problems in the supply. The least number of errors occurred due to mechanical error problems. Mechanical errors were mainly due to the mechanical problems in the functioning of devices.

**Table 3: Percentage wise breakdown analysis of errors.**

Causes	Percentage
Mechanical	25.81
Eletrical	33.94
Manual errors	40.24

*Breakdown as per contract type or Inhouse repair*

Data of breakdown was analyzed according to the type of contract of the equipment (Table 4).

**Table 4: Breakdown analysis as per contract type or in-house repair.**

Contract	Breakdown	Percentage
AMC*	97	19.71
CMC**	23	4.67
Inhouse	326	66.26
Warranty	46	9.34
	492	100

\*Annual Maintenance Contract, \*\*Comprehensive Maintenance Contract

The number of breakdowns of equipment having in house repair were very high i.e. 326 out of 492 followed by AMC, Warranty and CMC i.e. 97, 46 and 23 respectively. This data analysis shows that about 66.26% of breakdowns were of the equipment having in house repair followed by AMC, Warranty and CMC equipments. The major cause of having high percentage of in-house breakdown was that all these in house repairs were small breakdowns.

**Contract analysis**

Data of total number of medical equipment in the hospital was collected and analyzed according to the type of maintenance contract. The maintenance contract is important to get idea about the maintenance practices in the hospital.

Total number of the medical equipment present in the hospital were 467. These equipment were under different type of contract as per the hospital policy and market trend. About 49% of equipment were repaired by in house technician. About 8.35% of equipment were under warranty period and hospital had not to pay any amount for the repair. The equipment under AMC contract were more i.e, 32.97% as the rate of this maintenance contract was low, and the spares were easily available in the

market. The equipment under CMC contract were less i.e. 9.63% as these were very costly and spare were not easily available in the market.

**Table 5: Equipment analysis according to type of maintenance contract.**

Contract type	No of equipments	%
AMC	154	32.97
CMC	45	9.63
Warranty	39	8.35
Inhouse	229	49.03
Total	467	100

#### **Downtime analysis**

Downtime for the breakdown was calculated from the month of January to May for 492 breakdowns. Later, the down time was analyzed as per the type of equipment contract type. The total hours lost due to breakdown were 9682. The total downtime was calculated for each type of repair. The average downtime was calculated accordingly.

The total loss of productive hours in five months were 9682 hours. The maximum number of breakdowns were of equipment having in house repairs, but maximum loss of

productive hours was due to equipment having AMC contract i.e, 5238 followed by in house, Warranty and CMC. The maximum downtime was of equipment having AMC contract and it was 54 hours.

**Table 6: Downtime analysis.**

Contract	Break down	Total downtime (in hrs)	Average (in hrs)
AMC	97	5238	54
CMC	23	506	22
Inhouse	326	2282	7
Warranty	46	1656	36
Total	492	9682	19.67

The down time for the equipment having CMC contract was about 22 hours. This shows that the downtime for equipment having AMC was much higher than the equipment having CMC. Downtime for the equipment having in-house repair was lower among all the others as the technical person could resolve the problem in hospital itself. For the equipment having warranty, downtime was 36 hours as it included replacement time for some equipment. Time for replacement of equipment was much higher than the others.

**Table 7: Knowledge, Attitude and Practices of Technicians (in %).**

Questions	Yes	No
Given training at the time of purchase?	85	15
The level of working of equipment is satisfactory	77.5	22.5
Are you given proper training to handle equipment?	80	20
Educational qualification required for doing this job?	45	55
Are regular meetings held between management, users and maintenance to set priorities?	35	65
Is computerized maintenance management system (CMMS) available in the hospital for all equipment?	82.5	17.5
Do you know how to handle CMMS?	70	30
Do you find any advantages of CMMS?	47.5	52.5
Is log sheet maintained?	95	5
Having experience to handle this equipment	100	0

#### **Analysis of knowledge, attitude and practices**

The collected data was analyzed to understand the efforts put in practice as maintenance is one of the serious aspects of workplace.

#### **Knowledge, Attitude and Practices of Technicians with regard to Maintenance (Table 7)**

A 15% technicians had not got any training at the time of purchase of equipment. According to 22.5% of technicians, working of equipment was not satisfactory. 20% of technicians were not given proper training about handling of equipment. 55% technicians were not educationally

qualified for job. According to 65% of technicians, regular meetings were not held between management and end users to set priorities right. 17.5% of technicians said CMMS was not available. 30% of technicians didn't know how to handle CMMS. 52.5% of technicians didn't find it advantageous. According to 5% of technicians log sheet was not maintained. All the technicians had some experience in handling the equipment.

#### **Knowledge, Attitude and Practices of Managers with regard to Maintenance (Table 8)**

According to 30% of managers, there were no guidelines for maintenance contract and 10% were not aware of any

such thing. 10% of managers were not even aware of the fact that the hospital had a separate maintenance department. They were newly joined managers. 10% of the managers said that top management was not supporting preventive maintenance and 30% were

unaware about the role of top management. 40% of managers were not satisfied with maintenance management by biomedical department and 10% were not able to answer the same.

**Table 8: Knowledge, Attitude and Practices of Managers (in %).**

Questions	Yes	No	Don't know
Are enough human resources available enough for carrying out the given task?	50	30	20
Are there any guidelines for setting maintenance contract?	60	30	10
Has hospital got a separate maintenance department?	90	0	10
Does top management support preventive maintenance system with their attention, money and authorizations?	70	10	20
Whether the work done by maintenance department is satisfactory?	50	40	10
Is there periodic review of high turnover, high cost items for problem solving?	40	30	30
Is there an annual review of spoilage, quantity in hand, reorder point and safety stock?	30	20	50
Are there any procedures followed to avoid spoilage?	30	40	30
Is there any strategic maintenance plan for near five year?	30	10	60

According to 30% of respondents there was no periodic review of high turnover, high cost equipment.

50% of respondents were not unaware about the annual review of spoilage, quantity in hand, reorder point and safety stock. 40% of managers were not following any strategy to avoid spoilage and 30% were not aware of this type procedure, if any. About strategic maintenance plan, for future five years, 60% were not aware of this type of plan and only 30% were affirmative about this.

## DISCUSSION

Breakdown data analysis showed that the major cause of breakdown was human errors. About 40% of breakdown that occurred in the hospital was mainly because of manual errors followed by electrical and mechanical issues. The cost of maintenance increases due to frequent breakdown of medical equipment.

This was mainly because of lack of awareness of the staff and lacunas in training programme. Regular training programs were not carried out in the hospital to increase efficiency of end users which in turn is important to attain efficient performance of any equipment. A study on downtime reduction of medical equipment by Adnan Bashir had found that failure rate due to electrical and mechanical causes were 42.3 and 22.6 percent respectively.<sup>10</sup>

Certain equipment is repaired in house by biomedical technician. AMC contracts are more than CMC contract as the cost of AMC contract is much lesser than CMC contracts. About 8% of equipment were in warranty period. There were no medical equipment having insurance. Cost for CMC maintenance contract is higher

so lowering this cost by good negotiation is also a crucial area for cost reduction. Also increasing the warranty period can reduce cost of maintenance.

Average down time for the time period of 5 months came to around 19 hours, which was quite high. Downtime for the equipment having warranty was 36 hours. The hospital was at loss by taking equipment under A.M.C. or C.M.C in case of certain equipment. A study conducted at Yenepoya Medical College Hospital, Mangalore, India over a period of 15 months (March 2017-May 2018) over ninety-nine biomedical equipment had found that the breakdown time was 19165.83 minutes/month.<sup>11</sup> Analysis of KAP questionnaire showed that about 55% technicians were not having the educational qualification required for handling the medical equipment. Also 15% were not given training at the time of purchase of the equipment.

The 30% of the managers said that the present human resource in maintenance department of the hospital was not adequate and 20% of them had no opinion on this. According to 30% of managers, there were no guidelines for maintenance contract and 10% were not aware of any such thing. 40% of managers were not satisfied with maintenance management by biomedical department and 10% were not able to answer the same. A study on maintenance management of medical equipment in hospitals by David Mutia et al, revealed that the combined percentage mean rating for the public, private, consultant and contracted maintenance organization were 58, 69, 75 and 81 per cent respectively.<sup>9</sup>

## CONCLUSION

Good and effective maintenance practices can reduce the cost of maintenance of equipment that arises due to

breakdown. For effective maintenance, hospital should earmark adequate space to maintenance department so that the repair activities can be carried out smoothly within the hospital. Managers of concerned department should also be involved in daily maintenance practices for effective functioning of equipment. To reduce the possibility of equipment malfunction following service or repair, all personnel involved in maintaining and servicing equipment should be trained. A cogent strategy for the maintenance must be followed by the hospital. Before going for any types of the contract it is necessary to find out what are the major problems that equipment could encounter and then how much will be the cost of repair and how frequently these breakdown can occur and then the management should be very careful to take the contract and insurance as it covers only the electrical damages and not the mechanical damage. So, instruments with higher probability of electrical damages should be taken under contract and insurance.

C.M.C. should be taken for equipment which are very costly and can be repaired only by the service engineer of the company and its spare parts are not available in the open market. A.M.C. should be taken for that equipment which are less costly can be repaired by the biomedical engineer of the hospital and its spare parts are available in the open market.

Management could give emphasis on in house maintenance by appointing expert biomedical engineer so that majority of repairs can be done within the hospital as downtime is very less for the in-house repairs. It will reduce the cost of maintenance.

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