A STUDY ON UTILIZATION OF CRITICAL EQUIPMENTS IN A PRIVATE HOSPITAL, CHENNAI

Mr. SUJEY PRASATH*

Mrs. BHOOMA DEVI**

ABSTRACT

The study aims to reduce the downtime of critical equipment. It is basically a study done by collecting data from five modalities in radiology department.Hence the study which was done based on the secondary data concludes that all critical equipments: MRI, CT, Ultrasound, Fluoroscopy and gamma camera were not utilized 100 percent and more over there were defects like late arrival of patients , late in transporting the patient, repeating of test procedures, contrast problems, poor preparation of the patient , mishandling of the equipments by the staffs and cancellation of test procedures which effects the utilization rate of the equipments .This is due to loop holes in the protocol followed in the department, which needs to be bridged so that less time is wasted by the patient and the overall process is more effective and patient friendly. Hence, proper training should be given to improve the utilization of machineries, by training the staffs and educating the patient.Therefore the study based on observationclearly reveals the defects.This research could not be extended to all critical equipments due to insufficiency in recorded data and time constraints. But there is further avenue of research possible to find the utilization of all critical equipment.

Keywords: Biomedical engineers, Breakdown, Equipment, Maintenance, Utilization

* Sri Ramachandra College of Management, Sri Ramachandra University, Chennai

** Senior Lecturer, Sri Ramachandra College of Management, Sri Ramachandra University, Chennai

INTRODUCTION:

The downtime of medical equipment is said to be the period during which the equipment is not in a condition to perform the proposed function. It is the sum of problem realization time diagnosis time, logistic time, alignment time, etc. The downtime calculation in hours is based on application of the equipment. The effectiveness of equipment is maximized by adopting total productive maintenance which will reduce the equipment breakdown throughout the lifecycle. The total productive maintenance involves routine maintenance of system by the paramedical staff or biomedical engineer, repeated training to end user as per schedule and training on problem solving skills.

The utilization time of medical equipments is the productive time which benefits both the patients and the hospital. If the equipment is utilized for more time it will enable staffs to do more diagnostic tests, monitoring and treatments for patients.This brings profits for the hospital. Idle time is the time associated with waiting, or when a piece of machinery is not being used but could be. Idle time could also be associated with computing, and in that case refers to processing time.

DEFINITIONS, ACRONYMS AND ABBREVIATIONS:

DPMO-Defects per Million Opportunities

PPM-Periodic Preventive Maintenance

FMEA-Failure Mode and Effect Analysis

TPM -Total Productive Maintenance

MRI- Magnetic Resonance Imaging

CT-Computed Tomography

USG -Ultra Sono Graphy

The critical equipments included in the study are:

- MRI machine
- CT 64 and CT-16 machine
- Ultrasound–I, II, III, IV machine(USG)
- Fluoroscopy machine
- Gamma Camera

The need of the study is to review the utilization time of the critical equipment, to check the breakdown of the critical equipment, to give suggestions to improve the utilization and reduce the downtime of these critical equipments

OBJECTIVES:

- To find the utilization time and downtime of critical equipments in the hospital.
- To give suggestions to maximize the utilization time and to improve the efficiency of critical equipments.
-

RESEARCH METHODOLOGY: Area of the study is 1500 bedded Private hospital, Chennai. Descriptive research design is used in the study. The data is observed and noted in the five modality of the radiology department and samples were collected for two months. Convenience sampling technique is used to collect the samples.The sample size for the study from all the five modalities of the Radiology Departmentis as follows:

- 832 samples for MRI machine
- 679 samples for CT-64 machine
- 1055 samples for CT-16 machine
- 690 samples for USG-I machine
- 669 samples for USG-II machine
- 451 samples for USG-III machine
- 430 samples for USG-IV machine
- 185 sample for Fluoroscopy machine
- 192 samples for Gamma camera

LIMITATIONS OF THE STUDY:

- The focus of the study was only on the five modalities in the entire Radiology department
- The generalisation of the result of the study cannot be applied to other hospitals
- Co-operation from staff in terms of availability of time was a major constrain.

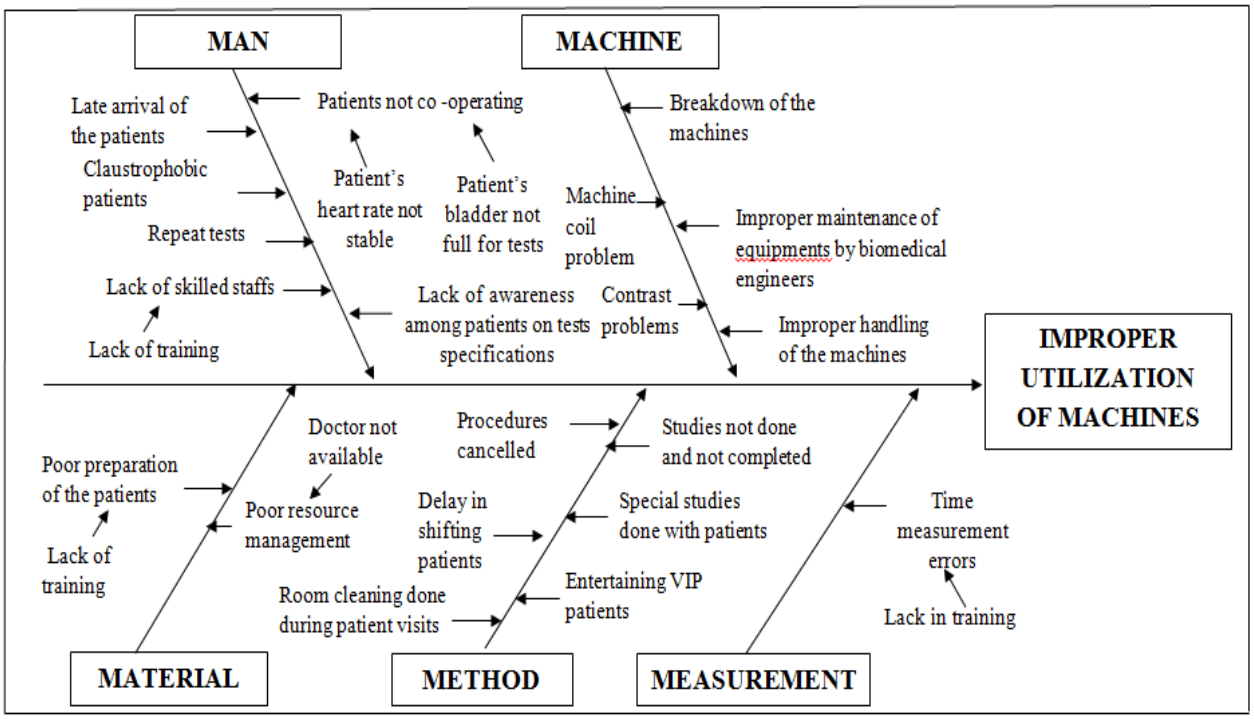
REVIEW OF LITERATURE:

Cook, (1997), designed a protocol for the measurement of downtime and availability. Otero, Ondategui-Parra, et. al., (1998), found that utilization management using the most appropriate resources was to achieve the best patient outcomes.Savory and Olson (2001), suggested that process mapping enabled organisations to improvise effectively to bridge the loopholes and make the process followed more efficient. Chompu-inwai and Rungchat(2008), described the pilot implementation and evaluation of Total Productive Maintenance (TPM) for the dental units in the Dental Hospital. Saadat,S.(2008), had given guidelines for the use of MRIs.Taghipour, S.et. al., (2011),presented a multi-criteria decision-making model to prioritize medical devices according to their criticality. Yang, Wei-hong (2011), designed a set of comprehensive evaluation index system which could accurately evaluate utilization level of equipment and find weakness.Adnan Al-Bashir and Akram Al-Tawarah (2012), stated that corrective and preventive maintenance procedures are needed to improve equipment performance.

ANALYSIS AND INTERPRETATIONS:

CAUSE AND EFFECT ANALYSIS:

The following cause and effect diagram shows the possible causes for the improper utilization of machines



- **Man:** Late arrival of the patients, Claustrophobic patients, Repeat tests, Lack of skilled staffs due to lack in training, Patients not co –operating due to patient's unstable heart rates and bladder not being full for tests, Lack of awareness among patients on tests specifications.
- **Machine:** Machine coil problem ,Contrast problems, Breakdown of the machines, Improper maintenance of equipments by biomedical engineers , Improper handling of the machines
- **Material:** Poor preparation of the patients due to lack in training, poor resource management due improper scheduling of doctors.
- **Method:** Procedures cancelled, Delay in shifting patients, Room cleaning done during patient visits, Studies not done and not completed, Special studies done with patients, Entertaining VIP patients
- **Measurement:** Time measurement errors due to lack in training

FAILURE MODE AND EFFECT ANALYSIS:

The following failure mode and effect analysis for USG–III machine and CT-64 is shown below

FAILURE MODE AND EFFECT ANALYSIS FOR USG-III MACHINE

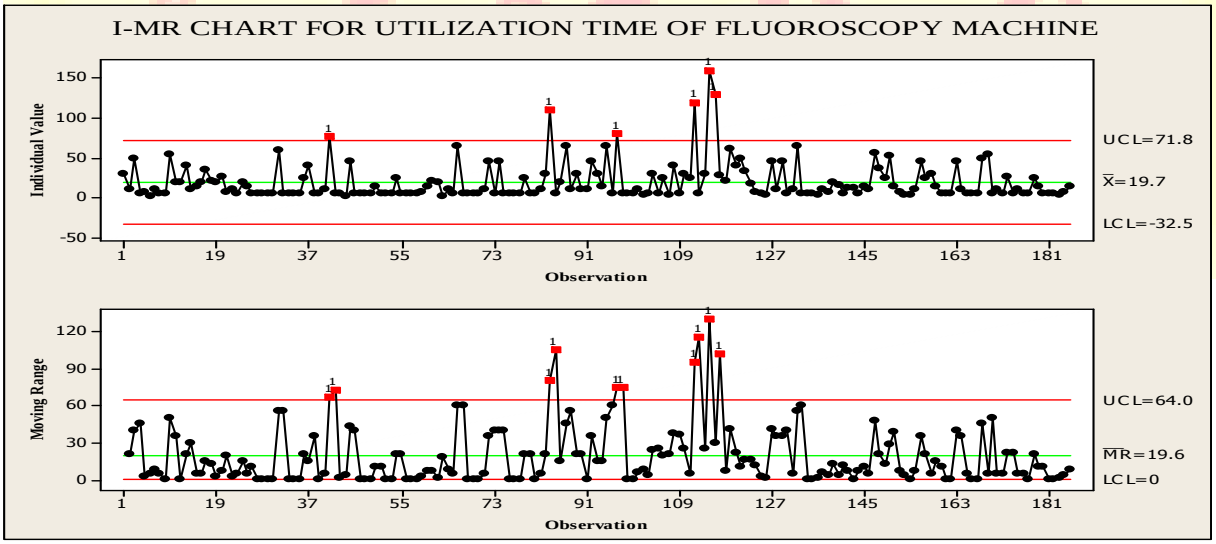
PROCESS	POTENTIAL FAILURE MODE	POTENTIAL EFFECTS OF FAILURE	POTENTIAL CAUSE OF FAILURE	CURRENT CONTROLS	O	S	D	RPN	ACTIONS RECOMMENDED
Utilization of USG-III machine	Machine is not being utilized properly	Patient access to care gets affected	Due to Late arrival of patients, Patient's Bladder not full, Doctor not available ,Room cleaning, Machine not working	Technologists, Doctors	2	6	5	60	Alternative equipments should be made available in case machine is under maintenance.
Idle State Of the USG-III Machine	Machine is idle	Machine Usage time is wasted	Late arrival of patients, Patient's Bladder not full, Doctor not available, Room cleaning	Technologists, Doctors	1	4	5	20	Patients must be intimated regarding the appointment time well before a day.
Downtime of the USG-III machine	Breakdown of the machine	Machine is down	Machine not working	Biomedical Engineers, service Engineers	5	8	4	160	The efficiency of the breakdown call system should be improved by implementing a hospital information system.

FAILURE MODE AND EFFECT ANALYSIS FOR CT-64 MACHINE									
PROCESS	POTENTIAL FAILURE MODE	POTENTIAL EFFECTS OF FAILURE	POTENTIAL CAUSE OF FAILURE	CURRENT CONTROLS	O	S	D	RPN	ACTIONS RECOMMENDED
Utilization of CT-64 machine	Not utilized to the maximum	Access of Care to patients gets affected	Repeat test, Due to Late arrival of patients, Patient Not cooperating, Contrast problems, Late in shifting the patient, Poor preparation of the patient, Test not done, Delay in test procedures, Patient Heart rate not stable.	Technologists, Doctors	4	7	2	56	The test should be scheduled properly to avoid delays in procedures.
Idleness of CT-64 machine	Machine being idle	Patient care and test gets delayed due to postponement of test schedules	Due to Late arrival of patients, Late in shifting the patient, Test not done, Delay in test procedures	Technologists, Doctors	3	6	2	36	Proper communication system should operate to improve communication among staffs in the hospital.
Breakdown of CT-64 machine	Machine is down	Equipment life reduces and affects the patient care	Improper handling of the equipments by staffs and power fluctuations	Biomedical Engineers, service Engineers	7	8	2	112	Proper scheduling of training programs for the staffs. Power fluctuations should be avoided. To mandate preventive and breakdown maintenance.

The RPN (Risk Priority Number) for down time of CT-64 machine and USG-III machine were more than 100, which interprets that the breakdown maintenance system needs some improvement in order to bring high quality rate. The failure mode, effects and cause behind it were evaluated and analyzed.

CONTROL CHART:

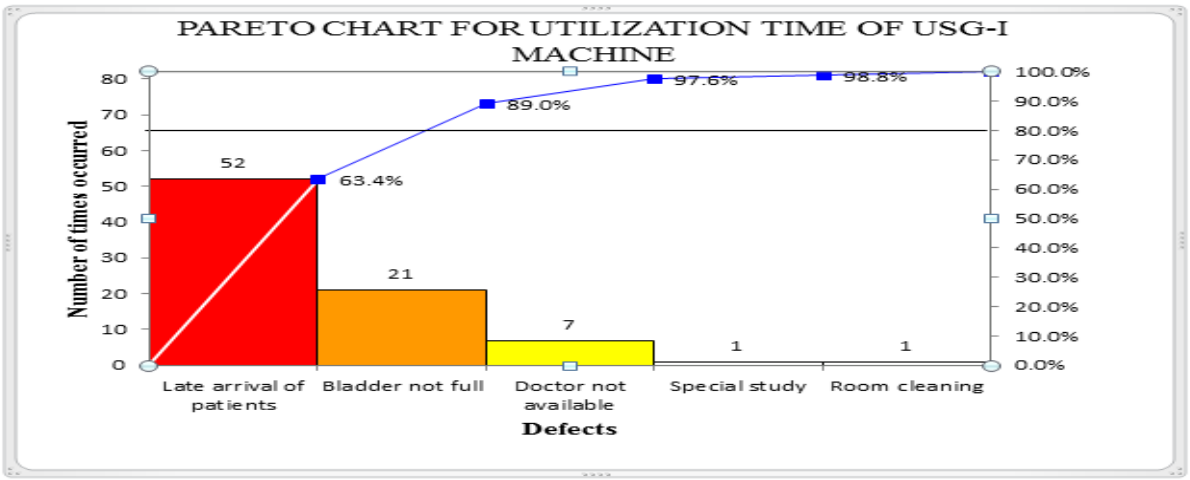
The following control chart shows the causes for the variation



The above chart for utilization time of Fluoroscopy machine shows that the sub group numbers 77, 80, 110, 120, 130, 160 are not within the control limits and reveals the root cause of variation.

PARETO ANALYSIS:

The following control chart shows that 20 percent of causes for 80 percent of problems in the utilization of USG –I machine



The above chart shows that the late arrival of the patients and bladder not full account for more than 89 percent of defects (vital fews) in the utilization time of USG-I machine

PROCESS CAPABILITY ANALYSIS:

Cp=UCL – LCL/ 6 Sigma

The following table gives the process capability for the utilization time of critical equipment

PARAMETERS	MRI	CT-64	CT-16	USG-I	USG-II	USG-III	USG-IV	FLUORO SCOPY	GAMMA CAMERA
Time	Utilization time	Utilization time	Utilization time	Utilization time	Utilization time	Utilization time	Utilization time	Utilization time	Utilization time
Standard deviation	12.23	8.57	6.86	7.06	10.55	8.77	15.31	24.03	9.73
Sample mean	26.08	7.16	5.36	9.60	11.69	12.27	16.06	19.68	29.80
Sample size	795	679	1055	690	669	451	430	185	192
USL	84	58	64	64	87	65	88	160	78
LSL	10	0	0	1	1	1	1	2	15
Cp	1.01	1.13	1.55	1.49	1.36	1.22	0.95	1.09	1.08

The above table shows that the Process Capability (Cp), with regard to the Utilization time , in all critical equipments except USG-IV machine are more than 1.This means the process variation is less than the specification and thus the process is capable of meeting the specifications. Process Capability (Cp) is less than 1 for USG – IV machine only, which means that the process is not capable of meeting the specifications. However, Cp is equal to 1 for the utilization time of MRI machine which indicates that the process is just meeting the specifications.

DEFECTS PER MILLION OPPORTUNITIES (DPMO):

The Defects Per Million Opportunities for this project is arrived based on the following:

DPMO = (Number of Defects×1,000,000)/Number of Defects Opportunities/Unit)*Number of Units

After calculating the DPMO values for the critical equipments the sigma level and Cpk value have been found by referring DPMO to sigma level conversion table and tabulated as follows:

S.NO	CRITICAL EQUIPMENTS	DPMO	SIGMA LEVEL	CPK(SIGMA LEVEL/3)
1	MRI	1,630.74	4.44	1.48
2	CT-64	1,825.811	4.41	1.47
3	CT-16	1,421.800	4.48	1.49
4	USG-I	1.153.79	4.55	1.516
5	USG-II	1,345.29	4.50	1.50
6	USG-III	1,402.11	4.49	1.496
7	USG-IV	1,724.13	4.42	1.473

From the table of DPMO for utilization time it shows that, the sigma level of CT-64 machine is 4.41 followed by sigma level of USG-IV machine 4.42, MRI machine is 4.44, CT-16 machine is

4.48, USG-III machine is 4.49 , USG-II machine is 4.50 and USG-I machine is 4.55. Therefore the yield percentage of these critical equipments is nearly ranging from 99.81 % to 99.87 %.

UTILIZATION RATE:

The utilization rate is calculated through the following arrivals as follows

Based on the assumption that the Radiology diagnostic center functions for some hours per day,

Average number of scans performed per day

Average Procedure time (in minutes) for performing a scan

Total time taken for all scans per day

Idle time (in minutes) of CT-64 machine per day

$$\text{Current utilization rate} = \frac{\text{Utilization of machine in minutes}}{\text{Daily availability ofmachine in minutes}}$$

S.NO	CRITICAL EQUIPMENTS	UTILIZATION RATE (IN PERCENT)
1	MRI	51.43
2	CT-64	12.29
3	CT-16	14.30
4	USG-I	28.17
5	USG-II	31.96
6	USG-III	26.21
7	USG-IV	29.95
8	Fluoroscopy machine	15.80
9	Gamma Camera	30.13

From the table of Utilization Rate, it shows that MRI machine has the highest utilization rate of 51.43 percent and CT-64 machine has the least utilization rate of 12.29 percent.

RECOMMENDATIONS:

- Lack of awareness among patients on test specifications and timings must be educated.
- Proper planning of the resources and scheduling of patient care should be done to avoid delays and cancellation of procedures.
- Patients must be intimated regarding the appointment date of the test well before a day time to avoid late arrival of patients
- Transport staffs who handle the patients from wards to the scan room should be trained to be efficient in shifting time.
- End users should be given periodic training on handling of the equipments to avoid occasional breakdown in equipments
- The hospital staffs must be trained to overcome delays in preparation of the patients which affects the utilization time of the equipments and makes patient uncomfortable due to delay in test procedures.
- All technologist who are taking charge of the patients in test procedures must be fully trained and confident enough to avoid repeating of test procedures, delays in procedures and contrast problems
- In accordance with the opinion of the respondents the disinfection of contaminated parts of the equipments should be mandated after every single procedure.
- The absence of the appointment system for test procedures causes disappointment in the patient. The patient who comes from far away distance to do the scan may have to go back without doing the test, if queue is too long. Hence, a prior appointment system should be introduced in the radiology department or even enable them to block a slot for the next day too.
- Displaying the time taken for doing a test should be incorporated in the radiology center, so that the patients can accordingly plan and decide, based on their convenience, whether to undergo the procedure at that point in time or not. It is a way of educating the patient of an aspect of the procedure he or she will be undergoing
- The doctors and other paramedical staffs should be managed properly to make patients accessible to the care at the right time.

- The biomedical engineers must be trained periodically to be updated with the technology and advancements in medical equipments.
- Communication between the manufacturers of the equipments and biomedical department should be efficient and effective enough to prevent major breakdowns in the equipments.
- All critical equipments must be under preventive maintenance plan to increase the life of the equipments and therefore reduce the downtime of the equipments.
- The efficiency of the breakdown call system in the hospital can be improved by implementing a fully-fledged hospital information system.
- In case of equipment breakdowns, alternative equipments should be utilized by a systematic preventive maintenance protocol.
- The hospital top management should give their full support to biomedical department by recruited fully qualified engineers and give proper training before they handle the costly equipments in the hospitals.

CONCLUSION:

Thus from the observation study it is concluded that all critical equipments: MRI, CT, Ultrasound, Fluoroscopy and gamma camera were not 100 percent utilized.But there is further avenue of research is possible to find the utilization of all critical equipments.

REFERENCES:

1. Cook DA, (1997) "A protocol for the measurement of downtime of medical equipment", from *British Journal of Radiology*Vol.70, pp.279-290
2. Hansel J.Otero,Silvia Ondategui-Parra,Eric M.Nathanson,Sukru Mehmet Erturk,Pablo R.,(1998)"Utilization Management in Radiology; Basic Concepts and Applications",from American Journal of Roentgenology;Volume2; pp 120-147
3. P. Savory and J. Olson (2001), "Guidelines for Using Process Mapping to Aid Improvement Efforts", Hospital Material Management Quarterly, Volume 22, No. 3, pp. 10-16.
4. Chompu-inwai, Rungchat,(2008) "Implementation of total productive maintenance in healthcare: A pilot study", from Service Systems and Service Management, International Conference; pp1-6.
5. Saadat S,(2008) "Overuse or underuse of MRI scanners in private radiology centers in Tehran", from *International Journal of Technology Assessment in Health Care*, Volume 24, issue 3, p. 277-281
6. Yang, Wei-hong,(2012)"Study on evaluation index system of equipment utilization on distribution network" from Conference Publications, pp1-5.
7. S Taghipour, D Banjevic and AKS Jardine,(2011)"Prioritization of medical equipment for maintenance decisions ",from Journal of the Operational Research Society, Vol. 62, Issue 9, pp. 1666-1687,
8. Adnan Al-Bashir and Akram Al-Tawarah, (2012)"Implementation of Six Sigma on Corrective Maintenance Case Study at the Directorate of Biomedical Engineering in the Jordanian Ministry of Health" ,from International Conference on Industrial Engineering and Operations Management Istanbul, Turkey