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## Implementation of standard criteria for effective medical equipment preventive maintenance practice in District General Hospital – Nawalapitiya, Sri Lanka.

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### ABSTRACT

*Scarcity of financial resources has resulted in limited inspection and preventive maintenance activities for the items of medical equipment in the hospitals of Sri Lanka. There is no standard criteria method applied for selecting items of medical equipment for maintenance strategies such as annual service agreements in public sector hospital of Sri Lanka. To implement effective medical equipment preventive maintenance practice in relation to service agreements of DGH Nawalapitiya. The study was carried out in year 2016 and a comprehensive data base for the medical equipment was developed initially. The new method was applied to prioritize the items of medical equipment of District General Hospital Nawalapitiya to select the items of medical equipment for annual service agreements. Total of 642 items of medical equipment were identified in the hospital and 430 (66.9%) items and 212 (33.1%) items were found to be functional and non-functional respectively. According to the Wang - Levenson criteria, AEMR values were calculated, and the functional items of medical equipment were prioritized in a descending order. AEMR values were varying from maximum value of 30 to minimum value of 2. The priority list was utilized for the annual service agreements of the hospital for year 2017 / 2018 and 80 % of the items were selected according to the list. The Provincial Health Department has already taken initiatives to implement the new method at DGH Nawalapitiya and planning to implement it in the other health care institutions of the province.*

**Keywords:** DGH Nawalapitiya, Medical Equipment, Wang & Levenson Criteria, Prioritization, Annual Service Agreements.

### 1. INTRODUCTION

Healthcare technology has become a very critical component of healthcare service delivery as it enables healthcare providers to diagnose, treat, monitor, and provide therapy to patients within appropriate environment of care.

Medical equipment is used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury; it can be used either alone or in combination with any accessory, consumables, or other piece of medical equipment. Medical equipment excludes implantable, disposable, or single – use medical devices (WHO, 2011a; WHO, 2011b).

According to the studies conducted by Dhillon, it was shown that much more money is spent on maintenance of medical equipment during its lifetime than amount spent for procurement of the equipment (Dhillon, 2008).

Unnecessary and excessive preventive maintenance could be also loss-making likewise inadequate level of maintenance in healthcare industries throughout the world (Keil, 2008).

Dharmarathna (2007) in his study done in selected five departments of four Base hospitals of Western province has revealed that the medical equipment availability is about 57%. According to him 43% of medical devices are unavailable due to equipment failures.

Dasanayake (2015) has found that 42% of medical equipment in Sri Lankan public sector hospitals is out of service and therefore unusable.

In 2004, Joint Commission on Accreditation of Healthcare Organizations (JCAHO) introduced standard EC. 6.10 for the hospitals involving in accreditation (JACHO, 2004). Using the above standard some hospitals recommend its clinical engineering departments to not to have schedule inspection or maintenance tasks for certain pieces or types of medical equipment, if these tasks are not needed for safe and reliable operation (Wang, Fennikoh & Smith, 2006a).

However, some developed countries in the world such as Canada include all their medical equipment in preventive maintenance programme (Taghipour, 2012).

In Sri Lankan public sector health care institutions, inspection, and preventive maintenance (IPM) of the medical equipment is getting done through the "Service agreements" with the relevant service providers. This research project was carried out at District General Hospital, Nawalapitiya (DGHN).

DGHN has a limited allocation for annual scheduled preventive maintenance of medical equipment. As the financial allocation for service agreements is limited it is vital to prioritize the most suitable medical equipment for service agreements in order utilize limited financial resources effectively.

### **1.1 General Objective**

To implement effective medical equipment preventive maintenance practice in relation to service agreements of DGH Nawalapitiya.

### **1.2 Specific Objectives**

1. To develop a data base for the medical equipment of DGH Nawalapitiya.
2. To describe the existing methods of prioritizing medical equipment for entering into annual service agreements in DGH Nawalapitiya.
3. To determine the list of medical equipment which is needed to be entered to annual service agreements using standard criteria.
4. To evaluate the perception on new practice among stake holders of the Central Provincial Health Department.

## **2. LITERATURE REVIEW**

Operating equipment are needed to be maintained to prevent and correct break downs (Preventive & corrective maintenance). Equipment life cycle ends with decommissioning and disposal activities (Lenel et al, 2000).

As fundamental aspects of Medical Equipment Management Programme (MEMP), inspection, preventive maintenance and testing of medical equipment should be reviewed continuously to keep up with today's technological improvements and the increasing expectations of health care organizations (Stiefel, 2009).

Those with higher criticality scores should be identified in order to appropriate management decisions such as 'preventive maintenance', 'user training', 'redesigning the equipment' and etc. (Taghipour, 2012).

JACAHO introduced the criteria introduced by two research, Fennigkoh and Smith on selecting medical equipment for MEMP. These criteria assisted in not to perform scheduled inspections or maintenance tasks for certain types of equipment for which these tasks are not necessary for its safe and reliable function (Wang, 2006). From that time the method introduced by Fennigkoh and Smith and its variants have been used by the clinical engineers for the prioritization of medical equipment (Rice, 2007).

Fennigkoh and Smith (1989) proposed risk assessment to group medical devices based on their Equipment Management Numbers (EMN), or the sum of the numbers assigned to the equipment's critical function, physical risk, and maintenance requirement.

Several researchers have modified the Fennigkoh and Smith criteria in selecting medical equipment for inspection and preventive maintenance program. American Society of Healthcare Engineering of the American Hospital Association (1996) published a new method of prioritizing medical equipment according to a "Total score" calculated using five criteria: equipment function, clinical application, preventive maintenance requirements, probability of equipment failure, and environmental use.

Wang and Levenson (2000) modified "Fennigkoh and Smith criteria" by introducing Equipment Management Rating (EMR) and Adjusted Equipment Management Rating (AEMR). They introduced "mission criticality" for each piece of equipment and it was described as the extent to which a device is crucial to the care delivery process of a hospital (Wang, 2006).

Aridi et al (2014) proposed a new method of prioritizing medical equipment in the process of replacement. They suggested five criteria as function of the equipment, mission criticality, age of the equipment, risk of a device and the maintenance requirement as the criteria.

In the study done by Jamshidi et al (2014) propose risk-based prioritization framework for selecting best maintenance strategy for medical equipment.

Wang and Levenson's algorithm calculate and "Equipment Management Rating" (EMR) using a mission critical rating from 1 to 10 (with 10 being assigned to equipment most critical to the health care organization), combined with Fennigkoh & Smith values

of risk and maintenance. Ridgway (2001) also proposes the “mission criticality” as one of the important criteria in prioritizing medical equipment.

Wang and Levenson also propose an adjusted EMR incorporating equipment utilization (from 0 to 100%) in the following algorithm (Wang and Levenson, 2000; Wang, 2006):

Adjusted Equipment Management Rating (AEMR)

$$\text{Adjusted EMR} = (\text{Mission Critical Rating} + 2 \times \text{Maintenance}) \times \text{Utilization} + 2 \times \text{Risk}$$

In this project, AEMR is used for the prioritization of medical equipment.

Manzoli (2014) has considered utilization rate and availability of backups or alternative devices in deciding mission criticality of medical equipment.

Wang (Atles, 2008) suggests classification of devices in three groups (Critical, Important, and Necessary) according to their mission criticality.

Utilization rate has been described by various researchers and organizations by different definitions (WHO, 2011b; Manzoli, 2014; Wang & Rice, 2003; Masmoudi et al, 2016; Saleh, 2014). Wang & Levenson (2000) described utilization rate of each device type as the average percentage of time each type of equipment is being used.

### 3. METHODOLOGY

This was an interventional project carried out at DGH Nawalapitiya.

All the items of medical equipment available at the medical equipment inventory of DGH Nawalapitiya were included for the study. WHO definition on Medical Equipment was used as the inclusion criteria for selecting medical equipment for the study. According to WHO definition Medical Equipment are medical devices which require calibration, maintenance, repair, user training and decommissioning – activities usually managed by clinical engineers

Developing a data base for the medical equipment of DGH Nawalapitiya was carried out using a check list. For the assessment of the existing methods of prioritizing medical equipment for annual service agreements in DGH Nawalapitiya was done using Key informant interviews with the Director and Surgical Pharmacist.

Two rounds of Focus Group Discussions were conducted with unit in-charges to assess how the prioritizing of medical equipment is done for preventive maintenance decisions.

A panel was nominated with the concurrence of participants and with the assistance of Director of DGH Nawalapitiya to apply criteria of “Wang and Levenson algorithms” (variants of Fennigkoh & Smith criteria).

The standard criteria were adapted to the medical equipment by the panel.

According to the Adjusted EMR, the pieces of equipment under study were sequenced in descending order from the highest priority one to the lowest priority one.

The priority list of equipment was submitted to the Director – DGH Nawalapitiya and it was forwarded to the office of the Provincial Director of Health Services – Central Province.

**Table 3.1: Criteria for the prioritization of medical equipment**

CRITERIA	CATEGORY	SUBGROUP	NUMERICAL VALUE
Function	Therapeutic	Life support	10
		Surgical & intensive care	9
		Physical therapy & treatment	8
	Diagnostic	Surgical & intensive care monitoring	7
		Additional physiological monitoring & diagnostic	6
	Analytical	Analytical laboratory	5
		Laboratory accessories	4
Computer & related		3	
Miscellaneous	Patient related & other	2	
Physical risk		Patient death	5
		Patient or operator injury	4
		Inappropriate therapy & misdiagnosis	3
		Equipment damage / ***inconvenience or delay	2

	No significant risk	1
Maintenance Requirement	Extensive: routine calibration & part replacement required	5
	Above – average	4
	Average: performance verification & safety testing	3
	Below average	2
	Minimal: visual inspection	1
Mission criticality	Each piece of equipment is assigned a value ranging from 1 to 10 based on the judgment of how critical the function of that piece of equipment is to the global mission of the health care organization, not to individual clinical department or the Clinical engineering department.	1 to 10
Utilization rate	Utilization rate is the average percentage of time each type of equipment is being used. When calculating the utilization rate, it should be considered as “being utilized” any equipment that is required to be available.	Non – utilization (0) to 100% utilization

Three rounds of Focus Group Discussions (FGDs) were conducted to assess the readiness to accept the new practice. A focus group guide is prepared under the guidance of Supervisor to guide the FGDs.

**4. RESULTS**

**Data base for the medical equipment of DGH Nawalapitiya**

There were very important findings revealed by analyzing the data base. There were total of 642 medical equipment were identified in the medical equipment inventory of DGH Nawalapitiya. 430 equipment out of the total items of equipment were found to be operational. Operational performances are shown in Table: 4.1

**Table 4.1: Operational performances of medical equipment of DGH Nawalapitiya**

Total number of medical equipment	Functional equipment	Performance % (OK / n)	Failure %
642	430	66.9%	33.1%

Table 4.2 shows the age and operational statuses of the items of medical of DGH Nawalapitiya. It shows that the operational performances of the items of equipment are reduced with the increasing age of the equipment.

**Table 4.2: Age & Operational status of the Medical equipment of DGH Nawalapitiya**

Age (Years)	Number of medical equipment	Functional	Operational performance
0-05	365	284	85.5%
06-10	190	114	60.0%
11-15	74	32	43.2%
16-20	13	0	0
	642	430	

Table 4.3 summarizes the operational performances of the items of medical equipment belonging to different department or unit of the hospital.

**Table 4.3: Summary of the Operational performances of medical equipment**

Department	OK	PF	Operational performance
Operating Theatre	55	41	57.3%
ICU	50	49	50.5%
ETU	20	06	76.9%
PBU	28	21	57.1%
LR	23	13	63.8%
Medical wards	67	20	77.01%
Surgical wards	26	05	83.8%
Gyn & obs wards	18	15	54.5%
Paediatric ward	17	16	51.5%
Laboratory	35	08	81.4%

Radiology	03	01	75.0%
Other	39	15	72.0%

**Existing method of prioritizing medical equipment for annual service agreements**

Annual service agreements are started from 01<sup>st</sup> of April of each year and lasted on 31<sup>st</sup> of March of succeeding year. It was revealed that the medical equipment list for service agreement is requested from the institution on first week of month of January of each year.

Usual, practice during last 05 years was to continue the existed service contracts and adding some equipment according to the requests made by Consultant Specialists.

**Determination of new priority list**

According to the findings, 102 types of items of medical equipment were included in Table 4.4, Table 4.5 and in Table 4.6. AEMR scores were given according to the criteria.

Table 4.4 shows the priority order from AEMR from 30 to 20

**Table 4.4: Items of medical equipment with AEMR score from 30 to 20**

Medical Equipment	Mission Critical (M.C.R)	Maintenance Requirement (MR)	Risk (R)	Utilization (UR)	EMR	AEMR
Ventilator (ICU)	10	5	5	100%	30	30
Ventilator - Neonatal	10	5	5	100%	30	30
Ventilator - CPAP (PBU)	10	5	5	100%	30	30
Defibrillator (All Units)	10	4	5	100%	28	28
Electrolyte Analyzer (LAB)	10	4	5	100%	28	28
Blood Gas Analyzer (ICU)	10	4	3	100%	24	24
Infant Resuscitator (PNW)	10	2	5	100%	20	24
Multi- Channel Monitor (ETU,ICU,PBU)	10	3	3	100%	22	22
Anaesthetic Machine (OT)	10	5	5	50%	30	20
Anaesthetic Machine (OT – Recovery)	10	5	5	50%	30	20
Multi- channel Monitor (Medical Male & Paed. Wd)	10	3	3	86%	22	20
Infant Incubator (PBU)	10	2	5	100%	20	20
Infant Incubator – Transport (PBU)	10	2	5	100%	20	20
Infant resuscitator (PBU)	10	2	5	100%	20	20

First 12 items have been planned for annual service agreements for DGH Nawalapitiya. In addition to above prioritized 12 items Endoscopy system, Eye operating microscope and ENT operating microscopes were included for service agreements relevant to medical equipment. Therefore 80% of items of equipment were selected according to the prepared priority list.

**4. DISCUSSION**

In this study, it was identified 642 items of medical equipment at the medical equipment inventory of the concerned hospital, District General Hospital – Nawalapitiya. Out of 642 items of equipment 430 items were found to be functional and it was 66.9% as a percentage and failure rate was 33.1%.

However, 14.5%, 40.0% and 56.8% of items of equipment are out of order in age group 0 -05 years, 06 – 10 years and 11 – 15 years respectively. This percentage indicates that the failure rate of equipment increases with the aging of the equipment.

Assessment of existing method of prioritization or selection of medical equipment for annual service agreements revealed that the current practice is mainly based on consensus and concurrences.

In this study, we have determined the utilization rate of each piece of equipment in each and every unit or department of the hospital. The priority list was presented to the Director of DGH Nawalapitiya and it was forwarded to the office of the Provincial Director of Health Services (PDHS) of the Central Province. Planning unit of the PDHS office followed the priority list and implemented the 60% of items considering the priority order. They have valued the new method in selecting equipment for annual service agreements of hospital and they are planning to apply the method to the other hospitals of the province.

**5. CONCLUSION AND RECOMMENDATIONS**

With the above conclusions and observations, following recommendations can be made,

- The standard criteria method could be fully applied to DGH Nawalapitiya to decide on annual service agreements, arranging user trainings and purchasing back up equipment.
- Central Provincial Health Department can apply this method to select equipment for service agreements of its larger health care institutions.

- Biomedical engineering unit of the Ministry of Health of Sri Lanka can utilize this study in the process of selecting pieces of equipment for annual service agreements of the medical equipment of healthcare institutions.
- A new study considering the price criterion to the standard criteria is recommended for the development of this new method further.

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