ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr1031

Evaluation of Medical Equipment Management Processes Across the Colombo, Gampaha, and Kalutara Districts

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Publication Date: 2026/05/07

Abstract: Biomedical Engineering (BME) professionals must continually refine equipment management strategies to keep pace with rapid technological advancement and rising expectations within healthcare systems. Over the past two decades, these strategies have shifted from a narrow emphasis on electrical safety toward adaptive, institution-specific frameworks that prioritize patient safety and operational reliability. Contemporary approaches advocate risk-based management, directing resources toward mitigating the clinical and operational consequences of equipment failure rather than focusing solely on devices with the greatest maintenance burden. This evolution underscores the need for dynamic, evidence-driven management models that strengthen safety, efficiency, and resilience in healthcare technology systems.

Keywords: *Biomedical Engineering (BME); Joint Commission on Accreditation of Healthcare Organizations (JCAHO); Medical Equipment Management Plan (MEMP).*

How to Cite: Prathapasinghe I. D.; Ariyadasa D. K.; Geethananda O.; Jayalath K. D.; Perera G. S. E.; Rajapaksha N. K.; Gajanayaka C. (2026) Evaluation of Medical Equipment Management Processes Across the Colombo, Gampaha, and Kalutara Districts. *International Journal of Innovative Science and Research Technology*, 11(4), 3574-3578. https://doi.org/10.38124/ijisrt/26apr1031

I. INTRODUCTION

Effective medical equipment management is fundamental to ensuring safe, continuous, and high-quality healthcare delivery. The increasing dependence on advanced medical technologies has heightened the need for structured systems that maintain equipment reliability, minimize service interruptions, and optimize resource utilization. Within the Department of Health in the Western Province, variations in maintenance practices and operational workflows across districts may influence equipment performance and service continuity. Understanding these differences is essential for strengthening system-wide efficiency and resilience.

Biomedical Engineering (BME) professionals are required to continuously reassess and enhance their equipment management approaches to keep pace with rapid technological advancements and the growing expectations of healthcare systems. Over the past two decades, management practices have progressively shifted from a primary emphasis on electrical safety compliance toward more flexible, context-sensitive frameworks tailored to the specific needs of individual healthcare institutions. Modern practice increasingly prioritizes the risks associated with equipment failure rather than focusing solely on devices with high maintenance demands.

It is no longer sufficient to evaluate risk at the level of individual devices and single patients. A more comprehensive perspective is necessary—one that considers the broader clinical impact of equipment failure on patient groups, particularly in the case of complex, high-dependency technologies essential for urgent diagnostic, therapeutic, or surgical decision-making. This necessitates the adoption of multi-criteria decision frameworks to guide effective medical equipment management strategies.

The medical equipment management standards introduced by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) have significantly influenced clinical engineering practice over the past two decades. As healthcare delivery and technology have evolved,

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these standards have been periodically updated to enable more efficient allocation of resources toward areas with the greatest impact on patient outcomes and organizational performance. In the Sri Lankan context, similar principles can be applied to optimize resource utilization and strengthen service delivery.

Maintenance planning should not follow a uniform schedule; instead, it should be stratified based on factors such as frequency of use and the potential severity of equipment failure on patient safety. For example, defibrillators used in emergency departments and intensive care units require more stringent maintenance strategies than those deployed in general wards or outpatient settings.

Another important refinement is the introduction of permissible grace periods for scheduled maintenance activities. This approach provides operational flexibility when planned maintenance cannot be performed on time due to unavoidable circumstances, such as equipment being in active clinical use or temporarily untraceable devices. In such cases, maintenance may still be considered compliant if completed within an approved grace period defined in the organization's Medical Equipment Management Plan (MEMP). For instance, quarterly maintenance may allow a one-month extension, while annual inspections may permit up to two months' flexibility.

Together, these strategies reinforce the fundamental principle that each healthcare institution should critically evaluate its equipment inventory and adopt maintenance strategies that ensure safe, reliable, and efficient operation. Practical experience in engineering management also highlights that some high-acuity monitoring devices may require minimal preventive maintenance, whereas certain lower-risk equipment may demand more frequent attention. Importantly, preventive maintenance does not always enhance reliability and, in some cases, may introduce additional points of failure.

Contemporary JCAHO frameworks also support the use of risk-based criteria to develop a prioritized Medical Equipment Management Plan (MEMP) inventory. While it is ideal to regulate all equipment under preventive maintenance and safety inspection systems, applying detailed failure analysis to low-risk, low-complexity devices such as otoscopes may not represent an efficient use of limited resources. Therefore, inclusion criteria for preventive maintenance and safety/performance inspections should extend beyond risk alone and incorporate factors such as operational impact, detectability of hidden failures, equipment hazards, reliability, and availability of spare parts. At a minimum, mission-criticality should be a core determinant, as failures in such equipment can significantly compromise patient safety and organizational effectiveness.

For clarity, preventive maintenance in this context refers specifically to scheduled replacement of consumable or wear-prone components intended to prevent predictable failures. With significant improvements in medical device reliability, the necessity for routine preventive maintenance has diminished in many cases, and for several devices, the non-serviceable period now exceeds their typical operational lifespan.

This study aims to explore the Medical Equipment Management process within the Department of Health in the Western Province. Specifically, it seeks to compare the preventive maintenance (PM) processes implemented across the three districts, examine differences in corrective maintenance (CM) practices, and assess equipment downtime as a key indicator of operational effectiveness. Based on these findings, the study further intends to develop an innovative Medical Equipment Management Plan (MEMP) to support standardized, efficient, and sustainable management of medical equipment across the region.

II. METHODOLOGY

A retrospective cross-sectional study was conducted covering the period from 1 January to 31 December 2025. Documentary data were extracted from records maintained by the Biomedical Engineering offices of the Colombo, Kalutara, and Gampaha districts and analyzed using Microsoft Excel. Due to the large number of equipment categories, certain items, such as blood pressure monitors, were excluded because of time constraints.

III. RESULTS

Table 1: Average Equipment Down Time, in all Three Districts

District	OTH Lamp	OT Table	Anesthetic Workstation	Multi Monitor	De-fibrillator
Colombo	1	1	0	11	3
Gampaha	6	5	6	13	6
Kalutara	16	6	14	10	7

Preventive maintenance activities were lowest in the Kalutara BME unit. However, it was observed that all preventive maintenance in the Kalutara District was fully carried out (100%) by the local agent.

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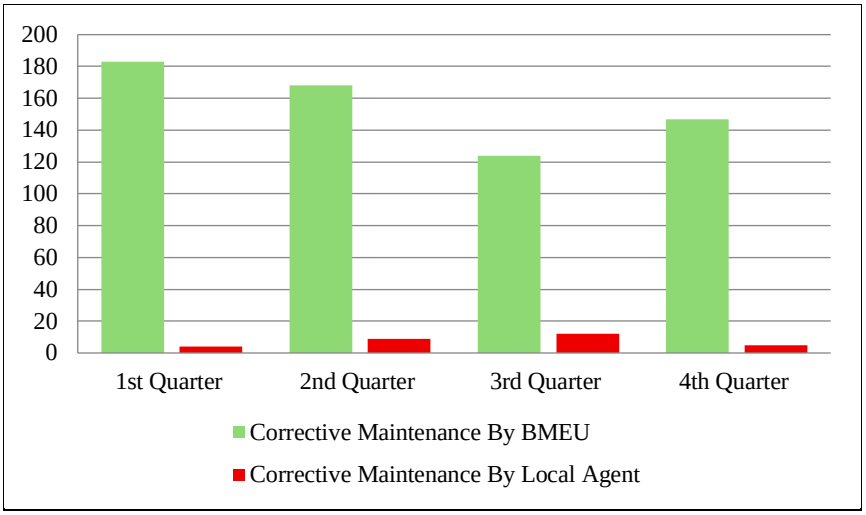

Fig 1: Quarterly Corrective Maintenance; Colombo

According to the figure 1 it is observed Majority of corrective maintenance in all four quarters done by the BME unit Colombo District. Very few, less than 10 in number done by the local agent.

Table 2: Comparative Corrective Maintenance

District	Corrective Maintenance		Total
	By BMEU	By Local Agent	
Colombo	622	30	652
Gampaha	311	13	324
Kaluthara	1483	72	1555

According to table.2, and figure 2 it is observed majority of equipment correctively maintained by the divisional Bio Medical Engineering units. As a percentage it is 95.99% in Gampaha district, 95.4% and 95.37% recorded in Colombo and Kaluthara respectively.

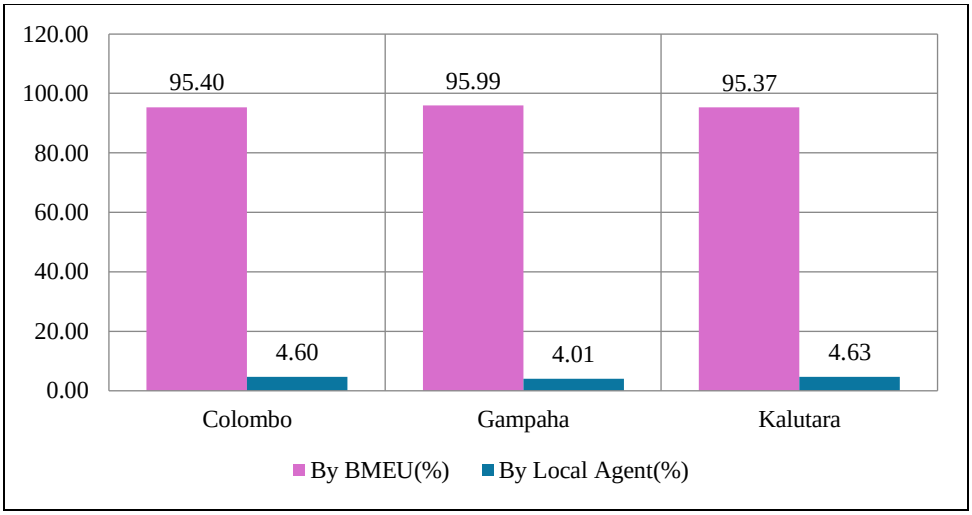

Fig 2: Comparative Analysis of the Status of Corrective Maintenance, Three Districts

Table 3: Medical Equipment Maintenance, Colombo District BME unit

Time Period	Preventive Maintenance		Corrective Maintenance	
	By BMEU	By Local Agent	By BMEU	By Local Agent
1st Quarter	20	2	183	4
2nd Quarter	22	2	168	9
3rd Quarter	19	2	124	12
4th Quarter	21	2	147	5
Total	**82**	**8**	**622**	**30**

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Table 4: Medical Equipment Maintenance in Kaluthara District

Time Period	Preventive maintenance		Corrective Maintenance	
	By BMEU	By Local Agent	By BMEU	By Local Agent
1st Quarter		14	370	18
2nd Quarter		10	263	26
3rd Quarter		3	462	12
4th Quarter		9	388	16
Total	**-**	**36.00**	**1,483.00**	**72.00**

According to the Table.4 it is observed Preventive maintenance in Kalutara district has been done by local agents only. But CM done by both BME and the local agents.

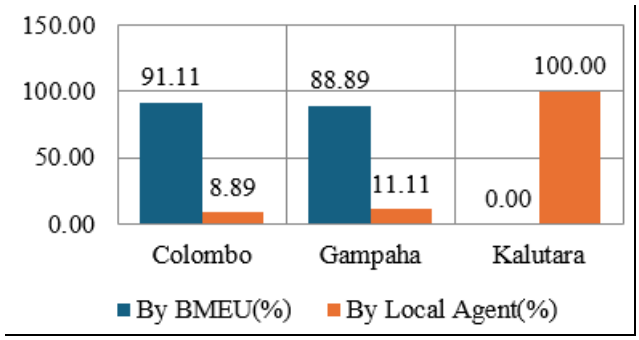

Fig 3: Comparative Preventive Maintenance in all Three Districts

According to the Figure 3 and Table 5 it is observed lowest preventive maintenance has been performed by Kaluthara BME Unit. It is confirmed 100% Preventive maintenance has been performed by the local agent in Kaluthara District.

Table 5 Preventive Maintenance; District Level

Time Period	Preventive maintenance		
	By BMEU	By Local Agent	Total
Colombo	82	8	**90**
Gampaha	48	6	**54**
Kalutara	0	36	**36**

IV. DISCUSSION

Developing a single Medical Equipment Management Plan (MEMP) that is suitable for all healthcare institutions is inherently challenging. A plan designed for high-volume District General or Base hospitals is typically more detailed and resource-intensive than what is necessary for smaller divisional hospitals. Accordingly, this discussion adopts a methodological perspective rather than offering rigid prescriptions, recognizing that practitioners must apply their own expertise and contextual understanding when formulating maintenance strategies.

The central objective is to encourage the adoption of innovative management approaches that reconcile resource limitations with the imperative to enhance patient safety, clinical outcomes, operational efficiency, and institutional goals. Time saved by reducing unnecessary scheduled maintenance can be redirected toward higher-value activities. For instance, staff may engage more actively in equipment planning and procurement processes, facilitating the selection of more reliable and appropriate technologies while potentially minimizing medical errors. Additionally, greater involvement in the training and education of clinical personnel can help reduce equipment misuse. Strengthening in-house repair capabilities may also decrease equipment downtime and reduce reliance on external vendors and rental equipment, thereby lowering operational costs.

A key advantage of this approach is the transition from viewing medical equipment as the sole source of patient safety risk to a more balanced assessment that considers both equipment-related and user-related factors. This broader perspective enables biomedical engineering professionals to extend their focus beyond the equipment itself and provide greater support to end users. Such a shift is likely to assist healthcare organizations in more effectively achieving their safety and performance objectives.

V. CONCLUSION AND RECOMMENDATIONS

The Kalutara District BME unit demonstrated comparatively weak performance in preventive maintenance, while achieving the strongest outcomes in corrective maintenance activities. In contrast, the other two districts exhibited moderate performance across both areas.

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Given these findings, it is advisable for the Kalutara BME unit to place greater emphasis on strengthening its preventive maintenance practices. At the same time, all BME units should be encouraged to apply their professional expertise and contextual understanding when designing and refining maintenance strategies, ensuring a balanced and sustainable approach to equipment management.

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