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Analysis of the Medical Device Maintenance System at Malahayati Islamic Hospital Medan

Putri Aulia Rahma[1]*, Wuni Barokah[1], Icha Febi Wardani[1], Nur Cahaya Hasibuan[1], Indah Doanita Hasibuan[1]

[1] Public Health Sciences, State Islamic University of North Sumatra, Medan, North Sumatra, Indonesia

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Corresponding author
Email: *putriauliar3@gmail.com*

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ABSTRACT
Ensuring efficient maintenance of medical equipment is crucial to maintaining the quality of hospital services and patient safety. However, many hospitals have difficulty carrying out this maintenance consistently. This study aims to examine the medical device maintenance system at the Malahayati Islamic Hospital in Medan and to assess the extent to which the system complies with the Standard Operating Procedure (SOP). In addition, this study also aims to identify various obstacles that arise during the process of implementing the system maintenance. This study uses a qualitative descriptive approach by conducting in-depth interviews with three main informants, namely the head of the medical support section, electromedical technicians, and members of the Hospital Maintenance Unit (UPRS The results of the study revealed that several maintenance activities had been carried out in accordance with Standard Operating Procedures (SOPs), such as preventive maintenance scheduling, annual calibration, and recording of technical documentation. However, several obstacles were found, including the limited number of qualified personnel (only one technician was available), limited maintenance budget, unavailability of special work space, and SOP coverage that did not yet cover all medical devices. In order for the maintenance system to run more effectively and sustainably, improvements are needed in aspects of human resources, supporting facilities, and more mature budget planning.

Keywords: Maintenance, Medical Devices, Hospital.

ABSTRAK
Pemeliharaan peralatan medis yang efisien sangat penting untuk menjaga kualitas layanan rumah sakit dan keselamatan pasien. Namun, banyak rumah sakit yang mengalami kesulitan dalam melaksanakan pemeliharaan ini secara konsisten. Penelitian ini bertujuan untuk mengkaji sistem pemeliharaan alat medis di Rumah Sakit Islam Malahayati Medan dan menilai sejauh mana sistem tersebut mematuhi Standard Operating Procedure (SOP). Selain itu, penelitian ini juga bertujuan untuk mengidentifikasi berbagai kendala yang muncul selama proses pelaksanaan pemeliharaan sistem tersebut. Penelitian ini menggunakan pendekatan deskriptif kualitatif dengan melakukan wawancara mendalam kepada tiga informan utama yaitu kepala seksi penunjang medis, teknisi elektromedis, dan anggota Unit Pemeliharaan Rumah Sakit (UPRS). Hasil penelitian diketahui bahwa beberapa kegiatan pemeliharaan telah dilaksanakan sesuai dengan Standar Operasional Prosedur (SOP) seperti penjadwalan pemeliharaan preventif, kalibrasi tahunan, dan pencatatan dokumentasi teknis. Namun demikian, ditemukan beberapa kendala antara lain terbatasnya jumlah personel yang berkualifikasi (hanya tersedia satu orang teknisi), terbatasnya anggaran pemeliharaan, belum tersedianya ruang kerja khusus, serta cakupan SOP yang belum mencakup seluruh alat medis. Agar sistem pemeliharaan dapat berjalan lebih efektif dan berkelanjutan, diperlukan perbaikan pada aspek sumber daya manusia, sarana penunjang, serta perencanaan anggaran yang lebih matang.

Kata kunci: Pemeliharaan, Alat Kesehatan, Rumah Sakit.

INTRODUCTION

A hospital is a health care institution for the community with its own characteristics. Hospitals provide professional health care, namely providing services provided by nurses, doctors and other health experts (Dewanto & Santosa, 2020). In order for this situation to be achieved, good and integrated management of health equipment is needed. This management can be started from the planning, procurement, utilization and maintenance stages (Mahardiananta et al., 2020).

Health equipment is one of the important factors in the delivery of health services, both in hospitals and in other health care facilities (Zamzam et al., 2021). In order to achieve good condition and function of health equipment and to support health services, it is necessary to have integrated health equipment management. In order for health equipment to be managed properly, there is a need for government policies in the management of health equipment in hospitals and other health care facilities (Ulina et al., 2023).

According to data from the World Health Organization (WHO) in 2018, more than 60% of medical equipment in developing countries is malfunctioning or not being used optimally. In some countries, less than half of the available equipment is routinely used. This is due to poor operation, lack of maintenance skills, and unavailability of funds for maintenance. In Indonesia, most medical equipment has not been properly managed in accordance with existing regulations (Wahyudi et al., 2024).

According to Minister of Health Regulation (Permenkes) No. 15 of 2023 concerning maintenance of health service facilities, to ensure the availability of medical devices according to service standards, quality requirements, security, benefits, safety, and feasibility of use in order to support the provision of safe and quality health services, it is necessary to maintain medical devices used in health service facilities. That the maintenance of health services used in health service facilities is not optimal because the number and capacity of resources that organize the maintenance of medical devices is still limited and not balanced with the number of medical devices (Menteri Kesehatan Republik Indonesia, 2023).

Maintenance of medical devices in hospitals is an important aspect that supports the smooth running of health services and patient safety (Haleem et al., 2022; Boppana, 2023). Medical devices used in diagnosis and treatment require good care and maintenance to keep them functioning accurately and efficiently. In practice, there are often malfunctions or damage to medical devices that are not immediately addressed, which has an impact on service delays and can even endanger patients. For example, failure of critical medical equipment such as ventilators can cause serious disruption in the healthcare process. Therefore, effective medical device maintenance management is urgently needed to reduce the risk of damage, extend equipment life, and maintain service quality in hospitals (Fitriardi et al., 2024).

General research on medical device maintenance emphasizes the importance of maintenance management for patient safety and service quality in general. Meanwhile, research at the Malahayati Islamic Hospital in Medan provides an in-depth and contextual analysis related to the implementation of the maintenance system in one hospital, focusing on evaluating SOP compliance and identifying specific obstacles faced. This makes the research more focused and provides concrete practical contributions to the development of a medical device maintenance system at the institutional level. Previous studies have discussed the importance of medical device maintenance in hospitals to maintain service quality and patient safety. For example, Fitriardi et al. (2024) highlighted the elements of maintenance management at Level III Brawijaya Surabaya Hospital which included planning and implementing equipment calibration, while Lestari et al. (2021) examined the logistics management of medical device procurement at Bogor Islamic Hospital. However, these studies are still general in nature and have not specifically described the implementation process of the medical device maintenance system in private hospitals with a comprehensive approach to aspects of human resources, funding, facilities, supporting documents, and SOP suitability.

In addition, previous studies tend to use a quantitative approach or are limited to one particular aspect of management, such as budget or procurement. Not many studies have examined in depth how the implementation of the medical device maintenance system is carried out practically in the field, as well as how real obstacles and solutions are identified and handled by technical implementers, especially in lower-middle type hospitals.

Therefore, this research comes to fill the void with a thorough qualitative descriptive approach, and focuses its study on Malahayati Medan Islamic Hospital as a case study. The novelty of this study lies in the contextual and practical approach in evaluating the implementation of the medical equipment maintenance system and its relationship with managerial and technical factors in the institution. This study aims to analyze the medical device maintenance system at Malahayati Medan Islamic Hospital, evaluate the suitability of its implementation with the Standard Operating Procedure (SOP), and identify various obstacles in the implementation process.

RESEARCH METHODS

This study uses a qualitative method with a descriptive approach that is specifically focused on the medical device maintenance system at the Malahayati Islamic Hospital in Medan. The research sample consisted of three main informants, namely the Head of the Medical Support Section, UPRS Medical/Electromedical personnel, and the UPRS Team who have a deep understanding of the medical device maintenance system at the hospital. The study was conducted on May 9, 2025 and aims to obtain a detailed picture of the implementation and obstacles in the medical device maintenance system at the institution.

The data collection technique was carried out through in-depth interviews with the third main informant to obtain primary data related to the medical device maintenance system. In addition, secondary data was obtained from literature studies in the form of documents and relevant previous research. Recorders and stationery were used to support recording and recording interview results. Data analysis was carried out using the Miles and Huberman model which includes data reduction, namely classifying and filtering the results of interviews and observations so that the information obtained is more focused and systematic.

RESULTS

The informants of this study were 3 informants, key informants (core) were 2 people, namely 1 female Head of Medical Support Division with a last education of D3, 2 male UPRS Medical/Electromedical Personnel with a last education of D3. While for supporting informants, there were 1 person, 1 male UPRS Team member with a last education of SMK.

Table 1. Characteristics of Research Informants

Informant	Gender	Education	Description
Informant 1 (Key)	Female	D3	Head of Medical Support Section
Informant 2 (Lock)	Male	D3	(UPRS Medical/Electromedical)
Informan 3(Pendukung)	Male	SMK	UPRS Team

Results of Interviews and Observations Regarding Human Resources in the Maintenance of Medical Equipment at Malahayati Islamic Hospital Medan

Based on the results of interviews and observations, the study shows that the Malahayati Islamic Hospital in Medan only has one specialist technician who is responsible for the maintenance of medical devices. This technician has a Diploma III Electromedical (ATEM) education background, which is a relevant qualification and in accordance with the needs of medical device maintenance. Although the number of technicians is limited, the hospital strives to improve the competence of these technicians through training and seminars, both held internally and externally. This reflects the hospital's concern in maintaining the quality of human resources that handle medical devices, although the limited number of personnel is a challenge in itself.

Statements from the Head of the Medical Support Section, the UPRS Team, and UPRS Medical/Electromedical personnel consistently emphasize that technicians with ATEM qualifications are the only technical officers who manage medical device maintenance. This indicates a high dependence on one individual, which has the potential to pose a risk if there are obstacles such as excessive workload or absence of the technician. Efforts to develop competence through training are a positive step, but the sustainability and effectiveness of this development need to be evaluated in order to ensure the quality of medical device maintenance consistently.

The hospital has one specialist technician for medical device maintenance with a D3 Electromedical education background in the medical device maintenance section or an Electromedical Engineering Expert (ATEM) education. Competence improvement is carried out through internal and external training and seminars. The answers during the interview:

"The hospital relies on officers with Electromedical Technician (ATEM) qualifications for medical device maintenance. The development of these officers' competencies is facilitated through various training programs and seminars, both internal and external." (Head of Medical Support Section)"

"The hospital has identified one technician who is responsible for medical device maintenance." (UPRS Team)"

The limited human resources in medical device maintenance at the Malahayati Islamic Hospital in Medan can be seen from the presence of only one specialist technician with a Diploma III Electromedical (ATEM) qualification. Although the technician's competence is improved through training and seminars, both internal and external, the high dependence on one personnel poses potential operational risks. The limited availability of personnel can hinder the continuity and quality of maintenance, especially when the workload increases or the technician is absent, thus requiring a better human resource management strategy, including the addition of personnel and effective division of tasks.

Results of Interviews and Observations Regarding Funding for Medical Equipment Maintenance at Malahayati Islamic Hospital Medan

Based on the results of interviews and observations, the study revealed that the Malahayati Islamic Hospital in Medan has provided special funds for the maintenance of medical devices that include preventive, corrective, and emergency maintenance. The allocation of these funds has been planned since the procurement stage of medical devices, indicating that hospital management is aware of the importance of ongoing maintenance. However, the availability of funds each year is often insufficient to meet all maintenance needs. This has an impact on budget priorities that are more inclined towards preventive maintenance, while funds for emergency and corrective maintenance are adjusted to incidental needs that arise suddenly.

Statements from the Head of the Medical Support Section, the UPRS Team, and UPRS Medical/Electromedical personnel consistently emphasize that the main obstacle lies in the limited budget that is not fully able to cover the hospital's annual needs. This indicates a gap between the actual need for medical device maintenance and the available funds, which can hinder the effectiveness of the maintenance system and potentially pose a risk of disruption to the operation of medical devices. The answers during the interview:

"The allocation of special funds for medical device maintenance has been budgeted since the procurement process, covering preventive, corrective, and emergency maintenance needs. However, the annual availability of funds is sometimes lacking." (Head of Medical Support Section)

"The allocation of special funds is prioritized for preventive maintenance of medical devices, while the budget for emergency maintenance is adjusted to incidental needs. The availability of funds for the maintenance of medical devices has not fully met the annual needs of the hospital." (UPRS Team)

Special funds for the maintenance of medical devices at the Malahayati Islamic Hospital in Medan have been allocated since the procurement process, covering preventive, corrective, and emergency maintenance. However, the availability of annual funds is often insufficient so that its utilization is prioritized for preventive maintenance, while corrective and emergency maintenance is adjusted to incidental needs. This budget limitation has the potential to hinder the implementation of optimal and sustainable maintenance.

The main theme that emerged was the existing but limited budget planning, where the hospital realized the importance of allocating funds but tried to provide for needs comprehensively. The priority of preventive maintenance is the main strategy, but funds for corrective and emergency maintenance are still inadequate. As a result, limited funds pose

operational risks, such as declining maintenance quality and potential equipment disruptions that can affect the quality of patient care.

Results of Interviews and Observations Regarding Supporting Facilities for Medical Equipment Maintenance at Malahayati Islamic Hospital Medan

Based on the results of observations and interviews, the study shows that the implementation of medical device maintenance at the Malahayati Islamic Hospital in Medan is still carried out directly at the location of the damaged device, because there is no special work space for maintenance. This indicates limited facilities that can affect the efficiency and comfort of the maintenance process. However, the storage facilities for medical devices in each unit are considered adequate, and the Hospital Maintenance Unit (UPRS) space is used optimally to store technical documents, medical equipment inventory, and material maintenance.

The work equipment needed for maintenance has been provided, but some additional tools are still in the procurement stage, while the availability of maintenance materials is situational and spare parts are obtained based on needs through external suppliers. This condition indicates that there are no difficulties in managing logistics maintenance, especially in terms of the availability of materials and spare parts that are not always ready to use, so that it can affect the smooth process of repairing and maintaining medical devices. The answers during the interview:

"The Hospital Maintenance Unit (UPRS) room is used to store technical documents and medical equipment inventory. Work equipment is placed on the first floor, and maintenance materials are stored in the sixth floor warehouse. The provision of maintenance materials is situational, depending on the type of repair required. Small spare parts are available in logistics, while procurement of materials for large equipment repairs generally involves third parties." (UPRS Team)

"The Medical Hospital Infrastructure Unit (UPRS) is the storage location for technical documents, medical device inventory, work equipment, and maintenance materials, sharing the scope with the General UPRS for building and air conditioning aspects." (UPRS Medical/Electromedical.

Malahayati Islamic Hospital Medan does not yet have a special workspace for medical device maintenance, so maintenance is carried out directly at the location of the damaged device. Storage facilities for medical devices and technical documents in each unit and the UPRS room are considered adequate. Basic work equipment is available, but some additional equipment is still in the procurement process, while the availability of materials and spare parts is situational and obtained as needed from external suppliers.

The main themes that emerged included the limited availability of special workspace facilities that hampered the efficiency and quality of care, optimization of storage and inventory management that was already running well, and challenges in procuring equipment and materials that required more structured planning. Dependence on external suppliers also poses a risk of delays in the maintenance process.

Results of Interviews and Observations Regarding the Availability of Guidelines and SOPs for Medical Equipment Maintenance at Malahayati Islamic Hospital Medan

Based on the results of interviews and observations, the study shows that the Malahayati Islamic Hospital in Medan systematically stores technical documents for medical devices obtained from the manufacturer, including brochures, manuals, warranty cards, function test cards, and minutes. Storing these documents is important as a reference in the implementation of maintenance and operation of medical devices. However, only about 30% of documents for large devices are stored, indicating a lack of complete documentation.

The implementation of medical device maintenance is claimed to have followed the existing Standard Operating Procedure (SOP), with standard procedures (SOP) for the operation and maintenance of medical devices. However, not all devices have complete maintenance SOPs, which can cause variations in the quality and consistency of maintenance. The availability of adequate technical documents and SOPs is crucial to ensure that the maintenance process runs according to standards and reduces the risk of operational errors.

Malahayati Islamic Hospital Medan stores technical documents of medical devices from the manufacturer such as brochures, manuals, warranty cards, and function test cards, although only about 30% of documents for large devices are complete. The maintenance process generally follows the Standard Operating Procedure (SOP), but not all devices have complete maintenance SOPs. In addition, there are standard operating procedures (SOPs) as a guide for the operation and maintenance of the device. The answers during the interview:

"The hospital owns and stores technical documents from the equipment manufacturer, such as brochures, manual books, warranty cards, function test cards, and minutes. The implementation of medical device maintenance is claimed to have followed the Standard Operating Procedure (SOP). More than 30% of documents for large-sized equipment have been stored. Fixed procedures for the operation and maintenance of medical devices are available, although not all types of devices have complete maintenance SOP documentation." (Head of Medical Support Section)

"Technical documents of medical devices, including manual books, are available and obtained from third parties who provide the equipment. The implementation of medical device maintenance generally follows Standard Operating Procedures (SOPs), as exemplified in routine checks of electrical voltage on electrical equipment." (UPRS Team)

The main themes that emerged included the importance of the completeness and availability of technical documentation as a basis for effective maintenance, the need to develop and standardize SOPs to ensure compliance and quality of care, and the role of SOPs as operational guidelines that help maintain consistency and safety in the use of medical devices.

Results of Interviews and Observations Regarding the Implementation Process of the Medical Equipment Maintenance System at Malahayati Islamic Hospital Medan

Based on the results of interviews and observations, research shows that the Malahayati Islamic Hospital in Medan implements a structured and systematic medical device maintenance system. Medical device inventory is carried out periodically every year to ensure that device data is always updated. Preventive maintenance schedules are arranged daily based on area or floor, and technicians carry out maintenance tasks according to the schedule consistently, including routine checks on the condition of the device every morning. This shows the hospital's commitment to maintaining the function of medical devices so that they are always in optimal condition. In addition to preventive maintenance, performance testing and calibration of electronic medical devices are carried out once a year by the Health Facility Security Center (BPAFK), with the last implementation in August 2024.

This testing is important to ensure the accuracy and safety of the device, especially for critical devices in the ER and Radiology units. The implementation of calibration carried out by a third party through an annual contract indicates external collaboration to maintain the quality standards of medical devices. The frequency of preventive maintenance varies according to the type of device, for example, air conditioners are maintained monthly or bi-monthly, adjusting to the specific needs of each device. The answers during the interview:

"The implementation of preventive maintenance by officers/technicians is carried out according to a gradual schedule, with a frequency that varies based on the type of equipment. For example, AC maintenance is carried out monthly or bi-monthly, while calibration of medical devices is carried out accumulatively every year." (UPRS Team)

"Technical officers consistently carry out preventive maintenance tasks according to a predetermined schedule, including routine checks of the condition of medical equipment every morning. Most of the medical equipment, with a priority on the ER and Radiology units, have undergone testing/calibration last on month August 2024. Activities This activity is implemented by a private party based on an annual contract." (UPRS Medical/Electromedical)

Medical device inventory is conducted annually to update data, while preventive maintenance schedules are prepared daily based on area and implemented consistently by technicians. Performance testing and calibration of electronic devices are conducted once a year

by BPAFK through a contract with a third party. The frequency of preventive maintenance varies by device type, such as monthly for AC and annually for medical device calibration.

The main themes that emerged included a structured and consistent maintenance system, the importance of collaboration with external parties for calibration to maintain device quality and safety, and adaptive maintenance frequency adjustments according to device characteristics for management efficiency.

Results of Interviews and Observations Regarding the Performance of Medical Equipment Maintenance Implementation at Malahayati Islamic Hospital Medan

Based on the results of interviews and observations, the study revealed that the Malahayati Islamic Hospital in Medan has provided quite complete documentation related to the maintenance of medical devices, including maintenance work reports and maintenance cards, especially for large devices. The process of updating this document is ongoing to improve the management and differentiation between medical device maintenance cards and general sections. Calibration reports and certificates are also available as evidence of the implementation of annual calibration, which is an important part of maintaining the quality and safety of the device.

In the case of emergency repairs that require special expertise, the hospital involves a third party, indicating the existence of an external collaboration mechanism to address issues that cannot be resolved internally. The main obstacle faced is limited funds, which causes repairs to be carried out in stages based on priority needs. Efforts to increase the efficiency of device use through correct procedures and proper maintenance are also important strategies to optimize the performance of the maintenance system. The answers during the interview:

"Maintenance work reports and tool maintenance cards are available, especially for large and medium-sized tools in the renewal phase. Calibration reports and certificates are generated after the annual calibration process is completed. Emergency repairs that require expertise beyond in-house capabilities will involve third-party technicians. The main obstacle in the implementation of maintenance is the limited budget, which is overcome by carrying out repairs in stages according to priorities." (Head of Medical Support Section)

"Blue medical device maintenance cards are available and are in the process of being updated to distinguish them from the general section's maintenance cards. Efforts made to overcome this include increasing the efficiency of equipment use through emphasis on correct procedures and proper maintenance, and optimizing the use of equipment power." (UPRS Team)

Work reports and equipment maintenance cards, especially for large equipment, are available and being updated, along with annual calibration reports and certificates as evidence of equipment performance testing. Emergency repairs that cannot be handled internally involve third-party technicians. Funding constraints are a major constraint, so repairs are carried out in stages according to priority, accompanied by efforts to increase efficiency through correct procedures and proper maintenance.

Key themes include structured documentation and monitoring, the importance of external collaboration for handling repairs, gradual repair strategies due to funding constraints, and efforts to increase efficiency in equipment use to maximize the service life and performance of medical devices.

DISCUSSION

Availability and Competence of Human Resources in Medical Device Maintenance

The finding that the Malahayati Islamic Hospital in Medan only has one specialist technician with a Diploma III Electromedical (ATEM) educational background is in line with several previous studies that highlight the limited human resources in the field of medical device maintenance in health institutions. The literature emphasizes the importance of adequate technician competence and continuous development through training and seminars as key factors in maintaining the quality and sustainability of the medical device maintenance system (Rahman & Putri, 2022). This is reinforced by statements from informants who emphasized the existence of internal and external training programs to improve technician competence. Although competency improvement through training has been carried out, dependence on a single technician poses

significant operational risks. Another study showed that the existence of an adequate team of technicians with a clear division of tasks is essential to avoid disruption of maintenance continuity (Johnson & Lee, 2019). In this context, the Malahayati Islamic Hospital in Medan still faces major challenges due to limited personnel, which can hinder maintenance effectiveness, especially when the workload increases or technicians are absent.

In general, human resources are a crucial factor in the success of a medical device maintenance system. Appropriate technician qualifications and continuous competency development are the main prerequisites to ensure that medical devices function optimally and are safe to use. However, limited personnel availability can be a serious obstacle in maintaining the quality and continuity of maintenance. This study shows limited integration between human resources and operational management in addressing the technician shortage problem. There is no integrated strategy involving systematic recruitment, training, and redistribution of tasks to reduce the workload of single technicians. This indicates the need for better coordination between departments to support the sustainability of the maintenance system.

Although training and seminars have been part of competency development, there has been no implementation of a comprehensive human resource management strategy, such as increasing the number of technicians, developing a maintenance team, or a job rotation system. The development of an information technology support system for monitoring workload and maintenance effectiveness has also not been seen, even though this could help optimize the use of existing resources.

This study has limitations in the scope of informants which is limited to only three key personnel, so it may not describe the entire dynamics of human resources in the hospital. In addition, this study does not explore in depth the aspects of strategic management and internal policies that affect human resource management in the maintenance of medical devices. Therefore, further studies with a wider scope and multidisciplinary approach are needed to provide a more comprehensive picture.

Planning and Budget Limitations of Medical Device Maintenance

This study found that hospitals have allocated special funds for medical device maintenance, including preventive, corrective, and emergency maintenance, which is in accordance with findings in previous literature. Related studies emphasize the importance of adequate and planned budgets to maintain the sustainability of the medical device maintenance system (Kumar et al., 2018; Sari & Nugroho, 2021). Allocation of funds since the equipment procurement stage is a recommended practice to ensure readiness for maintenance costs. However, annual funding limitations that are not always sufficient are also a common problem that is often reported in various studies.

Although the allocation of funds is in place, hospitals face obstacles in meeting the full annual budget needs. This is different from several other hospitals that are able to manage maintenance budgets more flexibly and responsively to incidental needs (Putra & Widodo, 2020). Prioritizing greater funds for preventive maintenance indicates a good prevention strategy, but limited funds for corrective and emergency maintenance can hinder a rapid response to equipment damage, potentially disrupting health services.

In general, adequate funding and proper allocation are essential to ensure the sustainability and effectiveness of the medical device maintenance system. Limited budget can lead to delays in repairs and maintenance, increasing the risk of equipment damage and reducing the quality of service. Therefore, efficient fund management and realistic budget planning are primary needs for hospitals. This study indicates minimal integration between the finance, procurement, and maintenance divisions in managing the medical device maintenance budget. There is no strong coordination mechanism to ensure sufficient and timely fund allocation, as well as transparent and accountable fund management. This can lead to inefficiency and a mismatch between maintenance needs and the available budget.

Although the fund allocation has been budgeted, there has been no development of innovative financial management strategies, such as the use of a performance-based budgeting system or alternative funding mechanisms (e.g., reserve funds or equipment insurance). In addition, there has been no effort to optimize the use of funds through periodic evaluations and internal audits to improve the efficiency of maintenance spending. The development of an

integrated financial management information system that connects maintenance needs data with the budget has also not been implemented optimally.

Availability of Facilities and Equipment Supporting Medical Device Maintenance

The finding that the lack of a dedicated workspace for medical device maintenance is a major obstacle in the implementation of maintenance is in line with previous studies. The literature confirms that the existence of a dedicated workspace is essential to improve the efficiency, safety, and quality of medical device maintenance (Anderson & Smith, 2019; Wijaya, 2021). In addition, the availability of adequate storage facilities and complete work equipment are supporting factors that are often mentioned in the literature as prerequisites for the success of a maintenance system.

Although the storage facilities for medical devices in each unit and UPRS room are considered adequate, the implementation of maintenance that must be carried out directly at the location of the damaged device shows significant facility limitations. Several other hospitals have provided dedicated workspaces equipped with complete equipment to support the maintenance process, thereby increasing productivity and reducing the risk of further damage (Putra et al., 2020). In addition, the availability of situational maintenance materials and dependence on external suppliers for large spare parts indicate challenges in logistics management that are not yet optimal. In general, adequate facilities, including dedicated workspace, complete equipment, and consistent availability of materials, are essential elements in supporting an effective and efficient medical device maintenance system. Limited facilities can reduce the quality of maintenance and potentially accelerate equipment failure.

This study shows that the management of maintenance facilities and materials is still fragmented between several units, such as UPRS, logistics section, and Hospital Infrastructure Unit. The lack of integration and coordination between these sections can cause delays in material procurement, lack of adequate equipment, and suboptimal utilization of work space. This indicates the need for an integrated management system that connects all parties involved in the management of maintenance facilities and materials.

Although basic storage facilities and equipment are available, there has been no development of a special work space adequate for medical device maintenance. In addition, the procurement system for materials and spare parts is still reactive and situational, not supported by a proactive and integrated inventory and logistics planning system. The development of a special work space, improvement of the logistics management system, and application of information technology to monitor material availability can be strategic steps that have not been developed to improve maintenance effectiveness.

Completeness of Technical Documents and Standard Operating Procedures (SOP) Maintenance

The finding that hospitals keep technical documents of equipment from the manufacturer, including brochures, manuals, warranties, and function test cards, and carry out maintenance in accordance with Standard Operating Procedures (SOPs), is in line with the literature that emphasizes the importance of complete documentation and compliance with SOPs in the maintenance of medical devices (Lee & Kim, 2017). Adequate technical documentation and clear SOPs are the main foundations for ensuring the reliability and safety of medical devices.

Although more than 30% of documents for large devices have been kept and there are standard operating procedures (SOPs) for operation and maintenance, not all devices have complete maintenance SOP documentation. This indicates a gap in the implementation of operational standards that can lead to inconsistencies in the quality of maintenance. Several other hospitals have succeeded in implementing a more comprehensive and integrated documentation system, thereby minimizing the risk of operational errors (Rahman & Widjaja, 2019).

In general, the existence of complete technical documentation and consistently applied SOPs is very important to ensure the quality and safety of medical device maintenance. Lack of documentation and incomplete SOPs can hinder effective maintenance processes and increase the risk of equipment failure. This study indicates a lack of integration between the technical document storage unit, maintenance team, and hospital management in ensuring the

completeness and updating of SOPs. This lack of coordination can cause technical documents and SOPs not to be updated regularly and not to be socialized properly to all related officers.

Although SOPs and technical documents are available, there has been no development of an integrated digital document management system to facilitate access, updating, and tracking of documents. In addition, routine training related to understanding and implementing SOPs has not been optimized, which is important to ensure compliance and consistency in maintenance implementation. The development of a technology-based maintenance management information system can be a practical solution that has not been implemented.

This study found that medical device inventory was carried out periodically every year and preventive maintenance schedules were prepared daily by area or floor, in accordance with recommended practices in the medical device maintenance management literature (Kumar et al., 2019). Consistent implementation of preventive maintenance by technicians and annual performance testing and calibration by official institutions such as BPAFK are also in line with national and international standards to ensure the reliability and safety of medical devices.

Process Implementation of Medical Equipment Maintenance System in Hospital

Although preventive maintenance schedules are structured and implemented consistently, different maintenance frequencies based on device type indicate variations in process implementation that can affect maintenance effectiveness. Several other studies emphasize the need for standardization of maintenance frequencies to optimize device life and prevent premature failure (Johnson & Lee, 2020). In addition, the implementation of calibration carried out by third parties through annual contracts is a common practice, but this dependency can be an obstacle if not managed properly in terms of time and cost.

Although preventive maintenance schedules are structured and implemented consistently, different maintenance frequencies based on device type indicate variations in process implementation that can affect maintenance effectiveness. Several other studies emphasize the need for standardization of maintenance frequencies to optimize device life and prevent premature failure (Johnson & Lee, 2020). In addition, the implementation of calibration carried out by third parties through annual contracts is a common practice, but this dependence can be an obstacle if not managed properly in terms of time and cost.

In general, the implementation of a medical device maintenance system that includes inventory, preventive maintenance, and calibration is an integral part of effective medical device management. Consistency in the implementation of preventive and calibration schedules is essential to maintain device function and patient safety. However, variations in frequency and dependence on external parties must be managed properly so as not to disrupt continuity of service. This study shows limited integration between maintenance units, hospital management, and external parties (BPAFK and contractors). Lack of optimal coordination can lead to potential delays in the implementation of calibration and maintenance, as well as information gaps related to the status of the equipment. This indicates the need for a more integrated communication and project management system to ensure the smoothness and effectiveness of the maintenance process.

Although the maintenance schedule and implementation are already running, there has been no development of an information technology-based maintenance management system that can monitor the status of the equipment, maintenance schedule, and calibration reminders in real time. The implementation of a computerized maintenance management system (CMMS) or similar application can improve the efficiency, accuracy, and transparency of the maintenance process. In addition, the development of ongoing training for technicians related to maintenance and calibration standards is also not optimal.

Evaluasi Kinerja Pelaksanaan Pemeliharaan Alat Medis

The finding that maintenance work reports and equipment maintenance cards are available, as well as calibration reports and certificates are prepared after annual calibration, is in accordance with the principles of maintenance management recognized in the literature (Kumar et al., 2018). Structured and updated documentation is essential to monitor equipment conditions and ensure the continued function of medical equipment. In addition, the involvement of third

parties in emergency repairs is also a common practice recommended to overcome internal resource limitations (Johnson & Lee, 2019).

Although maintenance documentation is available, limited funds are the main obstacle that causes repairs to be carried out in stages. This is different from several other hospitals that have a more adequate budget so that they are able to carry out repairs and maintenance more quickly and thoroughly (Putra & Widodo, 2020). Efforts to increase the efficiency of equipment use through correct procedures and proper maintenance are positive strategies, but without adequate financial support, their effectiveness can be limited.

In general, the performance of medical device maintenance implementation is highly dependent on the availability of complete documentation, consistent implementation of preventive maintenance schedules, and adequate budget support. Good documentation facilitates monitoring and evaluation, while regular preventive schedules help prevent equipment damage. However, limited funds are a major inhibiting factor that must be addressed to improve maintenance quality. This study shows limited integration between the maintenance unit, finance department, and hospital management in terms of budget management and maintenance implementation. This lack of coordination can lead to a mismatch between maintenance needs and available funds, as well as potential delays in equipment repair and calibration. Better integration between divisions is essential to ensure smooth and effective maintenance processes.

Although the maintenance schedule and documentation are in place, there has been no implementation of an information technology-based maintenance management system such as a computerized maintenance management system (CMMS) that can improve the efficiency, accuracy, and transparency of the maintenance process. In addition, the development of a more flexible funding mechanism and a risk-based maintenance priority strategy have not been optimized. Continuous training for technicians and periodic evaluation of maintenance effectiveness also need to be improved.

CONCLUSION

This study revealed that the medical device maintenance system at the Malahayati Islamic Hospital in Medan has been running with a fairly good structure, including periodic inventory, preventive maintenance schedule, maintenance documentation, and annual calibration by the authorities. However, there are several significant obstacles, such as limited human resources that only rely on one specialist technician, limited funds that cause repairs to be carried out in stages, lack of special work space for maintenance, and incomplete documentation and SOPs on several devices. Integration between sections related to maintenance management is also still minimal, which has the potential to hinder the effectiveness of the system as a whole.

The main implication of this finding is the need to increase human resource capacity, more adequate and planned fund allocation, development of special work space facilities, and standardization and digitization of documentation and SOPs. Increasing coordination between units and the use of information technology can strengthen the maintenance system to be more efficient and sustainable.

Recommendations for further steps include adding technicians and ongoing training to reduce reliance on single personnel, increasing realistic and flexible maintenance budgets, and providing dedicated workspaces to improve efficiency and safety. In addition, it is recommended to implement a technology-based maintenance management system (CMMS), complete and update SOPs and technical documentation thoroughly, and conduct further research with a broader scope to evaluate the effectiveness of maintenance system improvements and their impact on service quality.

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