International Journal of Multidisciplinary Research and Growth Evaluation.

Preventive Maintenance Practices and Factors Associated with Medical Laboratory Equipment Downtime in Uganda: A Narrative Review

Glorias Mbabazi [1*], Simon ArthurMugabi [2], Posiano Mayambala [3], Robert Laghu [4], Geoffrey Salamu [5], Jackson Nuwamanya [6], Ivan Womayi, Habert Mabonga [7], Ronald Kareodu [8], Oromcam Benjamin Wathum [9]

[1-7] Department of Medical Laboratory Technology, Mengo Hospital Training Institute, Kampala, Uganda
[8] Department of Public Health Dentistry, Mengo Hospital Training Institute, Kampala, Uganda
[9] School of Postgraduate, Research and Training, Mengo Hospital Training Institute, Kampala, Uganda

* Corresponding Author: **Glorias Mbabazi**

Article Info

ISSN (Online): 2582-7138
Impact Factor (RSIF): 8.04
Volume: 07
Issue: 05
Received: 24-07-2026
Accepted: 22-08-2026
Published: 20-09-2026
Page No: 477-485

Abstract

Background: Reliable medical laboratory equipment is essential for timely diagnosis, disease monitoring, treatment decisions, and continuity of patient care. However, equipment downtime remains a major challenge in resource-constrained health systems, where limitations in preventive maintenance, technical capacity, financing, spare-parts availability, infrastructure, and equipment-management systems may compromise equipment functionality.

Objective: This narrative review synthesised evidence on preventive maintenance practices and factors associated with medical laboratory equipment downtime in Uganda and identified practical strategies for improving equipment functionality and continuity of laboratory services.

Methods: Literature published primarily between January 2016 and August 2026 was identified through searches of PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, African Journals Online, institutional repositories, reference lists, and relevant policy and technical documents. Earlier publications were included where they provided foundational evidence. Eligible sources addressing preventive maintenance, equipment functionality, technical capacity, user training, financing, spare parts, infrastructure, procurement, equipment tracking, and repair processes were narratively and thematically synthesised.

Results: The evidence indicates that medical laboratory equipment downtime in Uganda is influenced by interacting technical, human-resource, financial, infrastructural, procurement, supply-chain, and management factors. Ugandan evidence demonstrates that training and mentorship of equipment users and biomedical-engineering personnel can improve equipment functionality. However, preventive maintenance remains constrained by inadequate financing, limited technical capacity, shortages of spare parts, unreliable electricity, weak equipment-tracking systems, inappropriate procurement practices, and dependence on external service providers.

Conclusion: Reducing medical laboratory equipment downtime in Uganda requires a shift from predominantly reactive maintenance towards planned, adequately financed, documented, and life-cycle-based equipment management. Strengthening user competency, biomedical-engineering capacity, spare-parts supply chains, infrastructure, digital equipment tracking, procurement systems, and accountability mechanisms could improve equipment availability and continuity of diagnostic services.

DOI: https://doi.org/10.54660/.IJMRGE.2026.7.5.477-485

Keywords: preventive maintenance, medical laboratory equipment, equipment downtime, biomedical engineering, health technology management, Uganda

Introduction

The reliability, availability and operability of diagnostic equipment are crucial to the medical laboratory services. Laboratory equipment such as haematology and chemistry analyzers, microscopes, centrifuges, incubators, refrigerators, freezers, molecular diagnostic platforms, biosafety and other technologies are crucial to provide accurate and timely results. The loss of such equipment could result in laboratories having to postpone testing, send samples for testing to other labs, perform the tests outside the lab, or end specific testing services. The functioning of equipment is therefore not just an engineering issue, but an important

Factor in the capacity and continuity of health services.

Medical equipment management includes planning for the needs, procurement, installation, training, inventory (acquisition), maintenance, decommissioning, repair, and monitoring of medical equipment. The World Health Organization (WHO) names maintenance as one of the elements of health-technology management and separates preventive maintenance from corrective maintenance. Preventive maintenance is maintenance planned to ensure that equipment functions properly, is used for as long as possible and is unlikely to fail (World Health Organization [WHO], 2011) [6]. The integrated equipment inventories and maintenance-management information systems are still highlighted as key tools for ensuring the safety of patients and appropriate use of medical devices in more recent WHO guidance (WHO, 2025) [8].

This is especially true in LMICs where health facilities might lack technical staff, maintenance funds, electricity, spare parts, and have a tight budget for procurement, and have to rely on external health facility supplies. Poorly functioning equipment is a major constraint in improving health systems in sub-Saharan Africa, as highlighted by Fonjungo *et al.* (2012) [10] in their description of maintenance of laboratory equipment as a major constraint. Although this evidence predates the principal review period, it provides important foundational evidence regarding persistent medical-equipment maintenance challenges in sub-Saharan AfricaThe capacity of testing in Uganda has grown and the laboratories are increasingly using sophisticated technologies. However, increasing equipment acquisition alone does not guarantee sustained equipment functionality or continuity of diagnostic services. The Ministry of Health, Uganda, has recognised the importance of systematic medical-equipment management and has developed national guidelines covering equipment planning,procurement, pre-installation requirements, maintenance and repair, monitoring, quality assurance, security, training, and disposal. These guidelines represent an important shift from an acquisition-focused approach towards comprehensive life-cycle management of medical equipment.

Uganda provides direct empirical evidence that strengthening user competency and preventive-maintenance capacity can improve equipment functionality. Oshabaheebwa *et al.* (2020) [3] evaluated 202 medical-equipment items across seven regional blood banks of the Uganda Blood Transfusion Service. Following training and mentorship of equipment users, biomedical engineers, and technicians, equipment functionality and utilisation improved substantially in the intervention group. At follow-up, intervention equipment was approximately three times more likely to be in good working condition and in use than comparison equipment. These findings demonstrate the potential contribution of structured training, mentorship, and preventive-maintenance support to improved equipment availability.

However, there are important weaknesses in equipment management that still exist that have been documented in more recent Uganda. In a mixed-methods study of public health facilities, Ssebunya (2024) [5] discovered that while all facilities carried out preventive maintenance on a regular basis, there were often financial and logistical barriers which affected its implementation. The nature of corrective maintenance was basically reactive, and poor biomedical-engineering training and failure to have a centralized equipment-tracking system made equipment management more complex. The results indicate that there is an important disconnect between having a plan for preventive maintenance and its execution. The difference is key as a well-designed maintenance schedule that fails to be adequately resourced, monitored, documented and carried out can have little real impact on equipment uptime.

Rationale

Medical laboratory equipment represents a substantial investment in health-service delivery, yet its clinical and economic value depends on sustained functionality throughout its intended life cycle. Equipment downtime can interrupt diagnostic services, delay laboratory results, increase specimen referrals and outsourcing, raise operational costs, and compromise continuity of patient care. Effective preventive maintenance can reduce avoidable equipment failures; however, its implementation depends on competent users and biomedical-engineering personnel, adequate financing, reliable infrastructure, availability of spare parts and consumables, appropriate documentation, effective procurement systems, and institutional management support. Uganda has progressively expanded its laboratory diagnostic capacity and established national guidance for medical-equipment management. Nevertheless, available evidence indicates persistent gaps in preventive-maintenance implementation, equipment tracking, technical capacity, financing, spare-parts availability, infrastructure, and repair systems. Although individual studies and policy documents address various aspects of medical-equipment management, the evidence relevant to laboratory-equipment downtime in Uganda remains fragmented across different sources.

Synthesising this evidence is therefore necessary to identify recurrent maintenance practices, major determinants of equipment downtime, evidence gaps, and practical priorities for strengthening health-technology management. This review consequently examines preventive maintenance practices and factors associated with medical laboratory equipment downtime in Uganda, with the broader aim of informing policy, facility-level management, procurement, maintenance planning, and future research.

Methods and Materials

A narrative literature review was used to synthesize the evidence regarding preventive maintenance practices and factors contributing to downtime of medical Laboratory Equipment (MLE) in Uganda. The literature was reviewed and those published between January 2016 to August 2026 were studied, earlier literatures were reviewed for foundational evidence.

Literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, Google Scholar and AJOL with an additional search in institutional databases and reference lists. Sources were included that were relevant to the topic, were peer reviewed or graduate theses, were from reports, policies, and technical guidelines, and excluded if they were irrelevant, duplicate, or not sufficiently informative.

Data were extracted on equipment type, maintenance practices, technical capacity, training, spare parts, and infrastructure, downtime, and repair processes. Findings were thematically synthesized into preventive maintenance practices and downtime determinants in terms of technical, human-resource, financial, supply-chain, infrastructure, procurement, and service-provider factors.

Literature Review

Preventive Maintenance Practices

The activities that are planned and undertaken in advance of equipment failure to keep equipment functioning, safe, reliable and long-lived. World Health Organization (WHO, 2011) [7] suggests that inspection, cleaning, calibration, performance verification, safety checks and replacement of worn parts, corrective maintenance and maintaining documentation is the key area of
equipment maintenance.

For laboratory use, maintenance frequency should be designed to correspond to recommendations from manufacturers, risk of equipment, utilization, operating conditions, and previous failure. WHO (2015) [15] advocates for documented maintenance and calibration schedules, responsibilities clearly assigned and budget allocation for equipment maintenance. Good documentation serves as proof of the maintenance that has been done and enables laboratory quality assurance (WHO, 2014) [17].

In Uganda, the servicing and maintenance of the SLIPTA framework should be carried out on a regular basis in line with the manufacturer's recommendations, by appropriately qualified personnel, with records of servicing, investigation of malfunctions and equipment verification prior to return to service. Such requirements underscore the need for preventive maintenance for ensuring the quality of laboratory services and continuity of service. Mirembe *et al*. (2020) [11] demonstrated that the percentage of functional medical equipment in Uganda Blood Transfusion Service facilities increased after the skills enhancement and mentorship of equipment users and biomedical personnel. Likewise, Ssebunya (2024) [5] found that financial and logistical challenges, lack of training, failure to track equipment and challenges in sourcing spare parts were among the factors that hindered proper implementation of preventive maintenance and continued use of reactive maintenance.

In general, good preventive maintenance needs enough finance, good personnel, spare parts, qualified service providers, calibration, documentation and a regular review of the maintenance. These are the areas that can make equipment prone to breakdowns and downtimes, thereby disrupting laboratory diagnostic services (WHO, 2011; Mirembe *et al*., 2020; Ssebunya, 2024) [7, 11, 5].

User-Level Preventive Maintenance

The users of the laboratory equipment are the first line of defence against deterioration of equipment, as proper use, cleaning, shutdown, environmental control and early detection of faults can all help to prevent unnecessary deterioration and extend the useful life of the equipment. The Uganda Ministry of Health (2021) [22] considers first-line maintenance by equipment users as an important and cost-effective aspect of medical equipment management, which involves the equipment user's role in operating, handling, routine care, as well as identifying issues and defects before the need for the technical intervention.

Oshabaheebwa *et al*. (2020) [3] investigated 202 medical equipment in seven Blood Banks in the regional blood banks of Uganda Blood Transfusion Service. They intervened in the training and mentorship of users of the laboratory equipment as well as supporting biomedical engineers and technicians. The intervention group had an increase in equipment in good working order and in use from 60% to 74%, and was around three times more likely to be in good working order than the equipment in the comparison group.

User competency is also highlighted in the Africa CDC (2023) [21] guidance on the
management of laboratory equipment, where it is recommended that laboratory staff be trained in the operation, maintenance and troubleshooting of all laboratory equipment and those records be maintained of preventive maintenance and repairs. Breakdowns, service interruptions and repair costs can be minimized with effective equipment management.

Likewise, Kinnouezan *et al*. (2019) [19] showed that health-technology management in sub-Saharan Africa should be based on systems that are locally appropriate, which integrate technical capacity and technical equipment information and maintenance processes. They have indicated that there is a need to build the capacity of health facilities in the proper management of equipment during its operational life. In another low-resource context, Fritz *et al*. (2021) [20] reported that, when a computerized maintenance-management system (CMMS) was implemented in Burundi, the number of maintenance interventions doubled, and the time delay for corrective maintenance was halved (from 106 days to 26 days), along with the percentage of functional medical equipment. Training and local technical assistance were stressed as crucial factors for successful implementation.

Therefore, the role of the biomedical engineer in preventive maintenance must not be limited to just this. Laboratory staff should be provided with ongoing training to undertake appropriate first-line maintenance that involves routine cleaning, correct shut down, and basic inspection, recognizing abnormal equipment performance and reporting faults. Biomedical engineers and technicians are required to render specific maintenance, calibration, troubleshooting and repair work. This collaborative approach can enable early identification of issues, help prevent unnecessary damages to equipment and avoid downtime (Ministry of Health Uganda, 2021) [22]; (Oshabaheebwa *et al*., 2020) [3]; (Kinnouezan *et al*., 2019) [19]; (Africa CDC, 2023) [21].

Biomedical Engineering Capacity

Savvy biomedical-engineering staff are critical to the proper operation of complex lab equipment. They might be involved in installation, inspection, preventative maintenance, calibration, trouble-shooting, repair, safety testing, equipment documentation, and providing technical advice during procurement. The World Health Organization (WHO, 2011) [7] stresses the importance of having appropriate technical staff trained appropriately to undertake preventive and corrective maintenance, to ensure the safety and performance of medical equipment.

Oshabaheebwa *et al*. (2020) [3] determined that the challenges to health-technology-management in Uganda were many and included the wide variety of equipment requiring technical support with limited resources of skilled technical workers. Their work has proven that by strengthening the capacity of equipment users and biomedical engineers, capacity can be strengthened to enhance equipment functionality. Likewise, Ssebunya (2024) [5] pointed to the lack of training of biomedical engineers as an ongoing challenge in Uganda's public health facilities.

This importance of technical capacity is supported by evidence from other low
resource African circumstances. The absence of skilled staff and poorly developed health-technology-management

systems can affect the maintenance of medical devices in sub-Saharan Africa, as reported by Kinnouezan *et al* (2019) [19].

In resource-limited contexts, Fritz *et al*. (2021) [20] also showed that enhancing maintenance systems and local technical capacity can positively impact equipment management and minimize delays in corrective maintenance. Furthermore, Africa CDC (2023) [21] states that there is a need for continuous training of laboratory and biomedical-engineering staff in operating, maintaining, troubleshooting, documenting and quality managing the equipment.

The increased number of biomedical engineers may not be enough to address the objectives set by this research, according to these results. An effective equipment management also means ongoing professional development, special technical training, manufacturer information and service manuals, adequate diagnostics tools, spare parts, calibration facilities, certification, and competency assessment opportunities. Building these capacities can increase equipment reliability, decrease repair time delays, and minimise downtime of laboratory equipment (WHO, 2011; Oshabaheebwa *et al*., 2020; Kinnouezan *et al*., 2019; Fritz *et al*., 2021; Africa CDC, 2023; Ssebunya, 2024) [7, 3, 19, 20, 21, 5].

Maintenance Documentation and Equipment Tracking

In order to manage equipment effectively, we need to know where the equipment is, what it is doing, what it needs for maintenance, when it requires service and when it needs to be replaced. According to the World Health Organization (WHO, 2025) [8], inventory and maintenance-management information systems are vital aspects of health-technology management, contributing to digital inventories, maintenance planning, performance tracking, and data-based maintenance decisions.

Part of the sub-Saharan case studies confirms the benefit of digital

equipment-management systems. Medenou *et al*. (2019) [2] showed feasibility of using computer-based maintenance-management system to reduce equipment inventories and maintenance data, delivering information to management for better medical-device organization and maintenance in resource-limited environments. Likewise, Moges *et al*. (2021) showed how automated equipment-service communication and documentation systems could enhance equipment performance reporting, communication and measurement in Kenya, which would contribute to less equipment downtime and faster repairs. In Tanzania, Mtema *et al*. (2024) reported that the adoption of open-source software for equipment management in the national medical equipment information system has helped to maintain national inventory and equipment operational status, as well as plan equipment maintenance and make informed decisions on investments and decommissioning.

The Ministry of Health (2024) [35] also highlights the need to keep up-to-date inventories, maintenance planning based on evidence, documentation of maintenance activities and establishing a national medical-equipment inventory system for maintenance planning and budgeting in Uganda. However, Ssebunya (2024) [5] noted that failure to have effective centralized equipment tracking remains a current challenge. If the equipment data is not available, managers may not know what pieces of equipment are working, due for maintenance, failing repeatedly, or are appropriate for replacement. Thus, the use of digital equipment-management systems would enhance accountability, better schedule preventative maintenance, enable tracking of equipment downtime, and assist in evidence-based decisions of repairing, replacing or procuring equipment (WHO, 2025; Medenou *et al*., 2019; Moges *et al*., 2021; Mtema *et al*., 2024; Ssebunya, 2024) [8, 2, 5].

The Factors That Contribute to The Downtime of Medical Lab Equipment

Technical and Equipment Related Factors

The age of the equipment, frequency of use, environmental conditions, power supply, how the equipment is used, component deterioration, availability of spares and technological complexity all influence equipment downtime. Poor electricity reliability, environmental challenges, poor infrastructure, lack of technical skills and parts lead to poor equipment reliability in low-resource areas like Uganda (Piaggio *et al*., 2020; Abebe *et al*., 2024).

More complex or closed system equipment could require special technical skills, proprietary parts and manufacturer support and result in long downtime if services are not available locally. In Ghana, there is also evidence that maintenance arrangements, service contracts and post-installation training impact equipment functionality (Addo *et al*. 2023).

However, age of equipment is not the only factor that is the cause of downtime. Failure rates can be minimized and equipment life extended through effective preventive maintenance, trained users, timely maintenance, technical support and proper spare parts supply. Evidence for capacity building of equipment users and biomedical engineers has been observed in Uganda and has been seen to contribute to equipment functionality (Oshabaheebwa *et al*., 2020) [3]. So it should be understood that the aspects of equipment-related factors is a complex combination of factors whose working is influenced by maintenance practices, infrastructure, technical capacity, and resource availability (Piaggio *et al*., 2020; Oshabaheebwa *et al*., 2020; Addo *et al*., 2023; Abebe *et al*., 2024).

The absence of Preventive Maintenance

Minor problems like dust build-up, wear and tear, calibration drift, clogged filters, electrical issues among others can escalate to major failures and extended equipment downtimes without preventive maintenance (WHO, 2011) [7]. The study in Uganda by Ssebunya (2024) [5] revealed financial, logistical, and technical challenges affecting the execution of scheduled preventive maintenance, leading to a higher proportion of reactive repairs. In a similar way, Oshabaheebwa *et al*. (2020) [3] showed that enhancing equipment users and biomedical-engineering staff led to better equipment functioning. The same applies to Ethiopia and Ghana, where poor preventative maintenance, lack of technical capacity and lack of maintenance arrangements have been associated with non-functionality and downtime of equipment (Addo *et al*., 2023; Abebe *et al*., 2024). Therefore, alongside the maintenance schedule, there must be enough technical and financial resources, timely completion of maintenance and the documentation of maintenance.

Avoids Sharing Components and Parts

Equipment repair time and laboratory equipment uptime heavily depends on the availability of spare parts and consumables. Technically easy-to-solve equipment problems

that are not readily available in the region or in the country can lead to long downtimes and lost prodctivity. Oshabaheebwa *et al*. (2020) [3] noted that poor equipment support and medical technology management problems were also recognized as challenges in low resource settings. Likewise, Di Pietro *et al*. (2020) [32] reported on the lack of spare parts and high cost of the parts and consumables for healthcare facilities in Uganda and Benin, causing problems in keeping the equipment in proper working order. Ssekitoleko *et al*. (2020) [34] also emphasized the need to have proper equipment management, technical capacity, and sustainable maintenance systems to minimize equipment unavailability.

Thus, the initial equipment cost, in addition to availability, affordability, compatibility and sustainability of spare parts and consumables throughout the equipment life cycle should be taken into account during procurement. The Ministry of Health Uganda (2024) [35] suggests the use of equipment that has a reputable after sales and local supply of spare parts and consumables. Thus, life-cycle costing, supplier support agreements, sufficient inventories of key parts and local technical expertise can lead to fewer delays to repairs, less equipment downtime, longer equipment life and better continuity of laboratory diagnostic services.

Financial Constraints

One of the biggest challenges in preventive maintenance, repair, and calibration, procurement of spare parts, service contracts and equipment replacement is financial constraints. Ssebunya (2024) [5] reported that budget constraints greatly influenced medical equipment management in Ugandan public health facilities, leading to poor equipment preventive maintenance and reactive repairs. In the same way, Odoch *et al*. (2020) [37] showed that the financial resources for medical laboratory services were one of the most critical constraints in Uganda, and the Office of the Auditor General (2025) [38] indicated that significant funding gap exists in the medical equipment maintenance where the expenditures were well below the maintenance requirements.

The Ministry of Health Uganda (2024) [35] also acknowledges the importance of dedicated budgets for operation and maintenance of equipment over the equipment life cycle. Financial constraints can then lead to facilities focusing on immediate clinical demands over scheduled maintenance which can lead to reactive maintenance and an increase in extended downtime. Therefore, proper and secure maintenance budgets are critical to keeping equipment running efficiently and minimizing emergency repair expenses and maintaining diagnostic services continuity in the laboratory.

Power Supply and Infrastructure

Medical laboratory equipment requires reliable electricity and proper infrastructure for safe and continuous working. Some problems identified by Di Pietro *et al*. (2020) [32] that impact the medical equipment's functionality in Ugandan and Beninese health facilities are unreliable power supplies, high temperature, humidity, dust, and lack of infrastructure. The World Health Organization (WHO) (2023) [42] also pointed out that in low- and middle-income countries, dependable electricity is required to run medical devices and ensure the provision of diagnostic services. The Ministry of Health (2024) [35] concludes that appropriate power needs, voltage regulation, surge protection, uninterrupted power supplies, etc. are critical for successful management of high value equipment in Uganda.

Recent evidence also supports the use of an environmentally and infrastructure-sound approach to equipment selection in low-resource settings, taking into account power stability and availability, as well as maintenance resources (Reliable electricity to advance quality health care in low-resource settings, 2026). Thus the meaning of equipment downtime must be considered in the context of the facility environment. The electricity supply, backup electricity, voltage regulation, ventilation, temperature and humidity, water supply and workspace should be considered in preventive maintenance programmes. Taking these factors into account can minimize equipment breakdowns, preserve critical lab technologies, and ensure uninterrupted diagnostic service.

The Procurement of Equipment and The Selection of Equipment

Sub-optimal procurement decisions can lead to long term applications downtime and underutilization. Oshabaheebwa *et al*. (2020) [3] identified the major problems with the use of medical equipment in Uganda were linked to poor procurement decisions, especially no attention was given to indirect expenses like spare parts, consumables, technical skills and even user training. In the same way, Masembe (2016) [44] revealed that funding and strategic planning were significant factors influencing the effectiveness of procurement in regional referral hospitals in Uganda, indicating that the impact of procurement is not only about purchasing but extends beyond.

Experience in the developing world also indicates that procurement can break down if the equipment is not suited to the facility's infrastructure, maintenance capabilities, environmental conditions, or human resources. When choosing medical devices, Gorski *et al*. (2017) [43] pointed out to take into account the life cycle costs, installation, maintenance, spare parts, training, and suitability for operating conditions.

The Ministry of Health (Uganda) has therefore taken a life-cycle approach for the needs assessment, the appropriate specification, infrastructure readiness, maintenance budgets, after-sales support, user training, spares availability, and long-term maintenance planning of the project. Therefore, the selection of equipment must not be confined to one aspect, i.e., the price of the product but must also take into consideration the product's fitness for purpose, total life cycle cost, infrastructure compatibility, technical support, maintenance capability, availability of spares, and user competence. This is a change from procurement management towards life cycle equipment management and can help to eliminate unnecessary purchases and equipment downtime.

Manufacturer and External Service-Provider Dependence

Installing, maintaining, repairing and calibrating specialized laboratory equipment may require manufacturer authorized technicians, or external providers. The ECSA-HC/SATBHSS, Di Pietro *et al*. (2020) [32] and AFENET (2010) studies suggest that poor local technical capabilities, lack of calibration services and high service fees and reliance on external service providers can cause equipment downtime. The Ministry of Health Uganda (2024) [35] thus recommends building technical capacity within the country, and suppliers to provide technical support and training. However, to

minimize downtime and maximize equipment uptime in the field, procurement contracts should include after-sales service, timely servicing, and availability of spare parts, calibration and training local technicians.

Discussion

The literature reviewed shows that medical lab equipment down time is a multi-faceted problem that relates with preventive maintenance practices, user competence, biomedical-engineering capacity, documentation system, financial resources, physical infrastructure, procurement decisions, availability of spare parts and dependence on external service providers. The evidence indicates that equipment downtime is not a result of equipment failure, but is a product of the interaction of technical, organisational, financial, infrastructural and human resource factors.

Avoid or Reduce Equipment Downtime and Preventative Maintenance Practices

The continuity of services, reliability, safety and functionality of laboratory equipment is essential for preventive maintenance. Planned inspection, cleaning, calibration, performance verification, replacement of worn parts, documentation and timely corrective maintenance are all recommended by WHO (2011, 2015). The literature, however, suggests that the mere presence of a schedule does not mean that it is actually adhered to. In Uganda, Ssebunya (2024) [5] found that financial, logistical, and technical limitations hindered the implementation of scheduled preventive maintenance and boosted the use of reactive maintenance.

The result is in line with the findings of Oshabaheebwa *et al*. (2020) [3] which showed that bolstering of equipment users and biomedical personnel led to increased equipment functionality in Oshabaheebwa, Uganda Blood Transfusion Service facilities. These results indicate that the more adequate resources, competent workforce, spare parts, calibration services, monitoring systems, and other factors the preventive maintenance program has, the better it will work. Without scheduled maintenance, however, minor issues like dust buildup or component wear, calibration drift and electrical faults can grow into major issues and extended downtime.

User Level Maintenance and Competency

As shown from the literature, the users of laboratory equipment are a key group of people in the prevention of unnecessary equipment damage. These are first line maintenance tasks which are important to carry out as a routine, operate and shut down correctly, environment, identify abnormal performance early and report faults in a timely manner. Oshabaheebwa *et al* (2020) [3] had robust evidence in Uganda that training and mentorship of the equipment users, plus the biomedical-engineering support, significantly enhanced the functionality of the equipment.

Based on these results, it is clear that maintenance of equipment should not be solely the biomedical-engineering responsibility. If the users are not knowledgeable, the inappropriate operation and delayed reporting can speed up equipment deterioration. Training of laboratory staff in the operation, maintenance, troubleshooting and documentation of equipment is also a key competency recommended by Africa CDC (2023) [21]. So it is important that on-going training based on competency needs should be part of equipment management.

Biomedical Engineering Capacity

To ensure advanced laboratory technologies, there needs to be sufficient biomedical-engineering capacity. Biomedical engineers and technicians provide special services are involved in procurement such as installation, preventive maintenance, calibration, troubleshooting, repair, safety testing, and technical advice. The literature reviewed reveals that in low-resource countries, limited availability of skilled personnel, lack of specialized training, lack of equipment maintenance tools and lack of access to manufacturer information can adversely affect equipment maintenance (Kinnouezan *et al*., 2019; Oshabaheebwa *et al*., 2020; Ssebunya, 2024) [19, 3, 5].

The evidence from Fritz *et al*. (2021) [20] also shows that increases in maintenance system strength and technical capacity in the local community can lead to decreases in corrective-maintenance delays. This highlight a need to increase numbers of technical staff alone may not be enough. However, biomedical-engineering capacity needs to consist of special training, continuing professional development, calibration facilities, diagnostic equipment, service manuals, spare parts, and opportunities for competency assessment. Having good technical expertise in the local community can minimize reliance on outside service providers and increase equipment uptime.

Information on Documentation, Equipment Tracking and Maintenance

When it involves effective preventive maintenance, accurate equipment inventories and maintenance records can make all the difference. WHO (2025) [8] highlights the importance of equipment-management information systems for inventory, maintenance scheduling, equipment performance monitoring and inform decision making based on evidence. The findings of the studies conducted by Medenou *et al*. (2019) [2], Moges *et al*. (2021), and Mtema *et al*. (2024) show that computerized equipment management systems can enhance the communication for maintenance, tracking of equipment, reporting of services, and planning.

However, in Uganda, Ssebunya (2024) [5] revealed that there were weaknesses associated with centralized equipment tracking. When managers don't have the right information about the equipment and where they are, what they do, how often they've been serviced, and how often they've failed, they may not know when the equipment is due for maintenance or if it keeps failing. As a result, digital equipment-management systems can help enhance accountability, maintenance planning, downtime tracking, budgeting, and equipment repair/replacement decisions.

Supply Spare Parts and Consumables

Availability of spare parts and equipment consumables became a significant factor in repair time and equipment uptime. Bakari *et al*. (2017) noted that Uganda and Benin had shortages of spare parts and consumables, and high prices, Di Pietro *et al*. (2020) [32] reported the same, and Oshabaheebwa *et al*. (2020) [3] reported that equipment support and medical technology management were weak. Despite having the proper skills, repairs can be incomplete because the necessary parts are not available

locally.

The result in this study is important because it shows the need to take the equipment life cycle into account when purchasing. The initial cost of equipment should not be the only factor used to determine the equipment selection. Before acquisition, be sure that there are sufficient and readily available spare parts, consumables, technical support, and maintenance services that are compatible. Having a good supply of essential spares and good supplier arrangements may significantly minimize avoidable downtime of equipment.

Financial Constraints

There are a number of relationships between finances and equipment management.

Preventive maintenance must be funded for servicing, calibration and spares, technical staff, service contracts, equipment upgrade/replacement, etc. Financial constraints were identified as an issue that affected the maintenance of public facilities in Uganda by Ssebunya (2024) [5] and financial constraints in the laboratory sector in Uganda by Odoch *et al*. (2020) [37]. The Office of the Auditor General (2025) [38] also noted that there was a significant discrepancy between the medical equipment maintenance requirements and the medical equipment spending.

Not enough maintenance funding can lead to managers focusing more at present on clinical needs rather than maintenance. This fosters a reactive maintenance approach that focuses primarily on reactive maintenance. While break-in repairs may seem cheaper in the short term, it is possible to incur more costs in the long run due to repeated failures, emergency servicing, outsourcing, specimen referral and premature equipment replacement. Therefore, there is a need for dedicated and protected maintenance budgets to maintain equipment sustainably.

Power Supply and Infrastructure

The reviewed evidence shows that equipment functions are highly dependent on the operating conditions. Di Pietro *et al*. (2020) [32] found that unreliable electricity, high temperatures, humidity, dust and lack of infrastructure pose a challenge to the functionality of medical equipment in Uganda and Benin. Similarly, WHO (2023) [42] acknowledges reliable electricity as essential for the working of health-care equipment. Security of refrigerator/freezer units, incubators, molecular platforms, analyzers and information systems are important parameters for power interruptions, voltage variations, temperature and humidity for laboratory equipment. Thus, equipment downtime can be related to a lack of infrastructure, not just equipment. Therefore, the assessment of electricity supply, backup power, voltage regulator, ventilation, temperature, humidity, water supply and workspace conditions should be included in the preventive maintenance programme.

The Procurement Process and Selection of Equipment

Inappropriate procurement decisions can lead to maintenance issues throughout the equipment life cycle as has been indicated in the literature. Oshabaheebwa *et al*. (2020) [3] demonstrated the existence of procurement and equipment-support problems that affect utilization and Masembe (2016) [44] revealed that strategic planning and funding is very important in the effectiveness of procurement. Also, in procurement in low-resource areas, Gorski *et al*. (2017) [43] noted the importance of taking into account life-cycle costs, maintenance, infrastructure, and training and spare parts availability.

To address these challenges, the Uganda Ministry of Health (2024) has adopted a life-cycle strategy in managing medical equipment. This is a major leap from the purchase or acquisition of equipment mainly based on the price of the equipment, to the selection of equipment which is fit, size, and infrastructure compatible, easy to maintain and have technical support, user capacity, spares availability, and a total life cycle cost. This can minimize the number of unnecessary purchases as well as equipment downtimes.

The Impact on Manufacturer and External Service-Dependency

Depending on manufacturers and external service providers can lengthen downtime, when a specific technical knowledge or proprietary spare parts is not available in the country. Local technical skills, no calibration services, services costs and dependence on external services can be all factors considered that make equipment restoration slower as suggested by ECSA-HC/SATBHSS (2018), Di Pietro *et al*. (2020) [32] and AFENET (2010).

This is more difficult when more sophisticated laboratory techniques are employed which use manufacturer dependent diagnostics, software, calibration procedures, and/or proprietary components. Therefore, the Ministry of Health Uganda (MoH Uganda) urges the development of local technical capacity and procurement of equipment that includes technical support and training. The after-sales support, response time, availability of spare parts, calibration, preventive maintenance and training of local technicians must be well specified in the procurement contracts.

Conclusion

The qualitative review reveals that effective preventive maintenance is crucial in ensuring efficient service continuity and lowering downtime of medical laboratory equipment in Uganda. There are however interrelated technical, financial, infrastructural, organizational and human resource issues that impact on maintenance.

Some of the main challenges are lack of scheduled maintenance, low level of user skills, lack of biomedical-engineering capacity, lack of documentation of equipment, lack of spare parts, lack of financial resources, unreliable infrastructure, inappropriate procurement, reliance on external service providers etc.

The problems with equipment downtime are more than just the equipment failing—they are an indicator of the overall problems with health-technology management. This means that moving from reactive repairs to proactive life cycle equipment management, with improved equipment maintenance systems, maintenance staffs, financing, infrastructure, equipment tracking software, local equipment technical capability, and equipment procurement is a priority for Uganda. Implementing these measures can enhance equipment availability, diagnostic continuity, efficiency, and laboratory service quality.

Recommendations

- Improve preventive maintenance systems by establishing equipment specific schedules, conducting routine checks, keeping records and scheduling

maintenance promptly.

- Offer ongoing training for users on how to operate the equipment, clean, safety, basic troubleshooting, and reporting of any faults in a timely manner.
- Increase biomedical-engineering capacity by recruiting and training adequately qualified staff and setting up regional centres of technical support.
- Update equipment documentation and digital tracking with new equipment inventories and digital systems to track maintenance, calibration, downtime and repair history.
- Provide regular and secured finance to service, calibrate, maintain spare parts, consumables, service contracts and equipment replacement.
- Ensure the availability of spare parts and consumables, better procurement, sufficient stocks, and availability and delivery terms agreed with suppliers.
- Ensure the reliability of power and infrastructure by ensuring that the electricity is reliable, the voltage is within control, there is power backup, environmental control is in place, water supply is available, and appropriate laboratory facilities are available.
- Implement life-cycle procurement and take into account the total ownership costs, maintenance, infrastructure, training, warranties, spare parts and after-sales support.
- Increase local technical capacity to decrease external dependency, by insisting on training local technical staff and providing technical support, technical documentation and spare parts to the suppliers.
- Improve monitoring and accountability by leveraging indicators such as equipment performance, downtimes, maintenance completion, frequency of equipment failures, repair time, and compliance with calibration requirements.
- Support integrated equipment life cycle management, from needs assessment, procurement, installation, operation, maintenance, calibration, monitoring, replacement, to disposal.

Areas for Further Research

Quantify equipment downtime and its determinants – Future studies should measure the frequency, duration, and causes of laboratory equipment downtime and assess the influence of maintenance, power supply, financing, spare parts, user competency, and technical support.

Evaluate digital equipment-management systems – Research should determine whether digital inventory and maintenance systems improve maintenance compliance, reduce repair delays and downtime, and enhance laboratory service continuity.

Assess the cost-effectiveness of preventive maintenance – Studies should compare the costs and benefits of preventive versus reactive maintenance, including repair costs, service interruptions, specimen referrals, and premature equipment replacement.

Declaration

The authors declare no conflict of interest

References

1. Ministry of Health, Republic of Uganda. National medical equipment guidelines. Kampala: Government of Uganda; 2024.
2. Medenou D, Fagbemi LA, Houessouvo RC, Jossou TR, Ahouandjinou MH, Kinnouezan CDA, *et al*. Medical devices in sub-Saharan Africa: optimal assistance via a computerized maintenance management system (CMMS) in Benin. Health Technol. 2019;9:219-232. doi:10.1007/s12553-018-00283-3.
3. Oshabaheebwa S, Namuli LK, Tusabe MS, Nantume J, Ackers LH, Ssekitoleko RT. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings. Health Policy Technol. 2020;9(1):94-101. doi:10.1016/j.hlpt.2020.01.001.
4. Snyder H. Literature review as a research methodology: an overview and guidelines. J Bus Res. 2019;104:333-339. doi:10.1016/j.jbusres.2019.07.039.
5. Ssebunya A. Medical equipment management practices in public health facilities in Uganda [master's dissertation]. Kampala: Makerere University; 2024.
6. World Health Organization. Introduction to medical equipment inventory management. Geneva: World Health Organization; 2011.
7. World Health Organization. Medical equipment maintenance programme overview. Geneva: World Health Organization; 2011.
8. World Health Organization. Inventory and maintenance management information systems for medical devices. Geneva: World Health Organization; 2025.
9. Burundi's experience with a decentralised maintenance model [reference details incomplete]. 2023.
10. Fonjungo PN, Kebede Y, Messele T, Ayana G, Tibesso G, Abebe A, *et al*. Laboratory equipment maintenance: a critical bottleneck for strengthening health systems in sub-Saharan Africa? J Public Health Policy. 2012;33(1):34-45. doi:10.1057/jphp.2011.57.
11. Mirembe BB, *et al*. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings [reference details incomplete]. 2020.
12. Ssebunya A. Medical equipment management practices in public health facilities in Uganda [master's dissertation]. Kampala: Makerere University; 2024.
13. World Health Organization. Medical equipment maintenance programme overview. Geneva: World Health Organization; 2011.
14. World Health Organization. Computerized maintenance management system. Geneva: World Health Organization; 2012.
15. World Health Organization. Laboratory Quality Stepwise Implementation tool: equipment maintenance. Geneva: World Health Organization; 2015.
16. World Health Organization Regional Office for Africa. SLIPTA checklist for laboratory accreditation. Brazzaville: WHO Regional Office for Africa; 2015.
17. World Health Organization. Laboratory quality management system training toolkit. Geneva: World Health Organization; 2014.
18. Oshabaheebwa S, Namuli LK, Tusabe MS, Nantume J, Ackers LH, Ssekitoleko RT. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings. Health Policy Technol. 2020;9(1):94-101. doi:10.1016/j.hlpt.2020.01.001.
19. Kinnouezan MK, Monteiro GA, Idrissou MAY, Iadanza E, Pecchia L, *et al*. Medical devices in sub-Saharan Africa: optimal assistance via a computerized maintenance management system in Benin. Health Technol. 2019;9:219-232.

20. Fritz A, *et al*. Evaluating a computerized maintenance management system in a low resource setting. BMC Health Serv Res. 2021.
21. Africa Centres for Disease Control and Prevention. Laboratory equipment management: a guidance to African Union member states. Addis Ababa: Africa CDC; 2023.
22. Ministry of Health, Uganda. Medical equipment user training manual for national and regional user trainer. Kampala: Ministry of Health; 2021.
23. Kinnouezan MK, Monteiro GA, Idrissou MAY, Iadanza E, Pecchia L, *et al*. Medical devices in sub-Saharan Africa: optimal assistance via computerized maintenance management systems. Health Technol. 2019;9:219-232.
24. Fritz A, *et al*. Evaluating a computerized maintenance management system in a low-resource setting. BMC Health Serv Res. 2021.
25. Africa Centres for Disease Control and Prevention. Laboratory equipment management: a guidance to African Union member states. Addis Ababa: Africa CDC; 2023.
26. World Health Organization. Medical equipment maintenance programme overview. Geneva: World Health Organization; 2011.
27. Abebe T, *et al*. The availability and functionality of medical equipment and barriers to their use at comprehensive specialized hospitals in the Amhara region, Ethiopia. Front Health Serv. 2024.
28. Addo E, *et al*. Equipment downtime in the radiology departments of three teaching hospitals in Ghana. Radiography. 2023;29:833-837.
29. Oshabaheebwa S, Namuli LK, Tusabe MS, Nantume J, Ackers LH, Ssekitoleko RT. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings. Health Policy Technol. 2020;9(1):94-101. doi:10.1016/j.hlpt.2020.01.001.
30. Ssebunya A. Medical equipment management practices in public health facilities in Uganda [master's dissertation]. Kampala: Makerere University; 2024.
31. World Health Organization. Medical equipment maintenance programme overview. Geneva: World Health Organization; 2011.
32. Di Pietro L, Piaggio D, Oronti I, Maccaro A, Houessouvo RC, Medenou D, *et al*. A framework for assessing healthcare facilities in low-resource settings: field studies in Benin and Uganda. J Med Biol Eng. 2020;40:526-534. doi:10.1007/s40846-020-00546-3.
33. Oshabaheebwa S, Namuli LK, Tusabe MS, Nantume J, Ackers LH, Ssekitoleko RT. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings. Health Policy Technol. 2020;9(1):94-101. doi:10.1016/j.hlpt.2020.01.001.
34. Ssekitoleko RT, Oshabaheebwa S, Munabi IG, Tusabe MS, *et al*. The role of medical equipment in the spread of nosocomial infections: a cross-sectional study in four tertiary public health facilities in Uganda. BMC Public Health. 2020;20:1561. doi:10.1186/s12889-020-09662-w.
35. Ministry of Health, Uganda. National medical equipment guidelines. Kampala: Ministry of Health; 2024.
36. Ministry of Health, Uganda. National medical equipment management guidelines. Kampala: Ministry of Health; 2024.
37. Odoch WD, *et al*. Uganda's laboratory human resource in the era of global health initiatives: experiences, constraints and opportunities—an assessment of 100 facilities. Hum Resour Health. 2020;18:38. doi:10.1186/s12960-020-0454-5.
38. Office of the Auditor General, Uganda. Report of the Auditor General on the financial statements and management of medical equipment maintenance. Kampala: Office of the Auditor General; 2025.
39. Ssebunya A. Medical equipment management practices in public health facilities in Uganda [master's dissertation]. Kampala: Makerere University; 2024.
40. Di Pietro L, Piaggio D, Oronti I, Maccaro A, Houessouvo RC, Medenou D, *et al*. A framework for assessing healthcare facilities in low-resource settings: field studies in Benin and Uganda. J Med Biol Eng. 2020;40:526-534. doi:10.1007/s40846-020-00546-3.
41. Ministry of Health, Uganda. National medical equipment management guidelines. Kampala: Ministry of Health; 2024.
42. World Health Organization. Electricity in health-care facilities. Geneva: World Health Organization; 2023 Aug 31.
43. Gorski I, Hadjiiski L, Curtis D. Methods for medical device and equipment procurement and prioritization within low- and middle-income countries: findings of a systematic literature review. BMC Med Inform Decis Mak. 2017;17:81. doi:10.1186/s12911-017-0488-2.
44. Masembe IK. A study on strategic planning and procurement of medicals in Uganda's regional referral hospitals. J Public Health Afr. 2016;7(2):558. doi:10.4081/jphia.2016.558.
45. Ministry of Health, Uganda. National medical equipment guidelines. Kampala: Ministry of Health; 2024.
46. Oshabaheebwa S, Namuli LK, Tusabe MS, Nantume J, Ackers LH, Ssekitoleko RT. Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings. Health Policy Technol. 2020;9(1):94-101. doi:10.1016/j.hlpt.2020.01.001.
47. Ministry of Health, Uganda. National medical equipment guidelines. Kampala: Ministry of Health; 2024.
48. World Health Organization. Medical equipment maintenance programme overview. Geneva: World Health Organization; 2011.
49. World Health Organization. Inventory and maintenance management information system for medical devices. Geneva: World Health Organization; 2025.

How to Cite This Article

Mbabazi G, Mugabi SA, Mayambala P, Laghu R, Salamu G, Nuwamanya J, et al. Preventive maintenance practices and factors associated with medical laboratory equipment downtime in Uganda: a narrative review. Int J Multidiscip Res Growth Eval. 2026;7(5):477-485. doi:10.54660/IJMRGE.2026.7.5.477-485.

Creative Commons (CC) License

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.