

# Optimizing Medical Equipment Lifecycle Management: A Qualitative Study of Biomedical and Radiological Technicians' Roles in Long-Term Care and Medical Supply Settings

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## ABSTRACT

Medical equipment lifecycle management is a critical aspect of healthcare delivery, particularly in long-term care and medical supply settings. Biomedical and radiological technicians play vital roles in ensuring the optimal functioning, maintenance, and disposal of medical devices. This qualitative study explores the experiences and perspectives of these technicians to identify best practices, challenges, and opportunities for improvement in medical equipment lifecycle management. Semi-structured interviews were conducted with a purposive sample of seven technicians from long-term care and medical supply settings. Thematic analysis revealed four main themes: (1) proactive maintenance and calibration, (2) effective communication and collaboration, (3) challenges in managing aging equipment, and (4) opportunities for training and professional development. The findings highlight the importance of preventive maintenance, interprofessional teamwork, strategic planning for equipment replacement, and ongoing education for technicians. Implementing these strategies can optimize medical equipment lifecycle management, leading to improved patient care, cost savings, and environmental sustainability. Further research is needed to develop and evaluate targeted interventions to support technicians in their critical roles.

**Keywords:** medical equipment, lifecycle management, biomedical technicians, radiological technicians, long-term care, medical supply

## INTRODUCTION

Medical equipment is a vital component of healthcare delivery, playing a crucial role in diagnosing, treating, and monitoring patients. As technology advances and the population ages, the demand for medical equipment continues to grow, particularly in long-term care and medical supply settings (Smith et al., 2020). However, managing the lifecycle of medical equipment poses significant challenges, including high costs, rapid technological obsolescence, and complex maintenance requirements (Jones et al., 2021). Optimizing medical equipment lifecycle management is essential for ensuring patient safety, maximizing equipment performance, and minimizing costs (Kumar et al., 2019).

Biomedical and radiological technicians are at the forefront of medical equipment lifecycle management. These professionals are responsible for installing, maintaining, repairing, and decommissioning medical devices (Nguyen et al., 2020). They work closely with healthcare providers, administrators, and other stakeholders to ensure that medical equipment is safe, reliable, and compliant with regulatory standards (Patel et al., 2022). Despite their critical role, there is limited research on the experiences and perspectives of biomedical and radiological technicians in long-term care and medical supply settings.

This qualitative study aims to explore the roles, challenges, and best practices of biomedical and radiological technicians in optimizing medical equipment lifecycle management. By gaining insights from these frontline professionals, we can identify strategies to improve equipment performance, reduce costs, and enhance patient care. The findings of this study will inform the development of targeted interventions and policies to support technicians in their vital work.

## LITERATURE REVIEW

Medical equipment lifecycle management is a complex process that involves multiple stages, from planning and acquisition to use, maintenance, and disposal (Kumar et al., 2019). Effective lifecycle management is essential for ensuring the safety, reliability, and cost-effectiveness of medical devices (Smith et al., 2020). However, healthcare organizations face numerous challenges in managing medical equipment, including rapid technological change, increasing costs, and limited resources (Jones et al., 2021).

Biomedical and radiological technicians play a critical role in medical equipment lifecycle management. These professionals are responsible for a wide range of tasks, including equipment installation, calibration, preventive maintenance, repairs, and decommissioning (Nguyen et al., 2020). They also provide training and support to healthcare providers, ensure compliance with regulatory standards, and contribute to strategic planning for equipment acquisition and replacement (Patel et al., 2022).

Previous research has highlighted the importance of proactive maintenance and calibration in optimizing medical equipment performance and safety. A study by Chen et al. (2021) found that implementing a comprehensive preventive maintenance program reduced equipment downtime by 30% and improved patient satisfaction. Similarly, Pham et al. (2020) demonstrated that regular calibration of diagnostic imaging equipment enhanced image quality and reduced radiation exposure to patients and staff.

Effective communication and collaboration among healthcare professionals are also crucial for successful medical equipment lifecycle management. Sakhivel et al. (2021) emphasized the importance of interprofessional teamwork in ensuring the timely identification and resolution of equipment issues. Their study found that regular meetings between biomedical technicians, clinicians, and administrators improved equipment reliability and reduced repair costs.

Despite the critical role of biomedical and radiological technicians, they often face challenges in managing aging equipment and keeping pace with technological advancements. A survey by Nguyen et al. (2020) revealed that technicians frequently struggled with obsolete equipment, limited spare parts, and inadequate training opportunities. Smith et al. (2020) also highlighted the need for strategic planning and budgeting to ensure the timely replacement of outdated equipment.

To address these challenges, several studies have emphasized the importance of ongoing training and professional development for biomedical and radiological technicians. Patel et al. (2022) found that providing technicians with regular training on new technologies and best practices improved their job satisfaction and retention rates. Similarly, Jones et al. (2021) recommended establishing mentorship programs and continuing education opportunities to support technicians' career growth and expertise.

While the existing literature provides valuable insights into medical equipment lifecycle management, there is a paucity of research focusing specifically on the experiences and perspectives of biomedical and radiological technicians in long-term care and medical supply settings. This qualitative study aims to address this gap by exploring the unique challenges and best practices of these professionals in optimizing medical equipment lifecycle management.

## METHODS

### Study Design

This study employed a qualitative descriptive design to explore the experiences and perspectives of biomedical and radiological technicians in long-term care and medical supply settings. Qualitative research is well-suited for investigating complex phenomena and generating rich, contextual data (Colorafi & Evans, 2016). The descriptive approach focuses on describing the experiences of participants in their own words, without imposing preconceived theories or hypotheses (Sandelowski, 2000).

### Participants and Sampling

A purposive sampling strategy was used to recruit biomedical and radiological technicians with experience in long-term care and medical supply settings. Purposive sampling involves selecting participants who can provide rich, relevant information about the topic of interest (Palinkas et al., 2015). The inclusion criteria were: (1) currently employed as a biomedical or radiological technician, (2) at least two years of experience in long-term care or medical supply settings, and (3) willing to participate in an in-depth interview.

Seven participants were recruited for this study, including three biomedical technicians, three radiological technicians, and one health information technology professional. The sample size was determined based on data saturation, which occurs when no new themes or insights emerge from additional interviews (Guest et al., 2006). Table 1 presents the demographic characteristics of the participants.

**Table 1:** Demographic Characteristics of Participants (N = 7)

Characteristic	n (%)
Gender	
Male	7 (100%)

Female	0 (0%)
Age (years)	
20-29	1 (14%)
30-39	4 (57%)
40-49	2 (29%)
Profession	
Biomedical Technician	3 (43%)
Radiological Technician	3 (43%)
Health Information Technology	1 (14%)
Years of Experience	
2-5	2 (29%)
6-10	3 (43%)
> 10	2 (29%)

### Data Collection

Semi-structured interviews were conducted with each participant, either in-person or via video conferencing, depending on their preference and availability. Semi-structured interviews allow for flexibility in exploring participants' experiences while ensuring that key topics are covered (DeJonckheere & Vaughn, 2019). The interviews were guided by an interview protocol that was developed based on the research questions and literature review (Table 2). The interviews lasted between 45 and 60 minutes and were audio-recorded with the participants' consent.

**Table 2:** Interview Protocol

Topic	Questions
Equipment maintenance and calibration	- How do you approach preventive maintenance and calibration of medical equipment?   - What are the main challenges you face in maintaining and calibrating equipment?   - Can you share an example of a successful maintenance or calibration strategy?
Communication and collaboration	- How do you collaborate with other healthcare professionals in managing medical equipment?   - What are the main communication challenges you encounter?   - Can you describe a situation where effective communication led to a positive outcome?
Challenges with aging equipment	- What are the main challenges you face in managing aging medical equipment?   - How do you prioritize equipment replacement and upgrades?   - Can you share an example of a creative solution for dealing with outdated equipment?
Training and professional development	- What training or professional development opportunities have been most valuable for you?   - How do you stay current with technological advancements in medical equipment?   - What additional training or support would help you optimize medical equipment lifecycle management?

### Data Analysis

The audio recordings of the interviews were transcribed verbatim and analyzed using thematic analysis, a method for identifying, analyzing, and reporting patterns or themes within qualitative data (Braun & Clarke, 2006). The six-phase approach to thematic analysis was followed:

1. Familiarization with the data: The transcripts were read and re-read to gain a deep understanding of the content.
2. Generating initial codes: Interesting features of the data were coded systematically across the entire dataset.
3. Searching for themes: Codes were collated into potential themes, gathering all relevant data for each theme.
4. Reviewing themes: Themes were checked against the coded extracts and the entire dataset to ensure coherence and distinctiveness.
5. Defining and naming themes: The essence of each theme was refined and clear names were assigned.
6. Producing the report: Vivid examples were selected to illustrate the themes and relate back to the research questions.

To ensure the trustworthiness of the findings, several strategies were employed, including member checking, peer debriefing, and maintaining an audit trail (Lincoln & Guba, 1985). Member checking involved sending a summary of the themes to the participants for feedback and validation. Peer debriefing was conducted with a

colleague who reviewed the coding and theme development process. An audit trail was maintained to document the research process and decision-making.

## RESULTS

The thematic analysis revealed four main themes related to optimizing medical equipment lifecycle management in long-term care and medical supply settings: (1) proactive maintenance and calibration, (2) effective communication and collaboration, (3) challenges in managing aging equipment, and (4) opportunities for training and professional development. Each theme is described below, with illustrative quotes from the participants.

### Theme 1: Proactive Maintenance and Calibration

The participants emphasized the importance of proactive maintenance and calibration in ensuring the optimal functioning and safety of medical equipment. They described various strategies for implementing preventive maintenance programs, such as following manufacturer recommendations, using checklists, and scheduling regular inspections. However, they also acknowledged the challenges of balancing proactive maintenance with competing priorities and limited resources.

"I try to stay on top of the preventive maintenance schedule, but sometimes it's hard when there are urgent repairs or other issues that come up. It's a constant juggling act." (Participant 2, Biomedical Technician)

"Calibrating the equipment regularly is critical for accuracy and patient safety. I use a checklist to make sure I don't miss any steps, and I document everything in the maintenance log." (Participant 6, X-ray Technician)

### Theme 2: Effective Communication and Collaboration

The participants highlighted the importance of effective communication and collaboration among healthcare professionals in managing medical equipment. They described the benefits of regular meetings, clear documentation, and open lines of communication in preventing equipment issues and resolving problems quickly. However, they also encountered challenges in coordinating with busy clinicians and administrators who may have competing priorities.

"I find that having regular check-ins with the clinical staff helps me stay on top of any equipment issues they're experiencing. It's all about building those relationships and keeping the lines of communication open." (Participant 1, Biomedical Technician)

"Sometimes it can be frustrating when I'm trying to convey the importance of a repair or upgrade, and the decision-makers are focused on other priorities. I've learned to frame it in terms of patient care and cost savings, which helps get their attention." (Participant 7, Health Information Technology)

### Theme 3: Challenges in Managing Aging Equipment

The participants described the challenges of managing aging medical equipment, including obsolescence, limited spare parts, and increased maintenance requirements. They emphasized the importance of strategic planning and budgeting for equipment replacement and upgrades, but also acknowledged the financial constraints faced by many healthcare organizations. The participants shared creative strategies for extending the life of older equipment, such as sourcing parts from decommissioned devices and collaborating with other facilities.

"It's a constant battle to keep up with the latest technology while also making sure the older equipment is still safe and functional. We have to be strategic about prioritizing replacements and upgrades based on clinical needs and available resources." (Participant 4, X-ray Technician)

"One time, we had an older patient monitor that needed a specific part that was no longer available from the manufacturer. I reached out to some colleagues at other hospitals and was able to find a decommissioned monitor with the part we needed. It was a creative solution that saved us from having to purchase a whole new device." (Participant 5, Biomedical Technician)

### Theme 4: Opportunities for Training and Professional Development

The participants emphasized the value of ongoing training and professional development in staying current with technological advancements and best practices in medical equipment management. They described the benefits of attending conferences, participating in online courses, and seeking mentorship from experienced colleagues. However, they also identified barriers to accessing training opportunities, such as limited budgets and time constraints.

"I try to attend at least one professional conference each year to learn about new technologies and network with other technicians. It's always valuable to hear about the challenges and solutions others are facing." (Participant 3, X-ray Technician)

"I would love to have more opportunities for hands-on training with the latest equipment, but it can be hard to find the time and resources. I think having a mentorship program or online training modules would be really helpful." (Participant 2, Biomedical Technician)

Table 3 summarizes the main themes and subthemes identified in the analysis.

**Table 3: Summary of Themes and Subthemes**

Main Theme	Subthemes
1. Proactive Maintenance and Calibration	- Preventive maintenance strategies   - Calibration procedures   - Challenges in balancing priorities
2. Effective Communication and Collaboration	- Benefits of regular meetings and clear documentation   - Importance of building relationships   - Challenges in coordinating with busy clinicians and administrators
3. Challenges in Managing Aging Equipment	- Obsolescence and limited spare parts   - Strategic planning for replacements and upgrades   - Creative solutions for extending equipment life
4. Opportunities for Training and Professional Development	- Value of conferences, courses, and mentorship   - Benefits of staying current with technological advancements   - Barriers to accessing training opportunities

## DISCUSSION

This qualitative study explored the experiences and perspectives of biomedical and radiological technicians in optimizing medical equipment lifecycle management in long-term care and medical supply settings. The findings highlight the critical role of these professionals in ensuring the safety, reliability, and cost-effectiveness of medical devices. The four main themes identified - proactive maintenance and calibration, effective communication and collaboration, challenges in managing aging equipment, and opportunities for training and professional development - provide valuable insights into the strategies, challenges, and opportunities for improving medical equipment lifecycle management.

The importance of proactive maintenance and calibration in optimizing medical equipment performance and safety is consistent with previous research (Chen et al., 2021; Pham et al., 2020). The participants in this study described various strategies for implementing preventive maintenance programs, such as following manufacturer recommendations and using checklists. However, they also acknowledged the challenges of balancing proactive maintenance with competing priorities and limited resources. These findings suggest that healthcare organizations need to prioritize preventive maintenance and provide adequate resources and support to enable technicians to carry out these critical tasks.

Effective communication and collaboration among healthcare professionals were also identified as crucial factors in successful medical equipment lifecycle management, echoing the findings of Sakthivel et al. (2021). The participants in this study described the benefits of regular meetings, clear documentation, and open lines of communication in preventing equipment issues and resolving problems quickly. However, they also encountered challenges in coordinating with busy clinicians and administrators who may have competing priorities. These findings underscore the importance of fostering a culture of interprofessional collaboration and providing dedicated time and resources for communication and coordination.

The challenges of managing aging medical equipment, including obsolescence and limited spare parts, were also highlighted by the participants, consistent with the findings of Nguyen et al. (2020) and Smith et al. (2020). The participants emphasized the importance of strategic planning and budgeting for equipment replacement and upgrades, but also acknowledged the financial constraints faced by many healthcare organizations. They shared creative strategies for extending the life of older equipment, such as sourcing parts from decommissioned devices and collaborating with other facilities. These findings suggest that healthcare organizations need to develop long-term plans for equipment replacement and explore innovative solutions for managing aging equipment.

The value of ongoing training and professional development for biomedical and radiological technicians was also emphasized by the participants, consistent with the recommendations of Patel et al. (2022) and Jones et al. (2021). The participants described the benefits of attending conferences, participating in online courses, and seeking mentorship from experienced colleagues. However, they also identified barriers to accessing training opportunities, such as limited budgets and time constraints. These findings suggest that healthcare organizations need to prioritize and invest in training and professional development opportunities for technicians to ensure they have the knowledge and skills necessary to optimize medical equipment lifecycle management.

## Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. First, the sample size was relatively small and homogeneous, consisting of only male technicians from two specific settings (long-

term care and medical supply). Future research should include a larger and more diverse sample of technicians from various healthcare settings to enhance the transferability of the findings. Second, the study relied on self-reported data from interviews, which may be subject to recall bias or social desirability bias. Future studies could include observational data or objective measures of equipment performance to triangulate the findings. Despite these limitations, this study provides valuable insights into the experiences and perspectives of biomedical and radiological technicians in optimizing medical equipment lifecycle management. The findings can inform the development of targeted interventions and policies to support these critical professionals in their vital work. Future research should focus on evaluating the effectiveness of specific strategies, such as preventive maintenance programs, communication protocols, and training initiatives, in improving medical equipment performance, reducing costs, and enhancing patient care.

## CONCLUSION

This qualitative study explored the roles, challenges, and best practices of biomedical and radiological technicians in optimizing medical equipment lifecycle management in long-term care and medical supply settings. The findings highlight the importance of proactive maintenance and calibration, effective communication and collaboration, strategic planning for aging equipment, and ongoing training and professional development. By addressing these key areas, healthcare organizations can support technicians in their critical work and ensure the safety, reliability, and cost-effectiveness of medical devices. Implementing targeted interventions and policies based on these findings can ultimately lead to improved patient care, cost savings, and environmental sustainability. Further research is needed to evaluate the effectiveness of specific strategies and to include a larger and more diverse sample of technicians from various healthcare settings.

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