

Digital Transformation of Medical Maintenance at PSAFHM

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Abstract

In this research, the researchers addressed the issue of digital transformation and its impact on the development of medical maintenance, and this topic is very important in the field of medical engineering. The researchers chose the military Hospital in Medina as his study location. The study aimed to identify and address the main challenges facing the digital transformation of medical maintenance at the Military Hospital in Medina. It seeks to analyze the current state of digitalization in medical maintenance operations, identify areas requiring improvement, and propose effective strategies to overcome obstacles. The study will evaluate the impact of digital transformation on efficiency, cost-effectiveness, patient care, and overall operational performance. At the end of the research, the researchers reached several results, including that introducing digital systems and technologies into medical maintenance can increase efficiency in various aspects, such as scheduling equipment maintenance, inventory management, and resource allocation. Researchers may find evidence of reduced downtime, streamlined workflow, and optimized use of resources. In addition, digital transformation initiatives in medical maintenance may focus on ensuring the safety and reliability of medical equipment. Research can reveal improvements in equipment reliability, decreased equipment failure rates, and improved patient safety outcomes. The researchers also recommended developing a comprehensive strategy for digital transformation: Based on the research results, it is recommended to develop a well-defined strategy that defines the hospital's vision, goals, and roadmap for the digital transformation of medical maintenance. This strategy should consider factors such as technology selection, resource allocation, timeline, and change management. Invest in a solid digital infrastructure: To support the digital transformation of medical maintenance, the hospital must invest in a reliable and secure digital infrastructure. This includes upgrading network capabilities, implementing cloud data storage and analysis platforms, and ensuring cybersecurity measures are in place.

Keywords

Digital Transformation, Medical Maintenance, Malfunctions

1. Introduction

The administration of the military hospital in Medina places significant emphasis on supporting maintenance, operations, and other auxiliary services. These services stand alongside medical specializations and contribute to the provision of distinguished therapeutic services. Driven by this focus, the Biomedical Engineering Department of the hospital, led by Engineer Ahmed Khaled Sabr and his team, aspired to make digital transformation one of their strategic plans. This aligns with the vision of His Highness the Crown Prince for 2030 and keeps pace with the modern technological revolution we are currently experiencing. They leverage the opportunities presented by new technology, such as cloud computing, artificial intelligence, and the Internet of Things. This is done with the aim of gaining a competitive edge by improving efficiency, enhancing the customer experience, and providing innovative services in response to the evolving expectations and aspirations of beneficiaries experiencing rapid and advanced changes. Over recent months, the Biomedical Engineering Department has dedicated itself to hard and earnest work, transitioning from a traditional work environment and paper-based procedures to digital maintenance management using the latest operational software at the lowest cost and in the shortest time frame. After the project's completion, we wanted to share our experience before and after automation [1].

2. Study Problem

This study aims to explore and address the pivotal challenges encountered during the digital transformation of medical maintenance at the Military Hospital in Madinah. The primary focus is to analyze the prevailing state of digitalization in medical maintenance procedures, pinpoint areas necessitating enhancement, and recommend effective strategies to surmount these hurdles. The study will evaluate the influence of digital transformation on efficiency, cost-effectiveness, patient care, and overall operational performance. Additionally, the research will delve into aspects like legacy systems, data management, change management, cybersecurity, integration, scalability, and the return on investment. The findings are anticipated to offer valuable insights and suggestions to steer the successful rollout of digital transformation endeavors in medical maintenance at the Military Hospital in Madinah [2].

3. The Study Aims

The aim of the study on the digital transformation of medical maintenance at

the Military Hospital in Madinah is to:

- Assess the current level of digitalization in the hospital's medical maintenance processes, including digital technologies, systems, and tools.
- Identify the primary challenges and obstacles preventing the effective implementation of digital transformation within medical maintenance.
- Evaluate how digital transformation affects various facets of medical maintenance, such as operational efficiency, cost-effectiveness, patient care, and staff productivity [2].
- Analyze the hospital's existing infrastructure—from legacy systems to data management practices and cybersecurity measures—pinpointing areas needing enhancement and modernization.
- Examine the readiness and capacity of the hospital staff to adopt and use digital technologies for medical maintenance tasks.
- Suggest strategies, solutions, and best practices to address the identified challenges, thereby bolstering the digital transformation of medical maintenance processes.
- Recommend the effective implementation and integration of digital technologies, prioritizing scalability, interoperability, and data security.
- Evaluate the return on investment (ROI) and cost-benefit of initiatives that digitally transform medical maintenance.
- Contemplate the ethical, legal, and regulatory implications of digitizing medical maintenance processes, giving special attention to patient privacy and data protection concerns [2].

By focusing on these study objectives, the research aims to deepen the understanding of the digital transformation of medical maintenance at the Military Hospital in Madinah. This will, in turn, offer actionable insights for the successful implementation and refinement of digital technologies within medical maintenance practices.

4. Study Importance

The study concerning the digital transformation of medical maintenance at the Military Hospital in Madinah is of paramount importance for several reasons:

- **Enhancing Efficiency:** Digital transformation holds the potential to streamline medical maintenance processes, automate tasks, and heighten operational efficiency. Through this study, we can optimize workflows, mitigate manual errors, and bolster overall efficiency by pinpointing areas ripe for digital technology implementation (**Figure 1**).
- **Improving Patient Care:** Digital transformation can profoundly enhance patient care, fostering better coordination, communication, and easy access to patient data. Such modification facilitates real-time monitoring, remote consultations, and tailored treatment plans. Through the study, insights can be gleaned on elevating patient care, safety, and outcomes.
- **Cost Reduction:** By incorporating digital medical maintenance technologies,

costs can be calculated through optimized resource allocation, streamlined operations, and preventive maintenance strategies. This study will shed light on the financial ramifications of digital transformation, spotlighting cost-effective measures that bolster return on investment [3].

- **Workforce Empowerment:** A successful digital transformation requires a competent and flexible workforce. The study can discern staff training prerequisites, competency requirements, and existing skill deficits by examining the digital overhaul of medical maintenance. This information can guide specialized training programs, capacitating employees to adeptly wield digital tools, thus enhancing job satisfaction and productivity [2].
- **Data-driven Decision Making:** The digital shift yields a treasure trove of data pivotal for informed decision-making and predictive analytics. By scrutinizing the digitalization of medical maintenance processes, the study can elucidate methods to capture, archive, and analyze data, extracting actionable insights to refine resource allocation and fine-tune maintenance strategies.
- **Future Readiness:** The healthcare sphere is in flux, making digital transformation an imperative to stay abreast of advancements. With this study, the Military Hospital in Madinah can manifest itself as a visionary entity that champions innovation and is poised to tackle imminent challenges in medical maintenance.
- **Knowledge Sharing and Collaboration:** This study augments the extant corpus of knowledge on digital metamorphosis in healthcare. The resultant findings and propositions can be disseminated amongst peer institutions, stimulating collaboration and facilitating the interchange of best practices [1].

In sum, the essence of this study is anchored in its potential to augment efficiency, patient care, and cost-efficiency, all while invigorating the workforce and readying the Military Hospital in Madinah for the digital epoch of medical maintenance.

5. Before the Digital Transition

Every morning, a small group of technicians from the Medical Engineering Department conducts rounds in the hospital buildings and departments to locate any malfunctioning medical devices left unattended in the corridors or nursing stations after working hours. The nursing department contacts the medical device maintenance department to report malfunctions. However, a response can sometimes be delayed due to the receptionist's unavailability during emergencies (**Figure 1**). Some medical departments directly call the mobile phone of the person responsible for medical devices in their department to report sudden malfunctions. However, they might find the phone turned off because of poor network coverage in some hospital areas (**Figure 1**). Furthermore, inpatient wards must wait for the designated staff member responsible for correspondence to return before submitting maintenance requests and addressing critical equipment malfunctions to the Medical Maintenance Department.

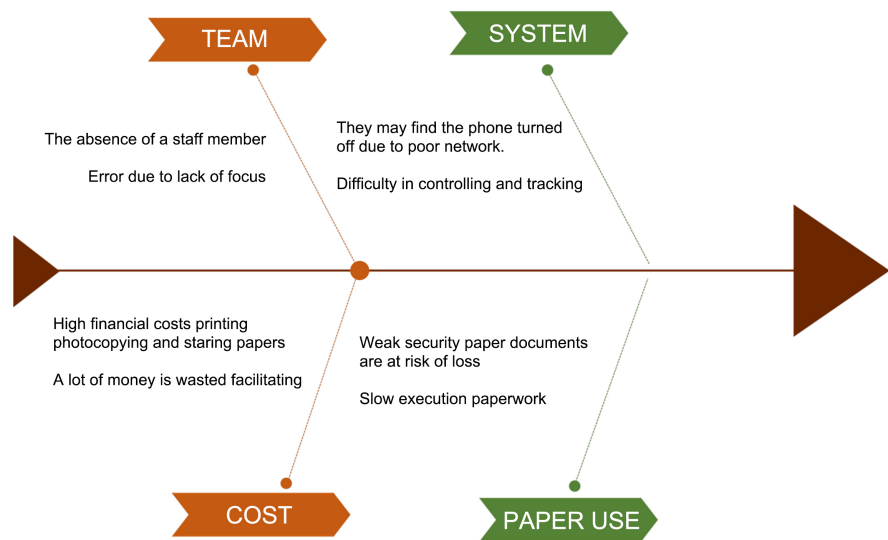


Figure 1. Fishbone diagram to illustrate medical maintenance problems in the absence of digital transformation [4].

Due to unclear handwriting, the Medical Engineering Department sometimes faces challenges deciphering maintenance requests written on paper, making it difficult to identify the malfunctioning devices or required accessories. To ensure the availability of the necessary spare parts or batteries in the warehouse, they must manually review and compare various supply and exchange documents or physically search through boxes and shelves. Occasionally, scheduled preventive maintenance is delayed because the inventory officer needs to update the device list in the Microsoft Excel program, identify devices due for maintenance, or refer to paper files containing information about all the medical devices. Furthermore, the Excel program's device list contains numerous errors, especially in the Serial Number column. When entering the system, letters and numbers get mixed up, leading to confusion between the letter "O" and the number "0" or between the letter "I" and the number "1".

6. Some Other Difficulties

- **Slow Execution:** Paper-based tasks are time-consuming due to the need for manual navigation and document processing (**Figure 1**).
- **Time and Effort Waste:** Retrieving specific information from paperarchives is laborious and time-consuming because there's no fast search method (**Figure 1**).
- **Storage Challenges:** Storing large volumes of paper documents is space-consuming and poses organizational challenges, increasing the risk of loss [3].
- **Communication Barriers:** Due to spatial and temporal constraints, there are difficulties in sharing documents and responding to periodicinquiries from entities like the Saudi Food and Drug Authority (SFDA).
- **Environmental Concern:** A heavy reliance on paper consumption hasa negative environmental impact.

- Security Vulnerabilities: Paper documents are prone to loss, theft, and destruction, undermining data confidentiality and security (**Figure 1**).
- Transfer & Access Limitations: Accessing or transporting paper documents from remote locations is challenging.
- Elevated Costs: Expenses related to printing, photocopying, and storage, such as maintenance of printers and purchase of inks, are significant (**Figure 1**).
- Tracking Issues: Tracking the workflow of paper documents and knowing with whom they've been shared is problematic (**Figure 1**).
- Inadaptability: Paper processes are rigid and struggle to keep up with fast-paced changes in the work environment [4].

7. Planning and Making Digital Transformation Decisions

An internal committee was formed in the hospital's Department of Biomedical Engineering, whose mission is to implement a project to improve the work environment and digital transformation in several stages:

- The first stage: Study the current traditional/paper-based work procedures and focus on the negatives and obstacles (problem identification stage).
- The second stage: Determine the electronic requirements to eliminate the mentioned negatives and transform obstacles into facilities (analysis stage).
- The third stage: Searching for electronic systems that meet limited needs, studying them, and ensuring their compatibility with the hospital's infrastructure (planning stage).
- The fourth stage: presenting the project after obtaining the necessary approvals and credits (implementation stage).
- The fifth stage: Evaluation of the project after its implementation (evaluation stage).

8. Digital Transformation and Automation

Within a mere 59 days of awarding the system project to the renowned company specializing in the OMS EXPERT system, Medical Engineering Solutions Corporation, the Biomedical Engineering Department at the Military Hospital in Madinah successfully transitioned from paper-based operations, eliminating the use of paper, files, cabinets, and various pens. Instead, they adopted touch screens displaying Dashboards, QR Codes, and Alerts [4].

The implementation began by installing the system on the hospital's servers and ensuring its full functionality. Staff members were trained according to their respective roles and responsibilities (**Figure 2**). A security and access control plan was implemented, restricting access only to authorized personnel. A technical support and maintenance plan was also rolled out, ensuring the system's uptime 24/7. The hospital then collaborated with the system's provider for potential updates [1].

Subsequently, details from manufacturers, agents, suppliers, and their contacts were logged. Hospital facilities, encompassing buildings, floors, departments,



Figure 2. A photo was taken during the Biomedical Engineering Department staff training on using the system at PSAFHM.

and rooms, were cataloged. Digital files were created for all Medical Maintenance Department staff, capturing personal and professional details. An electronic database was developed for all medical devices in the hospital, each file rich in more information like a tracking number, device name, location, manufacturer details, warranty, responsible engineer, purchase data, and more (Figure 1). Relevant documents and images were also attached [3].

Devices were labeled with a unique QR code, simplifying data retrieval and performance monitoring. Users could quickly access maintenance histories and generate reports through these codes. Proactive measures were also taken, scheduling preventative maintenance for devices ten years in advance, based on either manufacturer guidelines or FDA recommendations. Existing maintenance contracts were digitized, and an electronic notification system was introduced. The inventory included detailed electronic files for all spare parts, consumables, and supplies.

Furthermore, nursing supervisors were trained to use the OMS ENDUSER program to report equipment malfunctions electronically, oversee repair processes, approve tasks, evaluate performance, and track regular maintenance schedules. They were also equipped to generate necessary reports, enabling them to directly oversee the medical maintenance department's performance indicators on their screens.

9. Post-Digital Transformation

After transitioning to a system equipped with advanced features in the digital age, we experienced numerous benefits, the most notable of which include:

- **Strategic Planning and Decision-making:** The system-generated reports and analyses have enabled us to make informed decisions regarding the renewal, termination, or replacement of medical device maintenance contracts.
- **Scheduled Maintenance:** We can now delineate and set routine preventive maintenance schedules, ensuring that medical devices function optimally.
- **Transparent Documentation:** With the system, we have a precise record of every maintenance procedure, allowing us to trace each device's historical repairs and enhancements.
- **Minimized Downtimes:** The system's ability to swiftly identify issues reduced equipment downtime.
- **Efficient Inventory Management:** Tracking spare parts and other maintenance materials has become seamless, leading to optimal stock levels and minimized wastage (**Figure 1**).
- **Enhanced Communication:** It has bridged the communication gap between internal management and suppliers by offering timely notifications and reminders [4].
- **Performance Evaluation and Continuous Improvement:** By analyzing device data, we can assess the device's performance and the efficiency of the technical team responsible for its upkeep, pinpointing areas for improvement.
- **Ensuring Compliance:** The system has guided us towards adhering to local standards and regulations pertinent to the maintenance and operation of medical devices.
- **Cost Reduction:** Enhanced maintenance efficiency and decreased downtimes led to substantial savings, as we could sidestep expensive emergency repairs and unnecessary maintenance contracts, redirecting those funds to more pressing needs.
- **Improved Patient Satisfaction:** The consistent operation of medical devices has eliminated the need for patient transfers to other hospitals, thereby elevating patient satisfaction levels [1].

10. Comparisons Observed in the Project Evaluation Stage

- After activating the digital system in the Department of Biomedical Engineering, there was an increase in training for users to use medical devices, and the results improved as shown in (**Figure 3**). We note that the User error rate (UER) in the first five months (before the transformation) and the three months (UER) after the transformation:

$$\text{UER} = \frac{\text{total number of user errors}}{\text{total number of errors}} * 100$$

- After activating the digital system in the Biomedical Engineering Department, the technical department's response time to repair faults (RT) was reduced because the system automatically sends SMS messages to technicians when the user creates a request, specifying the name and location of the malfunctioning device as noted in (**Figure 4**).

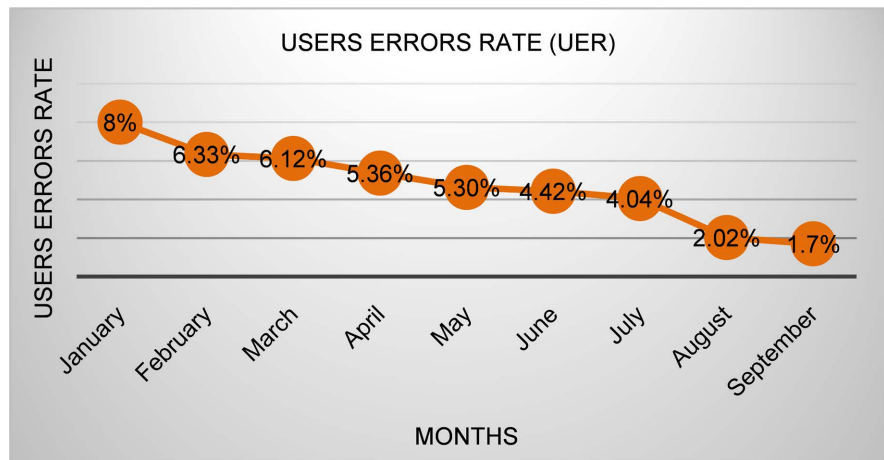


Figure 3. Clarifying the decrease in device malfunctions after intensifying user training due to the digital transformation.

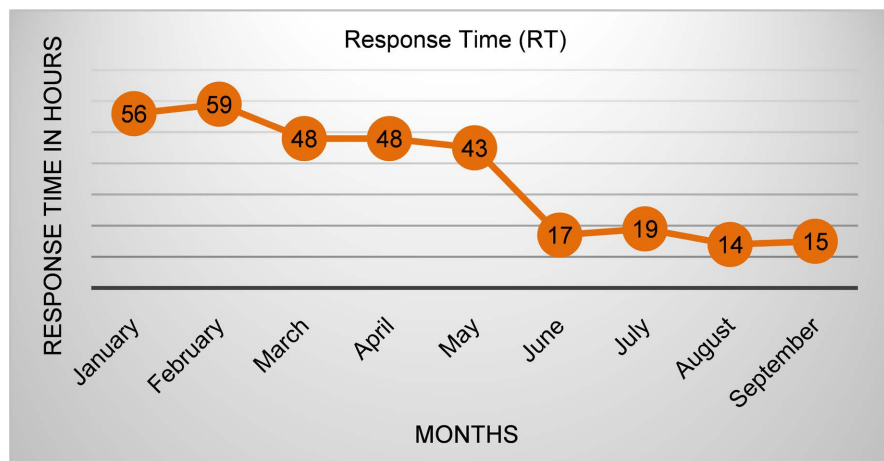


Figure 4. Clarifying the decline in the response time rate of technicians to repair malfunctions due to digital transformation.

11. Conclusion

At the conclusion of our research, we extend our gratitude to the hospital management for their unwavering support of the Biomedical Engineering Department. We also wish to express our appreciation to the Quality and Patient Safety Department for allowing us to highlight the experiences of the Biomedical Engineering Department at the Military Hospital in Al-Madinah Al-Munawwarah during its digital transformation. Remarkably, in just 59 days, they aligned with the ongoing technological revolution. We hope that sharing our experience is a model for others, particularly in places still relying on traditional manual medical maintenance management.

12. Results

1) Improved Efficiency: Introducing digital systems and technologies in medical maintenance could increase efficiency in various aspects, such as equipment

maintenance scheduling, inventory management, and resource allocation. Researchers may find evidence of reduced downtime, streamlined workflows, and optimized resource utilization.

2) **Enhanced Patient Safety:** Digital transformation initiatives in medical maintenance may focus on ensuring the safety and reliability of medical equipment. Research could reveal improvements in equipment reliability, decreased equipment failure rates, and enhanced patient safety outcomes.

3) **Cost Savings:** Implementing digital systems and technologies in medical maintenance has the potential to generate cost savings. Researchers might investigate the financial impact of digital transformation, including reduced maintenance costs, optimized equipment utilization, and improved resource allocation, leading to overall cost efficiency.

4) **Data-Driven Decision-Making:** Digital transformation often involves collecting and analyzing data for informed decision-making. Research could explore the impact of data-driven insights on maintenance strategies, equipment performance monitoring, and predictive maintenance practices.

5) **Technological Challenges and Barriers:** Research on the digital transformation of medical maintenance may also identify challenges and obstacles encountered during the implementation process. These could include issues related to system integration, staff training, data security, and infrastructure requirements.

13. Recommendations

Several recommendations may emerge based on the study's findings and analysis. Here are some potential suggestions that researchers might consider:

- **Develop a Comprehensive Digital Transformation Strategy:** From the research findings, it's recommended to formulate a clear plan detailing the hospital's vision, objectives, and digital transformation pathway for medical maintenance. This strategy should encompass technology choices, resource distribution, a set timeline, and change management processes.
- **Invest in a Robust Digital Infrastructure:** Hospitals should prioritize investing in a dependable and secure digital framework to facilitate the digital transformation of medical maintenance. This involves enhancing network capabilities, adopting cloud-based data storage and analytics platforms, and instituting strong cybersecurity defenses.
- **Enhance Staff Training and Education:** Offering in-depth training programs for personnel engaged in medical maintenance is imperative. This entails instruction on novel digital instruments, technologies, and operational flows. Further, nurturing a culture of perpetual learning and career growth can buttress the triumphant execution of digital schemes.
- **Foster Collaboration and Communication:** Synergy among various departments and stakeholders is pivotal for fruitful digital metamorphosis. Suggestions might encompass initiating communication mediums and platforms that ease teamwork and knowledge dissemination between medical main-

tenance squads, IT factions, and hospital governance.

- **Monitor and Evaluate Digital Transformation Effects:** Construct mechanisms to oversee and gauge the repercussions of digital transformation endeavors. This requires tracing pivotal performance metrics pertinent to efficacy, patient well-being, financial prudence, and employee contentment. Habitual assessment can spotlight enhancement zones and steer ensuing choices.
- **Ponder Scalability and Sustainability:** As digital transformation advances, there's a paramount need to certify the expandability and enduring viability of the solutions in place. Proposals might comprise periodic audits of the digital apparatus, tech scalability scrutiny, and contemplation of imminent progressions and budding trends in medical upkeep.
- **Continuously Adapt and Innovate:** Digital metamorphosis is a ceaseless journey. Suggestions might underscore the necessity of remaining up to date with tech breakthroughs, proactively garnering feedback from the workforce and clientele, and cultivating an innovation-centric ethos to pinpoint fresh betterment avenues.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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