Journal of Electronic Research and Application, 2025, Volume 9, Issue 4
http://ojs.bbwpublisher.com/index.php/JERA
ISSN Online: 2208-3510
ISSN Print: 2208-3502

Exploration of Medical Equipment Quality Control Management Based on Information Management System

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Abstract: Relevant documents issued by the General Office of the State Council and the Ministry of Health require hospitals to reduce operating costs and improve efficiency, which will place newer and higher demands on medical equipment management. However, the current process of medical equipment quality control in hospitals faces issues such as weak control awareness, untimely maintenance of faulty equipment, and a lack of informatization management tools. These problems severely restrict the development of medical equipment quality management. To address these issues, this article uses a tertiary hospital in Urumqi as an experimental platform to analyze the deficiencies in the current medical equipment quality control management system of public hospitals. Based on practical needs such as equipment procurement, contract management, and equipment management, the research is conducted from three aspects: system architecture, functional design, and talent training, utilizing an information management system. Suggestions are provided, aiming to make a modest contribution to promoting medical equipment quality control management in China.

Keywords: Information management; Medical equipment; Quality control

Online publication: August 7, 2025

1. Introduction

As the asset value of medical equipment in hospitals continues to expand, the total value of equipment in large tertiary hospitals generally exceeds 100 million yuan, and some even exceed one billion yuan [1]. Faced with significant growth in equipment quantity and value, traditional management methods have become inadequate to meet new management demands. For instance, there is a lack of effective reminder mechanisms for key events such as repair requests, maintenance, measurement, and testing. Additionally, it is impossible to dynamically monitor the operating status of equipment across the hospital in real time, which can easily lead to problems such as delayed or missed information, discrepancies in data across various information systems, and insufficient

accuracy in equipment benefit analysis. Without effective equipment quality control, hospitals are prone to frequent equipment failures, surging maintenance costs, and even medical risks [2]. Therefore, it is extremely necessary to conduct research on medical equipment quality control management based on an information management system.

2. Information management system

The "Guiding Opinions on Comprehensive Reform Pilots of Urban Public Hospitals" issued by the General Office of the State Council and the "Measures for the Administration of Medical Equipment in Medical and Health Institutions" issued by the Ministry of Health clearly require hospitals to significantly reduce operating costs and improve efficiency. This signifies newer and higher demands on medical equipment management [3]. As an important tool for modern hospital management, the information management system can provide a comprehensive, accurate, and real-time equipment management platform for hospitals by integrating data from the entire process of equipment procurement, contract management, inventory management, maintenance, and disposal.

3. Quality control management of medical equipment

3.1. The importance of quality control

The quality of medical equipment is directly related to the safety, effectiveness, and accuracy of medical services. A hospital in Henan Province has established a medical equipment quality control management system based on grid management since 2017. The data on medical equipment after adopting quality control measures is shown in **Table 1**. With the implementation of reasonable quality control measures, the failure rate of equipment has shown a decreasing trend year by year, while the intact rate and utilization rate of equipment have shown an increasing trend year by year. This data fully demonstrates the importance of quality control management for medical equipment. Therefore, strengthening the quality control management of medical equipment is a crucial measure for hospitals to improve their overall management level, ensure patient safety, and promote sustainable development [4].

Table 1. Comparison of equipment failure rates after implementing the medical equipment quality control system in a hospital

Year	Total medical equipment (units)	Equipment failures (incidents)	Failure rate (%)
2017	16,581	7,053	42.54
2018	19,042	6,780	35.61
2019	23,165	7,639	32.98
2020	24,079	7,208	29.93
2021	24,646	7,123	28.90
$\chi 2$			5.127
P-value			0.024

Note: $\chi^2 = 5.127 > 3.84$, indicating significant effects after quality control management; $P = 0.024 < 0.05$, representing significant results after equipment quality control management.

3.2. Current status of quality control management

Currently, there are several issues in the quality control management of medical equipment, including a lack of quality control awareness among staff, an inadequate quality control system, extended equipment service life, and insufficient reuse of materials. The specific issues are as follows.

3.2.1. Weak awareness of equipment quality control

Firstly, hospital staff lack risk awareness, and the implementation of quality control measures is inadequate. Secondly, engineers tend to overlook frequently used equipment during quality control inspections. Additionally, various aspects of equipment management rely on paper-based registration, resulting in low efficiency [5]. Finally, there is insufficient training on equipment operation, and medical staff lack the necessary skills for routine maintenance and troubleshooting [6].

3.2.2. Poor equipment control system

The entire process management of medical equipment lacks a sound quality control system, clear management norms, and effective supervision mechanisms [7]. There is a lack of unified implementation standards, and there are significant differences in management processes among various departments. The responsible persons for some large equipment are not clear. At the same time, to save costs, some hospitals even reuse disposable supplies in violation of regulations [8], which seriously affects management efficiency and service quality.

3.2.3. Unreasonable equipment demand and purchase

The purchase of equipment by departments lacks scientific evaluation, which can easily lead to functional overlap or technological backwardness [9]. Inaccurate or drifting parameters of overdue equipment may cause diagnostic errors and medical disputes [10].

3.2.4. Untimely maintenance of faulty equipment

Once equipment malfunctions, some units have cumbersome processes, insufficient personnel or spare parts, which will lead to long downtime of the equipment, or even operation with faults [11], which will exacerbate equipment wear and increase later costs. Therefore, establishing an efficient equipment maintenance mechanism to ensure that faulty equipment can be repaired in a timely manner is one of the key links to improving the quality control management level of medical equipment.

3.2.5. Lack of informatization management tools

Many hospitals rely on traditional manual records and paper files for medical equipment management, which is not only inefficient but also prone to errors. At the same time, key data is difficult to update in a timely manner, affecting maintenance efficiency [12]. In addition, this backward management model cannot monitor the specific usage status of equipment in real time [13]. Finally, the accumulation of hospital data and personnel changes have seriously hindered the smooth development of traceability work [14].

4. Information-based equipment quality control management

4.1. System architecture

This article is based on the Windows system platform, selects the mainstream and stable Oracle database in the

medical industry [15], and adopts Tomcat [16] as the application server to design the information system architecture, as shown in **Figure 1**.

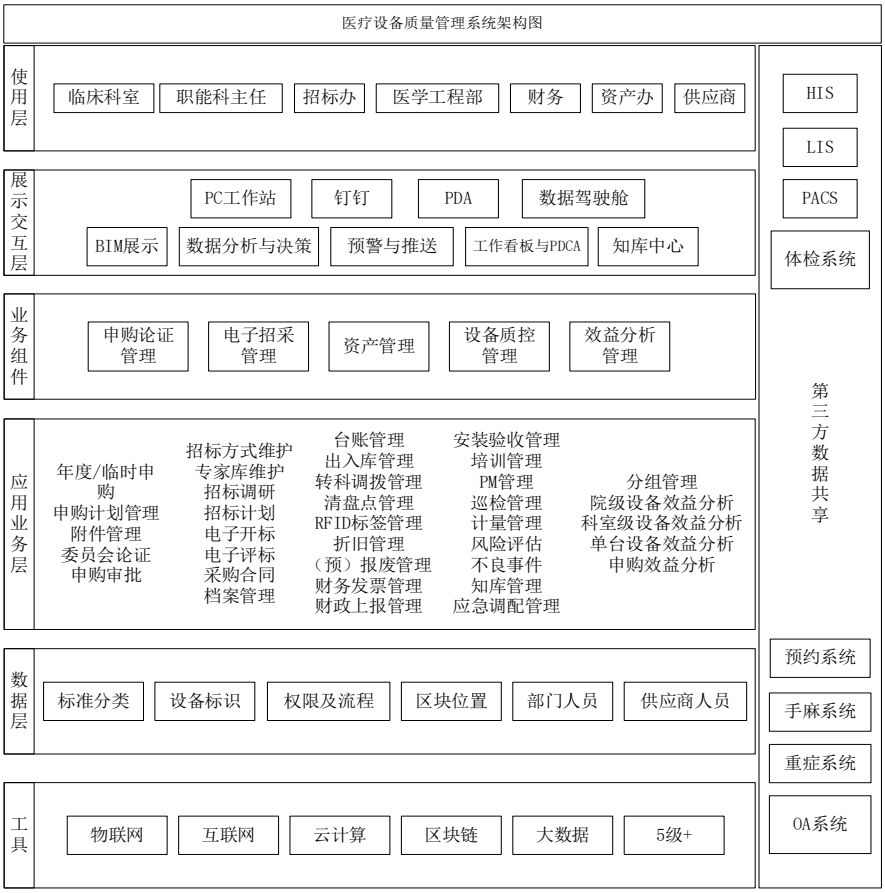

Figure 1. System architecture diagram (Abbreviations: PDA: Personal Digital Assistant; BIM: Building Information Modeling; RFID: Radio Frequency Identification; PM: Preventive Maintenance; HIS: Hospital Information System; LIS: Laboratory Information System; PACS: Picture Archiving and Communication Systems)

The system achieves data interaction and sharing with multiple network operation and management systems in the hospital, effectively connecting the work processes of clinical departments, medical equipment departments, finance, and other functional departments. The system supports access from different terminals, and users can operate through electronic devices such as mobile phones or PDAs [17]. In terms of architecture design, the system strictly follows industry standards, develops functional modules for the entire process of medical equipment quality management, and integrates technologies such as the Internet of Things, the Internet, and cloud computing, realizing the entire process of information management from procurement to scrap for medical equipment. The application process is shown in **Figure 2**.

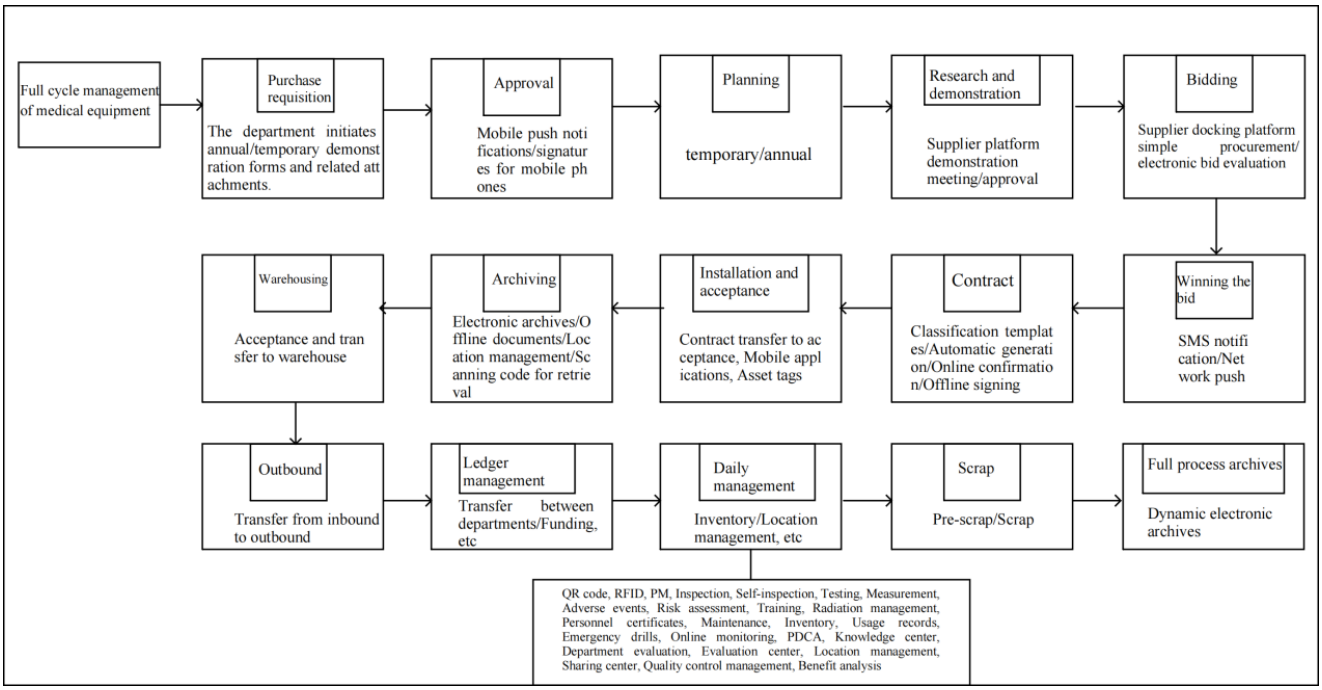

Figure 2. Application flowchart

4.2. Functional design

4.2.1. Purchase requisition function

The purchase requisition module requires each department to initiate an online application based on its own development needs, and fill in key information such as equipment funding sources, purchase channels, whether new technology applications are involved, and equipment disposal standards. After being signed by the department members, it will be uploaded to the system. Through this module, the equipment management department conducts a unified review and summary of the purchase requisitions from all departments, and then submits them to the Medical Equipment Management Committee for deliberation. After the purchase requisition project is approved by the committee, the system will automatically transfer it to the bidding and procurement office to enter the procurement process, thus realizing automated management of purchase requisition approval.

4.2.2. Basic information archive of equipment

The application of an information management system is equally crucial during the signing of purchase contracts and equipment installation acceptance. The system comes with a standardized contract template that covers important information such as equipment name, specifications and models, quantity, price, delivery date, and warranty period. It also generates a unique identification code for each piece of equipment. By integrating these codes, a complete digital equipment basic information archive is established, ensuring traceability from procurement to disposal. This effectively avoids disputes arising from unclear contract terms. After the contract is signed, the system can automatically track its execution, including key nodes like equipment shipment, transportation, and arrival, to ensure timely fulfillment.

During the installation and acceptance phase, the system provides detailed acceptance processes and standards, guiding staff to conduct comprehensive inspections and tests on the equipment. Acceptance results need to be entered into the system in real-time and compared with the procurement contract to ensure consistency

between equipment performance parameters and contract agreements. For issues identified during the acceptance process, the system can automatically generate rectification notices and track the rectification status until the problems are completely resolved. Through the information management system, equipment purchase contracts and installation acceptance work become more standardized and efficient, effectively improving the quality control and management level of medical equipment.

4.2.3. Equipment repair and maintenance

This module supports clinical departments to submit repair applications online. By uploading pictures, text, and video materials of equipment failures, it facilitates timely recording of equipment malfunctions, enabling engineers to accurately diagnose problems. The system detects repair applications in real-time and pushes them to engineers, who can record the repair process and results via mobile phones or PDAs, thereby improving repair response speed [18]. Meanwhile, the system automatically generates regular inspection and maintenance plans for equipment. Engineers execute maintenance tasks according to the plan and generate corresponding maintenance records. Through data analysis, the system can also predict potential equipment failures, arrange repairs ahead of time, and avoid clinical usage impacts. This provides comprehensive support for improving equipment operation quality and efficiency. To effectively avoid equipment quality risks and strengthen risk control in the equipment quality management process, the system follows regulatory requirements [19] such as the "Regulations on the Supervision and Administration of Medical Devices" to establish a preventive maintenance mode and develop detailed maintenance plans. Specific maintenance activities include equipment appearance inspection, cleaning and maintenance, functional testing, and electrical safety inspections. Dedicated maintenance cycles are set based on the risk levels of different types of medical equipment, ensuring proactive risk management from the source.

4.2.4. Equipment monitoring

This module manages all hospital equipment by dividing it into four categories: (1) Large medical equipment: Real-time monitoring of high-value equipment such as CT, MRI, and DSA is achieved through IoT technology. Intelligent analysis of equipment quality inspection data and precise calculation of equipment utilization rates provide data support for equipment procurement and performance management. (2) Life-support equipment: RFID and IoT technologies are used for real-time monitoring of equipment status, ensuring a 100% perfect condition rate. If any equipment develops quality issues, other good equipment is promptly allocated to meet clinical emergency needs. (3) ICU and operating room equipment: Monitors are used to detect real-time parameters and alarm information from devices like ventilators and patient monitors, reducing the workload of medical staff. (4) General ward and outpatient equipment: A scanning code registration system is adopted for usage management. Through graded supervision, this module achieves precise and intelligent management of various types of equipment.

4.3. Talent cultivation

The effectiveness of medical equipment quality management is closely related to the professional quality of personnel. Hospitals need to establish a professional equipment quality management team, adhering to the principle of specialized personnel for specialized positions, to ensure standardized information management work. Through a targeted training system, managers are helped to fully grasp the professional knowledge and operational skills of equipment information management, continuously improving the overall quality of the team and laying a talent foundation for the efficient operation of the management system. Hospitals can use QR code technology to optimize asset management processes, allowing medical staff to view key information such as equipment

parameters and instructions by scanning the equipment's QR code (**Figure 3**). For new staff or special equipment operations, operation guides can be quickly queried through the management system on mobile devices, improving asset management efficiency and ensuring standardized and safe equipment usage, thus guaranteeing equipment quality, safety, and reliability.

Figure 3. Equipment asset card style

5. Conclusion

Strengthening the quality control management of medical equipment based on an information management system is not only a response to policies but also a satisfaction of the needs of the times. Aiming at the deficiencies in the quality control management process of medical equipment, this article conducts research and provides suggestions from three aspects: system architecture, functional design, and talent training. It is hoped that this can provide a certain theoretical reference for the quality control management of medical equipment in China.

Funding

Urumqi Health Committee Science and Technology Plan Project (202343)

Disclosure statement

The authors declare no conflict of interest.

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