

# Research and application of mobile workbench for clinical medical engineers in hospital

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**Abstract:** To explore the practical application value of mobile workbench for clinical medical engineers in hospital. Methods The clinical medical engineer team of a large hospital in Xi'an developed mobile workbench for clinical medical engineers based on Android system. This paper studies the management effect of medical equipment after using the mobile workbench. Results After adopting the mobile workbench for clinical medical engineers, the maintenance records integrity rate and the timeliness of maintenance response were significantly improved ( $c_2=9.955$ ,  $c_2=22.650$ ;  $P<0.01$ ), and there was no significant difference in the inspection pass rate after maintenance ( $c_2=1.846$ ;  $P>0.05$ ). At the same time, in the annual management benefit statistics, the mandatory measurement pass rate of the medical equipment, the perfectness rate of large equipment and the operating rate of large equipment were all improved, reaching 99.86%, 98.92%, 99.51%, respectively. The ratio of maintenance cost to equipment original value was 1.44%, which dropped significantly. Conclusions The mobile workbench for clinical engineers can significantly improve the maintenance and management effect of medical equipment and improve the annual management benefit of medical equipment. In the process of hospital digitalization and wireless construction, research on the construction of mobile work platform for clinical engineers will improve the overall image of the hospital and help realize the wireless digital hospitals.

**Keywords:** Mobile workbench, Android system, Management effect, Wireless digital hospitals.

## 1. Introduction

With the development of medical technology, the number of medical equipment keeps increasing, the utilization rate of equipment keeps improving, and the information related to equipment increases rapidly. However, the daily basic work of clinical medical engineers in hospitals for medical equipment, such as asset management, installation acceptance, measurement and testing, quality control, maintenance, application risk analysis and cost effectiveness evaluation, still remain in the paper and manual stage. The development of information technology has promoted the gradual realization of paperless, film-free and wireless clinical diagnosis and treatment in hospitals [1], making clinical diagnosis and treatment more convenient, timely and accurate. As clinical medical engineers who undertake important management and service functions, it is necessary to study and establish a full information mode.

The medical equipment management department of a large hospital in Xi'an has a team of engineers with a high level of scientific research. Starting from solving the problems encountered by engineers in their actual work, the team developed a mobile workbench for clinical medical engineers. This paper studies the management effect of the mobile workbench.

## 2. Research materials and methods

### 2.1. General materials

Taking the medical equipment of a hospital in xi'an city as the research object, the inclusion conditions were as follows:(1) medical equipment in the hospital asset management database; (2) the equipment was within the measurement validity period; (3) the equipment itself did not have a radioactive source; (4) patients were not injected with radionuclide drugs during treatment. The exclusion

conditions were as follows :(1) the equipment is put on trial by manufacturers; (2) equipment used to carry out clinical trials of medical devices; (3) The equipment was determined as faulty equipment to be scrapped by clinical medical engineers. According to inclusion and exclusion criteria, a total of 36,472 medical devices were included in the study.

### 2.2. Research methods

The mobile workbench system for clinical medical engineers based on Android Studio3.5.2 was built. During the process, Java files were compiled using JDK1.7, and JDK paths were configured in the operating system parameters. The mobile workbench system connects with the database of the hospital's equipment asset management system, equipment maintenance management system and consumables asset management system to realize the whole process tracking management of medical equipment and consumables from admission to abandonment, including acceptance, warehousing, repair, maintenance, regular inspection, disinfection and sterilization, and scrapping. Engineers can use Android intelligent wireless terminals (including mobile phones and laptops) through the hospital's wireless LAN to achieve data query, input and other work.

#### 2.2.1. Logical architecture system of the mobile workbench system for clinical medical engineers

The architecture design of the mobile workbench is shown in Figure 1, which adopts three-layer logical structure, including Data Access Layer (DAL), Business Logic Layer (BLL) and User Interface Layer (UI).

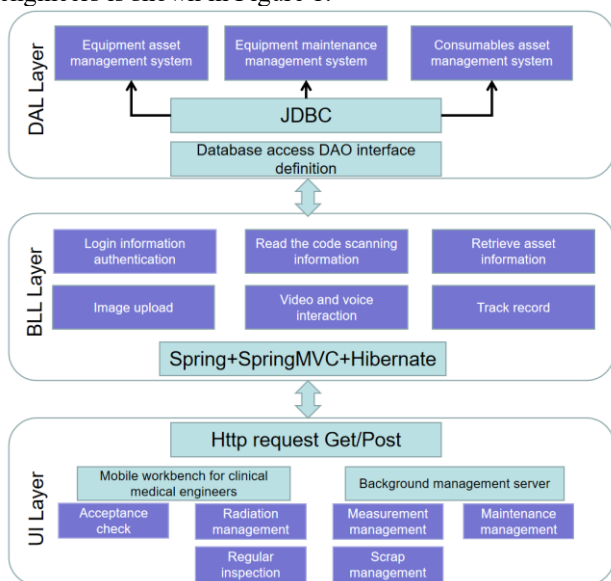
DAL layer realizes data query, update, insert, delete and other operations, providing basic source data for the whole system architecture.

BLL layer is the core of the logical architecture of the whole system. It is located in the middle of UI layer and DAL layer and plays the role of connecting the preceding and the following in data interaction. After receiving the call

instruction from UI layer, BLL layer calls DAL layer for data processing and returns the data processing result to UI layer. The BLL layer is used to implement the logical processing of all functions of the mobile workbench. BLL layer is implemented by Spring+SpringMVC framework and Hibernate framework.

The UI layer, as the outermost layer, is used to provide clinical medical engineers with an interactive operation interface with the mobile workbench system. Background administrators manage data through the server, and clinical medical engineers input requests and read data processed by the BLL layer at the UI layer [2].

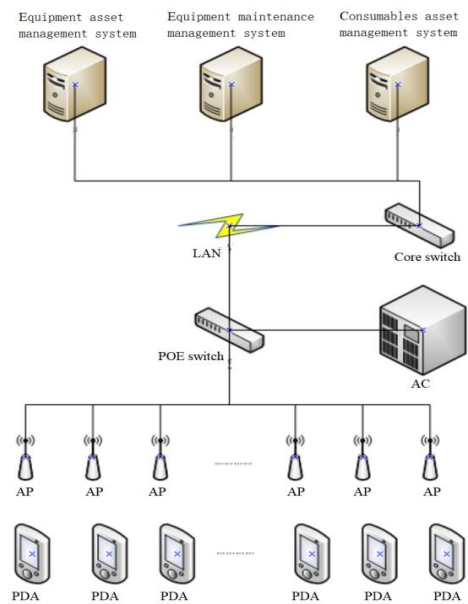
The system sets two system roles: clinical engineer and system administrator. The clinical engineer side is realized on the Android platform, and the system administrator side is realized on the Web front-end technology. The logical architecture of mobile workbench system for clinical engineers is shown in Figure 1.



**Figure1.** The logical architecture of mobile workbench system for clinical engineers

## 2.2.2. Network topology of the mobile workbench for clinical engineers

In the traditional wireless networking mode, each AP is responsible for information transmission and encryption authentication independently. Therefore, each AP needs to be configured independently. As a result, the workload is heavy and unified management is difficult, and maintenance is difficult when a fault occurs. Fit AP+AC mode is recommended for the mobile workbench of clinical engineers. This mode implements unified management of all APs through wireless controller AC. Each AP is only responsible for radio frequency and communication. After passing 802.11 encoding, all the signals received by AP enter AC controller through encryption tunnel, and AC controller performs unified encryption, authentication and security control for data [3]. An AC can be used to configure, manage, maintain, and upgrade APs in a unified manner, and the association time between wireless terminals and APs is greatly shortened. In addition, an AC can be used to quickly switch wireless terminals over a WLAN and provide fast roaming functions. The network topology of mobile workbench for clinical engineers is shown in Figure 2.



**Figure 2.** The network topology of mobile workbench for clinical engineers

## 2.2.3. Application scenarios of mobile workbench for clinical engineers

1) Automatic input of consumables and equipment information

With the help of advanced computer technology and bar code recognition technology, the hospital has built the equipment asset management system, consumables asset management system and equipment maintenance management system based on bar code management. The equipment and consumables will be affixed with bar code labels recording the basic information of equipment and consumables when leaving the warehouse, which is convenient for future management.

When receiving the device management work, clinical medical engineers rush to the device site in time. They first should open the mobile workbench on the Android smart phone or tablet (hereinafter referred to as Android terminal), scan the bar code label attached to the device, and automatically input the basic information of the device into the workbench system. It indicates that engineers have received and responded to the work task from now on. At the same time, the engineers can also read all the information of the equipment from the Android terminal, including the manufacturer, dealer, purchase price, date of warehousing, quality assurance information, maintenance information and regular inspection information of the equipment before receiving this task, so as to avoid returning to the reference room to search for relevant information during the work, saving the cost of working time. It provides important reference for this work task.

2) Timely upload of task information

During the interval of tasks, engineers can summarize the work information and content in the form of words and pictures and input them into the mobile working platform, ensuring the accuracy of the input information content. It can avoid errors when returning to the office to record work records based on memory after the task is completed, so as to form standardized and accurate work record content, which is convenient for monitoring and evaluating the work quality of engineers in the future and backtracking of the working status of equipment in the life cycle [4].

### 3) Voice and video communication at work

Clinical medical engineers would inevitably encounter difficult problems in field work and need to consult with leaders or discuss solutions with colleagues. In this case, the VoIP communication module in the engineers' mobile workbench can be used for instant two-way voice and video communication, which is equivalent to a live video teleconference [5]. Work problems encountered would be timely solved, greatly improve work efficiency and quality.

### 4) Monitoring of engineers' work quality behavior

It is inevitable for clinical medical engineers to inspect and maintain equipment in all buildings of the hospital, and sometimes they have to run back and forth between the new hospital and the old hospital. Through the GPS positioning and track recording module of mobile workbench, the work behavior of the engineers can be properly supervised and monitored, and clinical medical engineers can be urged to complete work tasks with high quality and high quantity.

### 5) Application in warehouse management of consumables and equipment

Due to the large number and variety of hospital consumables and equipment, they are distributed in various departments or warehouses. If there is no effective supervision, it will cause long-term idle waste and low utilization rate of consumables and equipment. If we can make full use of the wireless and portable characteristics of the mobile workbench terminal of engineers, as well as the advanced bar code identification technology, the warehouse management personnel can often check the assets in the departments, and timely follow up the changes of consumables and equipment assets, we can effectively eliminate the waste of consumables and equipment resources, asset loss and other situations.

## 2.3. Observation indicators

### 2.3.1. Comparison of maintenance management effect of medical equipment

The maintenance and management effects of medical equipment for 30 days before and after the adoption of clinical engineer mobile workbench were compared, including the maintenance records integrity rate, the timeliness of maintenance response, and the inspection pass rate after maintenance.

### 2.3.2. Comparison of annual management benefits of medical equipment

The management benefits of medical equipment before and after the adoption of mobile workbench for clinical engineers were compared, including the mandatory measurement pass rate of the medical equipment, ratio of maintenance cost to equipment original value, the perfectness rate of large equipment, and the operating rate of large equipment.

## 2.4. Statistical analysis

The medical equipment maintenance management effect data in 2.3.1 were counting data and analyzed by Chi-square test.  $P < 0.05$  indicated statistically significant difference. Management benefit in 2.3.2 was expressed as a percentage.

## 3. Results

### 3.1. The comparison results of maintenance management effect of medical equipment

Table 1 shows the comparison of maintenance and management effects of medical equipment for 30 days before and after the adoption of mobile workbench for clinical medical engineers. It can be concluded that the maintenance record integrity rate and the timeliness of maintenance response were significantly improved after the adoption of mobile workbench for clinical engineers ( $\chi^2=9.955$ ,  $\chi^2=22.650$ ;  $P < 0.01$ ), and there was no significant difference in the inspection pass rate after maintenance ( $\chi^2=1.846$ ;  $P > 0.05$ ).

### 3.2. The comparison results of annual management benefits of medical equipment

Table 2 shows the comparison of annual management benefits of medical equipment before and after the adoption of mobile workbench for clinical engineers. It can be concluded that after the adoption of mobile workbench for clinical engineers, the mandatory measurement pass rate of the medical equipment, the perfectness rate of large equipment and the operating rate of large equipment were all improved, reaching 99.86%, 98.92%, 99.51%, respectively. The ratio of maintenance cost to equipment original value was 1.44%, which dropped significantly.

**Table 1.** Comparison of maintenance and management effects of medical equipment for 30 days [n (%)]

Group	Times of medical equipment maintenance	Maintenance record integrity rate	Timeliness of maintenance response	Inspection pass rate after maintenance
Before	831	729(87.72)	626(75.33)	798(96.03)
After	807	795(98.51)	787(97.52)	802(99.38)
$\chi^2$	-	9.955	22.650	1.846
$P$	-	0.002	0.000	0.174

**Table 2.** Comparison of annual management benefits of medical equipment (%)

Group	Mandatory measurement pass rate	Ratio of maintenance cost to equipment original value	Perfectness rate of large equipment	Operating rate of large equipment
Before	94.53	2.73	94.73	97.84
After	99.86	1.44	98.92	99.51

## 4. Discussion

The mobile workbench for clinical engineers is a new work mode for clinical engineers under the background of hospital wireless and information construction. It is a work management system for clinical engineers with mobile workbench as the core. The workbench fully achieves the fine management of medical equipment and consumables. It can not only realize instant information sharing for clinical medical engineers, improve engineers' ability of operation and maintenance management of medical equipment, improve clinical departments' satisfaction with engineers' work, but also fully mobilize the use turnover rate of equipment and consumable assets, avoid resource waste and realize reasonable allocation of resources.

However, as it is a wireless management workbench, the following aspects should also be paid attention to in the mobile work service mode of clinical medical engineers:

(1) The rationality of the layout of wireless LAN in the hospital

The construction of mobile workbench wireless LAN for clinical medical engineers must be forward-looking, considering the needs of future hospital construction of mobile medical, mobile nursing and other systems. In the design scheme, it should be considered as far as possible that the existing wireless central monitoring systems, wireless injection pump systems should share the APs with the wireless LAN of the mobile workbench in a certain area. The layout of wireless LAN should take into account the comprehensive signal coverage, easy to operate, maintain and upgrade. The local network should be maintained and upgraded on the premise of keeping the main network architecture unchanged and not affecting the performance and operation of the main network, and hardware investment should be minimized [6]. Meanwhile, the wireless LAN layout should ensure the stability of the whole network operation after the local network upgrade. In addition, the wireless controller should be able to quickly locate network faults.

(2) Security of wireless LAN access in the hospital

To solve this problem, it is suggested to encrypt and authenticate the wireless LAN in the hospital, and set different levels of permissions for staff with different identities in the hospital, so that they can access the corresponding wireless network according to their different permissions, and those without corresponding permissions cannot access the wireless network in the hospital. In addition, a MAC address access control list can be set on APs. Only wireless devices in the MAC address list can access the network [7].

(3) Stability and anti-interference of wireless AP signal

In order to ensure the stability of signals in the hospital's internal wireless LAN, it is recommended that enterprise-class wireless access APs that support 2.4ghz and 5GHz and conform to 802.11n technical standards should be adopted. In addition, signal interference test should be carried out in the areas where layout is required [8]. For areas with multiple interference sources and fast signal attenuation, the number of APs can be moderately increased.

## 5. Conclusions

The mobile workbench for clinical engineers is an

Android-based work management system. After the adoption of the mobile workbench for clinical engineers, the maintenance records integrity rate and the timeliness of maintenance response were all significantly improved. The mobile workbench can significantly improve the maintenance and management effect of medical equipment. At the same time, the mandatory measurement pass rate of the medical equipment, the perfectness rate of large equipment and the operating rate of large equipment were all improved. The ratio of maintenance cost to equipment original value was dropped significantly. The mobile workbench can also improve the annual management benefit of medical equipment. In the process of hospital digitalization and wireless construction, research on the construction of mobile work platform for clinical engineers will improve the overall image of the hospital and help realize the wireless digital hospitals. With the gradual maturity of the mobile workbench mode, more and more large hospitals will gradually promote the construction and layout of the mobile workbench, which will become a routine way of working for clinical medical engineers in the future.

## Acknowledgements

This work was supported by grants from Innovation Capability Support Plan of Shaanxi Province(2017KCT-36), Natural Science Special Project of Shaanxi Province(2020SF-035), Social Development Project of Shaanxi Provincial Key Research and Development Program(2021SF-173).

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