

# ***Research on Implementation Effect of Preventive Maintenance of Hospital Medical Devices Based on SPSS Analysis and Likert Scoring System***

**Qinfeng Liu<sup>1</sup>, Qianyu Zhang<sup>2</sup>, Xianjiao Zhang<sup>3</sup>, Hui Liu<sup>1</sup>, Shuanglin Wei<sup>1</sup>, Jialan Chen<sup>4,\*</sup>**

<sup>1</sup>*Medical Equipment Management Department, Shaanxi Provincial People's Hospital, Xi'an Shaanxi, 710068, China*

<sup>2</sup>*School of Life Science and Technology, Xi'an Jiaotong University, Xi'an Shaanxi, 710004, China*

<sup>3</sup>*Scientific Research Management Department, Shaanxi Provincial People's Hospital, Xi'an Shaanxi, 710068, China*

<sup>4</sup>*Department of Gynaecology, Shaanxi Provincial People's Hospital, Xi'an Shaanxi, 710068, China*

*\*Corresponding author*

**Keywords:** Preventive maintenance, medical devices management, SPSS analysis, Likert scoring system

**Abstract:** Objective To explore the value of preventive maintenance to medical devices management in hospitals Methods The management method of preventive maintenance have been carried out in the medical devices management of the whole hospital, and the management effect of preventive maintenance system was analyzed and verified by SPSS analysis and Likert scoring system. Results After the implementation of preventive maintenance system, the normal operation rate of medical devices and the stain-free rate of devices surface were increased ( $t=4.041$ ,  $t=5.701$ ;  $P<0.05$ ), 93.75% of medical staff were generally satisfied with the use of medical devices, 95.83% of medical staff were generally satisfied with the services of clinical medical engineers, only 6.82% of patients were not satisfied with the services of device-assisted treatment, and the overall satisfaction of patients with inpatient services reached 97.73%. Conclusions Effective preventive maintenance of medical devices can effectively reduce the failure rate of devices, reduce the cost of hospital maintenance and improve the effective services time of devices. At the same time, this management method can improve the satisfaction of the services of clinical medical engineers in clinical medical technology departments, and improve the overall satisfaction of patients with inpatient services in hospitals.

## **1. Introduction**

Modern hospitals need a large number of medical devices to assist doctors in diagnosis, treatment, monitoring and life support for patients. The use of medical devices greatly promotes the accuracy, convenience and effectiveness of clinical diagnosis and treatment, and reduces the labor intensity of medical staff [1]. For a long time, all levels of hospitals put the clinical diagnosis and treatment in one of the most important position, but neglected to medical devices preventive maintenance work. It causes some medical devices to run for a long time, and then a variety of

mechanical, electronic and software failures occur, resulting in the sudden interruption of auxiliary diagnosis and treatment of medical devices, affecting medical safety, but also increasing the economic operation cost of hospitals [2]. Making full use of the idle time of medical devices to do a good job of preventive maintenance can effectively reduce the failure rate of medical devices, prolong the start-up time of medical devices, and prevent the occurrence of medical devices related adverse events[3].

In order to reduce the failure rate of medical devices, improve the effective start-up time of medical devices and improve the overall operation efficiency of the hospital, a large hospital in Xi 'an city adopts the preventive maintenance system in the management of medical devices. This paper studied the management effect of the preventive maintenance system on medical devices in hospitals.

## **2. Research materials and methods**

### **2.1. Research materials**

This study takes medical devices of a hospital in Xi 'an as the research objects, excluding a small part of trial devices not listed in the hospital account. The hospital has 3400 beds and 14,213 medical devices in normal use registered in the hospital account.

### **2.2. Research methods**

#### **2.2.1. Preparation stage**

First of all, after a long time of research and discussion, hospital administrators have determined that the preventive maintenance system of medical devices is mainly implemented by the medical equipment department and the clinical medical technology departments. The preventive maintenance system mainly includes: the three-level preventive maintenance system of medical devices for key departments, preventive maintenance system for key medical devices, and the medical devices running security inspection system of clinical medical engineers.

Secondly, the hospital requires clinical medical technology departments to set up medical devices quality and safety management team, responsible for the overall management of the devices quality of the department. The management team consists of no less than 3 people, led by the head of the department. The work content of the management group mainly includes: the supervision of the use of medical devices, the quality supervision of the maintenance of medical devices, the supervision of the maintenance process, and the registration and management of the devices maintenance record books. The management team should hold a meeting at least once every quarter to discuss the operation of medical devices and the implementation of preventive maintenance of medical devices, and propose improvement measures for the problems found in the system and process, so as to continuously improve the management quality.

#### **2.2.2. Implementation stage**

##### **1) Three-level preventive maintenance of medical devices for key departments**

In key departments, nursing staff in clinical medical technology departments are required to carry out daily maintenance of medical devices (level-1 maintenance) every day, and clinical medical engineers carry out quarterly maintenance of medical devices (level-2 maintenance) every quarter, and then clinical medical engineers and manufacturer engineers jointly carry out half-year maintenance of medical devices (level-3 maintenance) every six months, and the medical devices operation records are filled in timely.

The contents of level-1 maintenance include: (1) Nursing staff should clean and disinfect the surface of the medical devices every day, wiping away all stains on the surface of the devices. And they should check the integrity of the accessories, and tidy up all of them; (2) Nursing staff should check every day whether the power supply is electric, whether the gas supply is normal, whether the devices that needs pure water can be supplied water normally; (3) Nursing staff should check the rechargeable devices to be used every day, especially the emergency rescue and transfer devices to see if the power is sufficient, and charge the medical devices those are insufficient in time; (4) Nursing staff should start up the key devices and test them in the self-test procedures every day to ensure that the self-test procedures can pass smoothly and start up normally. If any error is reported in the self-test, contact the clinical engineers in time to deal with it; (5) For medical devices with air filter screens, check whether the filter screens need to be cleaned and replaced [4].

The contents of level-2 maintenance include: (1) Clinical medical engineers should disassemble the machine to clean the internal dust of medical devices; (2) The engineers should check the performance of the rechargeable batteries of the rechargeable medical devices to see whether the batteries are seriously attenuated and need to be replaced; (3) The engineers should check whether the internal consumables of the devices are seriously damaged after long-time use and need to be replaced; (4) Clinical medical engineers use a variety of professional instruments and equipment to check and evaluate the safety of electricity, gas and waterway, and timely deal with potential problems. First, check whether the power supply voltage is normal to prevent damage to the equipment caused by high voltage. Secondly, check whether the gas supply is normal, whether the pressure is in the normal range, if the pressure is low, to maintain the gas supply terminal. Thirdly, check whether the water supply is normal, check whether there is leakage in the water supply pipeline, whether there is leakage in the cleaning tank; (7) The engineers should check and adjust the performance parameters of various medical devices to ensure that the parameters are within the normal range, and timely repair problems found; (8) The engineers should start the machine for self-inspection and enter the quality calibration procedure for testing. For the items that are not passed in the process of self-inspection and quality calibration, refer to the technical data or consult the engineers of manufacturers to solve them; (9) The engineers should check whether the functional components of medical devices can work normally and deal with the problems found in time [5].

The 3-level maintenance is based on the 2-level maintenance. Clinical medical engineers of the hospital and the engineers of manufacturers work together to replace the consumable parts with high installation difficulty, debug the dynamic technical status of the medical equipment, and calibrate the main precision of the important parts, including the adjustment and elimination of noise and vibration, and the adjustment of the level and focal length.

#### 2) Preventive maintenance system for key medical devices in the hospital

The key medical devices of the hospital, including large medical devices in the hospital and high-end precision devices. The preventive maintenance of such devices includes the maintenance of the medical devices themselves, the maintenance of auxiliary devices, and the control requirements for the environment. It mainly includes:(1) Nursing staff should clean the environment every day to ensure that the environment is clean , without dirt and dust, and clean up all kinds of waste liquid and used consumables; (2) Disinfect and clean the medical devices every day; (3) For the devices with requirements on the temperature and humidity of the environment, nursing staff of the department should measure the temperature and humidity of the environment with instruments every day, check the operation status of the precision air conditioner, water cooler and other equipment, and eliminate the alarm in time if there is any; (4) Engineers should clean the outdoor units of air conditioners and water coolers regularly to ensure that the air inlets and outlets are smooth; (5) The devices operators in clinical medical technology departments should perform self-

check upon starting up every day, check the devices status, report the faults found in self-check in time, and record the starting time and shutdown time every day; (6) The devices operators should test the quality calibration procedure of medical devices every day to ensure that all functional modules are normal; (7) Clinical medical engineers and engineers of manufacturers regularly debug the parameters and calibrate the quality of medical devices together, and check the running status of the auxiliary equipment [6].

3) The medical devices running security inspection system of clinical medical engineers

Clinical medical engineers inspect the running status of medical devices in their respective departments every three months. The contents of the inspection include: (1) The engineers should ask the devices operators about the recent running status of devices and whether there are suspected failures; (2) The engineers should check whether the surface of the devices to be used is clean and whether the devices status identification cards are correctly marked; (3) The engineers should check whether the labels of periodic mandatory testing devices are within the qualified use period; (4) The engineers should make a comprehensive assessment of the operating environment of the devices and check the possible risks; (5) The engineers should check the record of the devices operation record books, and analyze the suspected failure situation registered in the record books; (6) The engineers should make an overall assessment of the running status of medical devices, ask the departments to stop using the devices with potential safety risks and conduct timely inspection.

## **2.3. Observation indicators**

### **2.3.1. Comparison of management effects**

The management effects of medical devices in the same department before and after the implementation of the preventive maintenance system were compared. In this study, 132 medical devices in the emergency surgery department were selected as the research objects, and the records included the total number of use times, normal operation times and the number of stain-free surface of medical devices.

### **2.3.2. Satisfaction survey**

Three months after the implementation of the preventive maintenance system, 50 medical staff were randomly selected from all clinical technical departments of the hospital to conduct a questionnaire survey on the satisfaction of the use of medical devices and the services of clinical medical engineers. At the same time, 50 inpatients were randomly selected from the hospital to conduct a questionnaire survey on the satisfaction of the devices inspection, treatment and inpatient services.

## **2.4. Data analysis**

The count data in 2.3.1 were processed by SPSS20.0 software and compared by  $\chi^2$  test, and  $P < 0.05$  indicated that the difference was statistically significant; the international Likert scoring system was used for the satisfaction survey of 2.3.2, and the results were analyzed.

## **3. Results**

### **3.1. Comparison of management effects results**

The comparison of medical devices management effects before and after the implementation of preventive maintenance system is shown in Table 1. It can be seen that after the implementation of

preventive maintenance system, the normal operation rate of medical devices and the stain-free rate of devices surface are improved ( $\chi^2=4.041$ ,  $2=5.701$ ;  $P < 0.05$ ).

Table 1: Comparative analysis table of medical equipment management effects [n (%)]

Group	Total number of devices used	Normal operation	Stain-free surface of devices
Before	972	938(96.50)	895(92.08)
After	979	976(99.70)	966(98.67)
$\chi^2$	-	4.041	5.701
$P$	-	0.044	0.017

### 3.2. Satisfaction survey results

Satisfaction survey results after the implementation of preventive maintenance system are shown in Likert 5 scale of Table 2, in which 48 valid questionnaires were collected by medical staff and 44 valid questionnaires by inpatients. It can be concluded that 93.75% of medical staff were generally satisfied with the use of medical devices, 95.83% of medical staff were generally satisfied with the services of clinical medical engineers. Only 6.82% of inpatients were not satisfied with the services of device-assisted treatment, and the overall satisfaction of patients with inpatient services reached 97.73%.

Table 2: Likert 5 scale table of satisfaction questionnaire results after preventive maintenance implementation [n (n %)]

Questionnaire object	n	Survey item	Very/relatively satisfied	Moderately satisfied	Relatively/very dissatisfied
Medical staff	48	Satisfaction with medical devices use	32(66.67)	13(27.08)	3(6.25)
		Satisfaction with engineers services	35(72.92)	11(22.91)	2(4.17)
Inpatients	44	Satisfaction with the services of device-assisted treatment	31(70.45)	10(22.73)	3(6.82)
		Satisfaction with inpatient services	35(79.55)	8(18.18)	1(2.27)

### 4. Discussion and summary

At present, most medical devices lack effective preventive maintenance. When the medical devices are completely out of service, they could only be repaired by clinical medical engineers or manufacturer engineers. Only some medium and large high-end medical devices within the warranty period can obtain part of the preventive maintenance work provided by the engineers of the manufacturer. On the other hand, in order to ensure the safe operation of high-end medical devices, the hospital will purchase extended warranty services from the medical devices manufacturer outside the warranty period, and the manufacturer engineers will provide preventive maintenance and warranty services [7]. This situation is mainly caused by the following reasons:

(1) Clinical medical engineers in many hospitals have a low level of education, many of them are at the undergraduate or even junior level, and their professional sources are also board. In addition to a small number of engineers from biomedical engineering majors, many engineers come from mechanical, electronic and automation majors, resulting in uneven levels of engineers. Many

engineers do not have the knowledge reserve of clinical medicine, resulting in the lack of basic maintenance knowledge of medical devices.

(2) The duties of the medical equipment department in many hospitals are confused and unclear. Clinical medical engineers are busy with various affairs irrelevant to their own work every day, so they do not have enough time to inspect and maintain medical devices in various clinical and medical technology departments, and they do not even have enough time to learn relevant skills.

(3) Many medical devices manufacturers do not provide sufficient training on preventive maintenance for clinical medical engineers and medical staff in hospitals, resulting in the lack of preventive maintenance skills of medical devices for engineers and medical staff.

(4) The workload of clinical medical engineers in many hospitals is too large and their salaries are too low. As a result, the hospitals lack relevant incentive policies for the assessment and management of engineers, leading to the lack of motivation for engineers to carry out proactive preventive maintenance work [8].

As a result, the devices failure rate of the hospital is high, and the devices failure and shutdown affect the normal operation of the departments.

In this study, in order to improve the management efficiency of medical devices, a hospital in Xi'an adopted the preventive maintenance system in the management of medical devices. Due to the active elimination of possible hidden dangers of devices, and timely cleaning and disinfection of devices surface, the normal operation rate of medical devices and the stain-free rate of devices surface were improved ( $\chi^2=4.041$ ,  $2 = 5.701$ ;  $P < 0.05$ ); after the preventive maintenance system was adopted, engineers took the initiative to carry out preventive maintenance of medical devices in the department, so that the medical devices were in good condition, and medical staff's satisfaction with the use of medical devices reaches 93.75%, and medical staff's overall satisfaction with the services of clinical medical engineers reaches 95.83%; as the medical devices were in good condition and no various faults occurred during the device-assisted treatment, the inpatients' satisfaction with the services of device-assisted treatment reached 93.18%, and the overall satisfaction with the inpatient services reached 97.73%.

In conclusion, effective preventive maintenance of medical devices can effectively reduce the failure rate of devices, reduce the cost of hospital maintenance and improve the effective services time of devices. At the same time, this management method can improve the satisfaction of the services of clinical medical engineers in clinical medical technology departments, and improve the overall satisfaction of patients with inpatient services in hospitals [9]. The management method of preventive maintenance of medical devices can improve the management efficiency of medical devices and should be popularized and applied in hospital management.

## 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), Science and Technology Planning Project of Xi'an (2019114613YX001SF044(14)).

## References

- [1] Kadakia Kushal T, Beckman Adam L, Ross Joseph S et al. *Renewing the Call for Reforms to Medical Device Safety-The Case of Penumbra*. [J]. *JAMA Intern Med*, 2022, 182: 59-65.
- [2] Shamayleh Abdulrahim, Awad Mahmoud, Farhat Jumana, *IoT Based Predictive Maintenance Management of Medical Equipment*. [J]. *J Med Syst*, 2020, 44: 72.
- [3] Alsohime Fahad, Temsah Mohamad-Hani, Hasan Gamal et al. *Reporting adverse events related to medical devices: A single center experience from a tertiary academic hospital*. [J]. *PLoS One*, 2019, 14: e0224233.

- [4] Al-Duais Fuad S, Mohamed A-B A, Jawa Taghreed M et al. Optimal Periods of Conducting Preventive Maintenance to Reduce Expected Downtime and Its Impact on Improving Reliability. [J]. *Comput Intell Neurosci*, 2022, 2022: 7105526.
- [5] Saleh Neven, Balestra Gabriella, Comprehensive framework for preventive maintenance priority of medical equipment. [J]. *Annu Int Conf IEEE Eng Med Biol Soc*, 2015, 2015: 1227-30.
- [6] Saleh Neven, Sharawi Amr A, Elwahed Manal Abd et al. Preventive maintenance prioritization index of medical equipment using quality function deployment. [J]. *IEEE J Biomed Health Inform*, 2015, 19: 1029-35.
- [7] Hernández-López L Angelica, Pimentel-Aguilar Ana B, Ortiz-Posadas Martha R, An index to prioritize the preventive maintenance of medical equipment. [J]. *Health Technol (Berl)*, 2020, 10: 399-403.
- [8] Alikhani Parivash, Vesal Sahar, Kashefi Parviz et al. Application and preventive maintenance of neurology medical equipment in isfahan alzahra hospital. [J]. *Int J Prev Med*, 2013, 4: S323-9.
- [9] Webber Christina M, Martínez-Gálvez Gabriel, Higuera Manuela Lopera et al. Developing Strategies for Sustainable Medical Equipment Maintenance in Under-Resourced Settings. [J]. *Ann Glob Health*, 2020, 86: 39.