

Research on Improvement of Turnover Rate of Deployment Equipment in the Medical Equipment Deployment Center of Hospital Based on FMEA Risk Model

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Abstract: *Objective To explore the improvement effect of FMEA risk model on the turnover rate of deployment equipment in the medical equipment deployment center of hospital. Methods In the management of deployment equipment in the medical equipment deployment center, FMEA risk model was used to conduct failure mode analysis on the potential risk factors leading to the low turnover rate of deployment equipment, the key potential risk factors of the low turnover rate of deployment equipment were screened out and corresponding improvement measures was formulated according to the key potential risk factors. The effects of the improvement measures before and after implementation were compared and analyzed. Results After the implementation of FMEA risk model improvement measures, the monthly equipment turnover rate of deployment equipment tended to increase month by month, and the quarterly turnover rate increased significantly. It increased from 25.88% before the implementation of the measures to 30.27% after the implementation. Conclusions FMEA risk model could significantly reduce the failure rate of the equipment, reduce the loss rate and damage rate of equipment accessories, and improve the monthly and quarterly turnover rate of the deployment equipment. FMEA risk model can improve the turnover rate of deployment equipment in the medical equipment deployment center, and this method is suitable for promotion and application in equipment management of hospitals.*

Keywords: *FMEA risk model, Turnover rate, Risk factor, Failure mode*

1. Introduction

In recent years, in the construction of the hospital, clinical departments have purchased a large number of medical equipment. As most of the clinical departments of hospitals adopt "self-management and self-use" mode in the management of medical equipment, it is difficult to borrow medical equipment between clinical departments, resulting in the repeated purchase of medical equipment between clinical departments in the hospital [1,2]. Among them, the utilization rate of some equipment in the departments is not high, excepting for emergency and special cases. Most of the time the equipment is idle, resulting in the waste of medical resources. The medical equipment deployment center of the hospital is the equipment management office established to alleviate the temporary peak demand for medical equipment in the clinical department of the hospital. The medical equipment deployment center can avoid the repeated purchase of medical equipment by clinical departments, reduce the idle rate of equipment, improve the utilization rate of equipment, adjust the temporary demand of clinical departments for medical equipment during the peak period of patients' visit and hospitalization in different clinical departments. And it can also cope with the temporary demand for medical equipment during the waiting period of medical equipment maintenance, so as to ensure the smooth operation of clinical departments [3]. In the actual management of medical equipment deployment center, the failure rate of deployment equipment is too high, and some equipment is rented and used by one single clinical departments for a long time but not returned, resulting in a low turnover rate of deployment equipment, affecting the normal flow of deployment equipment. In order to improve the utilization and turnover rate of medical equipment

in the deployment center, it is necessary to effectively manage the equipment in the deployment center.

Failure Mode and Effect Analysis (FMEA) risk model management method is a risk intervention method to analyze potential failure modes and formulate corresponding improvement measures. It was first used in the field of aviation and automobile industry quality control, and in recent years, it has been gradually applied in the field of medicine, for the management of risk in medical management [4-6]. In this study, FMEA risk model was used to analyze the risk factors in the management of medical equipment in the medical equipment deployment center, so as to verify the improvement effect of FMEA risk model on the turnover rate of medical equipment in the medical equipment deployment center.

2. Research Materials and Methods

2.1. Research Materials

The medical equipment deployment center of a hospital in Xi 'an is subordinate to the Medical Equipment Management Department. There are 4 clinical medical engineers in charge of the management. Among them, 3 engineers are responsible for arranging and maintaining the equipment every day, and 1 engineer is responsible for the deployment of the equipment. The deployment center has 154 sets of medical equipment, including ventilators, monitors, blood glucose meters, islet pumps, micropumps, infusion pumps, defibrillation devices and so on. Since July 2021, the FMEA risk model management has been implemented in the deployment center to improve the equipment turnover rate. This study took all medical equipment in the deployment center as the research objects.

2.2. Research Methods

FMEA risk model was used to analyze and manage the medical equipment in the deployment center. The specific implementation steps include the following aspects.

2.2.1. Identify the Central Theme of the Study

There were many failure modes in the management of medical equipment in the deployment center. These failure modes directly affected the turnover rate of equipment in the deployment center. This paper analyzed the failure modes of medical equipment management in the deployment center.

2.2.2. Set up the Management Team

The FMEA management team composed of the clinical medical engineers in charge, the medical staff of clinical departments and the medical staff of the Medical Department was established. The team was responsible for the data record, failure mode analysis, cause analysis, measure formulation, supervision and implementation of measures, and analysis of the data of assessment indicators during the entire FMEA risk model management process. After the establishment of FMEA management team, team members firstly accepted the FMEA risk management training, team members were required to be able to master the FMEA risk management process and analysis methods [7].

2.2.3. Identify the Process

The FMEA management team summarized all kinds of problems that led to low equipment turnover rate in the past equipment management of the deployment center, sorted out the process of equipment management of the deployment center, and identified the weak links in the management for failure mode analysis [8].

2.2.4. Establishment of Quantitative Evaluation Criteria for Failure Mode Parameters

The FMEA management team quantifies the failure mode parameters of potential risk factors for low equipment turnover rate in the deployment center. The parameters evaluated included the Occurrence frequency(O), the Severity(S) and the Detectability(D) of the risk factors of medical equipment management in the deployment center. The evaluation value of these three parameters ranges from 1 to 10. The larger the score of O, the higher the occurrence frequency of the risk factor, the larger the score of S, the more serious the consequences of the risk factor after the occurrence of the risk factor, The higher the score of D, the more difficult the risk factor is to be detected in equipment management [9,10]. After rigorous and objective research and analysis, the FMEA management team defined the evaluation criteria for each parameter index score.

2.2.5. Calculation of Risk Factor RPN Value

The FMEA management team made a list of potential risk factors for the low turnover rate of medical equipment in the deployment center, and evaluated the failure mode parameters O, S, D of each risk factor according to the evaluation criteria of parameter index score. The Risky Priority Number (RPN) of each risk factor was calculated according to the failure mode parameter values of each risk factor. The RPN value can be calculated as $RPN=O \times S \times D$ [11]. According to the RPN value of each risk factor, the list of potential risk factors was sorted out, and the key potential risk factors with RPN value greater than 125 were screened [12], and the selected key potential risk factors and their adverse consequences were analyzed. The key potential risk factors are shown in Table 1 below.

Table 1: Analysis of key potential risk factors for low turnover rate of medical equipment in medical equipment deployment center

Key potential risk factor	Adverse consequence	O	S	D	RPNvalue
Medical staff had a weak sense of responsibility for the management of employment equipment	Equipment was roughly operated and handled, which led to equipment failure.	8	10	6	480
Clinical medical engineers had a weak sense of responsibility for the management of employment equipment	When arranging equipment in the deployment center, hidden trouble was not found in time, which led to equipment failure	9	10	7	630
Equipment rental costs were too low	Clinical departments were not sensitive to the use fee of rented equipment and they did not return the equipment in time	10	8	4	320
The equipment failure rate was too high	The equipment was in the breakdown maintenance period for a long time and could not be put into use	7	9	8	504
High loss rate and damage rate of equipment accessories	The equipment could not be put into use after the equipment accessories were lost or damaged	8	7	7	392
The equipment vibrated violently and fell down accidentally during the transportation of the equipment	Vibration, accidental fall caused equipment failure	4	9	10	360
Medical staff were not familiar with the operation of employment equipment	Misoperation of equipment led to equipment failure	5	10	7	350

2.2.6. Develop Improvement Measures

For the key potential risk factors screened above, the FMEA management team formulated corresponding improvement measures to intervene the key potential risk factors leading to the low equipment turnover rate in the deployment center. Through brainstorming, the following improvement measures were identified.

(1) Personal literacy training for medical staff and clinical medical engineers

Through personal quality training for medical staff and clinical medical engineers, the awareness of dedication of medical staff and clinical medical engineers, the awareness of caring for medical equipment and active participation in management should be strengthened. In such a case, in the operation and use of the rental equipment, the medical staff could handle the equipment with care and reduce the damage of deployment equipment and accessories caused by the rough use of the equipment by the medical staff. At the same time, due to the improvement of personal literacy, clinical medical engineers took the initiative to manage the deployment of equipment, and in the process of equipment management, they could timely deal with potential safety hazard found.

(2) Medical staff should be trained in the operation, use and simple maintenance of the employment equipment

Clinical medical engineers and manufacturers' engineers provided medical staff with training on the operation, use and simple maintenance of the employment equipment. They conducted on-site operation training for medical staff, and explained common troubleshooting methods and parameter setting methods in the daily operation of rental equipment, which could reduce equipment failures caused by

medical staff's misoperation of the equipment.

(3) The preventive maintenance system for employment equipment should be developed

The preventive maintenance system for employment equipment should be developed, including preventive maintenance of equipment that had been deployed to clinical departments and preventive maintenance of equipment to be deployed in the deployment center. The preventive maintenance of the equipment that had been deployed to the clinical department was completed by the medical staff, including cleaning the surfaces of the equipment, checking the equipment and accessories, charging the equipment with insufficient power in time, promptly repairing the faulty equipment, transporting the faulty equipment to the deployment center for maintenance. The preventive maintenance of the equipment to be deployed in the deployment center is performed by clinical medical engineers, including cleaning the surfaces of the equipment, arranging and inspecting the equipment and accessories, replacing the consumables of the equipment, dusting the inside of the equipment, checking the hidden troubles inside the equipment, calibrating the equipment regularly, and timely repairing faulty equipment.

(4) The rental cost of deployment equipment should be appropriately adjusted

The rental cost of the equipment in the deployment center should be adjusted, and a step-by-step rental fee should be implemented, in which the longer the rental period was, the higher the daily rental fee was. By adopting this method, clinical departments could return the equipment in time after use.

(5) The accessories of the equipment should be marked with significant identification labels of the deployment center

The equipment accessories of the deployment center should be marked with significant identification labels of the deployment center to ensure that the equipment would not be used alternately with other equipment accessories in the clinical departments, which would lead to damage and loss of the accessories.

(6) Clinical departments should be equipped with special deployment equipment transport carts

The clinical departments should be equipped with special deployment equipment transport carts for the deployment equipment acquisition and delivery process. The transport carts adopted shock absorption design and was equipped with binding for fixed equipment, which could minimize the damage caused by vibration and fall during the equipment transport process. The engineers of the deployment center regularly inspected the transport carts to eliminate the hidden trouble of the transport carts.

2.2.7. Supervise the Implementation

The FMEA management team supervised the process to ensure the effective implementation of the improvement measures.

2.3. Evaluation Indicators

Before and after the implementation of the FMEA risk model improvement measures, the turnover rate of deployment equipment in one quarter was compared, including the monthly turnover rate and quarterly turnover rate of deployment equipment. The turnover rate of the equipment deployment refers to the turnover frequency of the equipment in the deployment center within a certain period of time. The turnover rate of deployment equipment = the total times of equipment deployed / (the total number of deployment equipment × the total number of days) × 100%.

2.4. Statistical Analysis

The above data were input into Excel table for statistical analysis, and the turnover rate was expressed as percentage.

3. Results

Before and after the implementation of FMEA risk model improvement measures, the quarterly turnover rate of the equipment deployment is shown in Table 2 below. It can be concluded that after the implementation of FMEA risk model improvement measures, the monthly equipment turnover rate of deployment equipment tended to increase month by month, and the quarterly turnover rate increased significantly. It increased from 25.88% before the implementation of the measures to 30.27% after the

implementation.

Table 2: Statistics on the device turnover rate of the medical device deployment center before and after the implementation of the improvement measures

Group Period	Before			After		
	Q2 2021			Q3 2021		
	Apr	May	Jun	Jul	Aug	Sep
Monthly deployment times (n)	1227	1218	1221	1354	1448	1486
Monthly turn over rate (%)	25.70	26.36	25.58	29.31	30.33	31.13
Quarterly turnover rate (%)	25.88			30.27		

4. Discussion

The establishment of medical equipment deployment center can optimize the overall medical equipment allocation of the hospital, avoid the repeated purchase of the same type of medical equipment by different clinical departments, save medical equipment resources, reduce hospital costs, and meet the temporary increase in equipment use needs of clinical departments, which is the development direction of modern hospital construction. In order to reduce cost and increase benefit, more and more hospitals have set up medical equipment deployment center. At present, the development of equipment management in the medical equipment deployment center is still in the primary stage. The clinical departments do not cherish the equipment rented from the deployment center, and the medical staff are not skilled in operating the equipment of the deployment center, the equipment might bump and fall on the way of transporting. In addition, the equipment does not accept preventive maintenance. The above situations lead to a high failure rate of the equipment. At the same time, due to the lax management of equipment accessories, the loss and damage rate of accessories is high, and the equipment allocated to clinical departments is not returned in time, which finally makes the turnover rate of employment equipment in clinical departments is not high. Improving the turnover rate of deployment equipment can greatly improve the utilization rate of the deployment equipment, and give full play to the role of the deployment equipment in regulating the use of medical equipment in clinical departments.

In this study, FMEA risk model was used to conduct failure mode analysis on potential risk factors leading to low equipment turnover rate in the management of deployment equipment. The quantitative evaluation standard was formulated for the failure mode parameters of the risk factors, and the RPN values of the risk factors was calculated according to the failure mode parameters. Then the key potential risk factors of low turnover rate of deployment equipment were screened out, and corresponding improvement measures were formulated according to the key potential risk factors. After the implementation of the improvement measures, medical staff received the personal literacy training, and the operation and simple maintenance training of deployment equipment, medical staff cared more about the use of deployment equipment, and they were able to operate the equipment correctly and perform simple maintenance on deployment equipment. Simple faults could be dealt with in a timely manner, and medical staff used special transport carts to transport deployment equipment, avoiding falling and bumping during the transport process. In addition, clinical medical engineers carried out effective preventive maintenance on the deployment equipment, and calibrated the deployment equipment in time, so that the failure rate of the equipment and accessories was significantly reduced. Meanwhile, the identification labels of the deployment equipment accessories could effectively reduce the loss rate of equipment accessories. And the rental cost of employment equipment was appropriately adjusted to urge clinical departments to return the used deployment equipment in time. As a result, after the implementation of the FMEA risk model improvement measures, the monthly equipment turnover rate of deployment equipment tended to increase month by month, and the quarterly turnover rate increased significantly. It increased from 25.88% before the implementation of the measures to 30.27% after the implementation. The use of FMEA risk model had obvious effect on the improvement of the turnover rate of deployment equipment in the deployment center.

5. Conclusions

In the management of deployment equipment in the deployment center, FMEA risk model was used to analyze the risk factors of low turnover rate of deployment equipment, and corresponding improvement measures were formulated, which could significantly reduce the failure rate of the equipment, reduce the loss rate and damage rate of equipment accessories, and improve the monthly and

quarterly turnover rate of the deployment equipment. FMEA risk model can improve the turnover rate of deployment equipment in the deployment center, and this method is suitable for promotion and application in equipment management of hospitals.

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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