

Research on the Improvement Effect of Quality Improvement Measures Based on Fishbone Diagram Analysis Method on the Management of Emergency Equipment in Hospital

Qinfeng Liu¹, Weibin Zhai², Hui Liu¹, Tao Wang³, Enke Zhang^{1,*}

¹Medical Equipment Management Department, Shaanxi Provincial People 's Hospital, Xi 'an, Shaanxi, 710068, China

²Information Management Department, Shaanxi Provincial People 's Hospital, Xi 'an, Shaanxi, 710068, China

³Department of Medical Imaging, Hospital of Stomatology, Xi 'an Jiaotong University, Xi 'an, Shaanxi, 710004, China

*Corresponding author

Keywords: Emergency equipment, fishbone diagram, root cause, management effect

Abstract: Objective To explore the application value of quality improvement measures based on fishbone diagram analysis method in improving the management effect of emergency equipment in hospital. **Method** Facing the problems in the use and management of emergency equipment, a hospital in Xi 'an adopted fishbone diagram analysis method to analyze the root causes of the problems from the five aspects of Man, Machine, Material, Method and Milieu. The corresponding improvement measures were put forward according to the problems. The management effects of emergency equipment before and after the implementation of the improvement measures were compared. **Results** In the comparison of the use and management effects of emergency equipment to be used, after the implementation of quality improvement measures based on fishbone diagram, the ratio of emergency equipment without stains on surfaces, the ratio of fully charged emergency equipment, the ratio of emergency equipment in the qualified measurement period increased significantly ($\chi^2=18.587$, $\chi^2=72.090$, $\chi^2=9.207$; $p<0.05$); in the comparison of failure rates of emergency equipment in the whole hospital, the failure rate of emergency equipment in the whole hospital decreased from 2.54% before the implementation of quality improvement measures to 0.79% after the implementation. **Conclusions** The quality improvement measures based on fishbone diagram analysis method can significantly improve the management effect of emergency equipment, and has great application value in the management of emergency equipment in hospitals.

1. Introduction

The treatment level of critically ill patients is an important symbol to measure the medical level of a hospital. The effective treatment of critically ill patients is inseparable from the use of emergency

equipment, which is an important part of hospital equipment. Compared with other medical equipment, the state of emergency equipment directly affects the success rate of emergency treatment and the safety of medical treatment [1]. Therefore, in the hospital equipment management, the management of emergency equipment is particularly important. The good state of emergency equipment can ensure the smooth and orderly operation of the emergency process, and ensure that patients get effective treatment. The effective maintenance and use management of emergency equipment is an important guarantee for the normal operation of medical activities in hospitals.

The fishbone diagram method is a method to find out the root cause of problems through analysis and discussion. It is a common method in modern enterprise quality management. The fishbone diagram method is also known as causal method or 5M factor method. It is used to analyze the root causes of problems from five aspects including Man, Machine, Material, Method and Milieu, and corresponding management measures according to the root causes are formulated, so as to improve the current situation of problems and achieve the purpose of quality improvement [2-4].

In order to improve the management effect of emergency equipment, a hospital in Xi 'an adopted fishbone diagram method in the quality management of emergency equipment, and took quality improvement measures based on fishbone diagram analysis method. This study compared and analyzed the management effects of emergency equipment before and after the implementation of quality improvement measures, so as to verify the application value of quality improvement measures based on fishbone diagram analysis method in improving the management effect of emergency equipment in hospitals.

2. Research materials and methods

2.1. Research materials

This study took all the emergency equipment in use in the hospital as the research objects. The hospital has emergency medicine department, emergency surgery department, pre-hospital emergency department, ICU, EICU, RICU, CCU and other departments responsible for patient first aid. There are 1654 sets of emergency equipment, including ventilators, cardiac defibrillation apparatuses, cardiopulmonary resuscitation apparatuses, expectorators, electric aspirators, simple breathing apparatuses, injection pumps, infusion pumps, monitors and so on.

2.2. Research methods

2.2.1. Using problem summary

Medical equipment management department and clinical departments jointly set up a Continuous Quality Improvement (CQI) Team to check the emergency equipment in the hospital and summarize the problems found [5]. The main problems in the use of emergency equipment are as follows: (1) mechanical and circuit control faults occurred in the equipment; (2) leakage of liquid and air due to aging of consumables such as pipes and rubber rings in the equipment; (3) regular consumables of the equipment were not replaced on time; (4) damage of the shell of the equipment; (5) the equipment failed to pass the startup self-tests;(6) accessories of the equipment were aging or incomplete, resulting in inaccurate measurement data or equipment alarms; (7) the equipment software system time is not accurate; (8) equipment batteries were not fully charged;(9)there were various stains on the surfaces of the equipment; (10)no status label was attached to equipment;(11)no operation procedure description was attached to equipment;(12) equipment was not in a fixed position (13) equipment was not within the valid time of qualified measurement;(14) there was no complete handover record of equipment; (15) equipment maintenance records were incomplete; (16)patients

were treated with emergency equipment for a long time, resulting in the formation of pressure ulcers on the local skin.

2.2.2. Fault cause analysis

For the above problems encountered in the use of emergency equipment, the CQI team held a quality improvement meeting, in which members had a brainstorming discussion, and made a deep analysis of the causes of the failures from five aspects of the fishbone diagram [6].

1) Man

In terms of Man factor, the analysis was mainly carried out from three perspectives: clinical medical engineers, medical staff and patients. In terms of clinical medical engineers, the main causes were that engineers did not regularly carry out inspection of emergency equipment, did not timely carry out preventive maintenance of emergency equipment, engineers lacked of maintenance skills, lacked of understanding of the internal mechanical structure and circuit function modules of emergency equipment, and engineers did not timely carry out measurement and quality control of emergency equipment. In terms of medical staff, the main causes were that they did not turn on emergency equipment every day to check whether it was fault, did not clean and tidy up the equipment properly, did not record the handover of emergency equipment on time. Meanwhile, they were not familiar with the operation and maintenance process of emergency equipment, they were not familiar with the transport process, so that they could not place the equipment properly during the transport process, which led to the equipment falling to cause failures, and they did not know how to prevent and care for pressure ulcers. In terms of patients, the main causes were the damage to the equipment caused by the pulling and dumping of the treatment related equipment caused by patients' abnormal behaviors, and the patients' own skin allergy led to the formation of pressure ulcers when they were treated by the equipment.

2) Machine

In terms of Machine factors, the main causes were the aging of internal electronic components of the equipment, which led to occasional failures of the equipment, or the medical staff could not set the parameters of the equipment correctly, which led to problems in use.

3) Material

In terms of material factors, the main causes were the aging of consumables or accessories caused by long-term use or damage caused by improper use, and the improper selection of consumables and materials led to the formation of pressure ulcers after long-term use.

4) Method

In terms of Method factors, the main causes were the lack of preventive maintenance system of emergency equipment, the lack of quality control and measurement management of emergency equipment, the lack of daily use management system of medical staff for emergency equipment, the lack of behavior management system for preventing pressure ulcers, and the lack of transport management system.

5) Milieu

In terms of Milieu factors, the main causes was that the milieu of the ward where emergency equipment was used was crowded and there were many sundry things, which led to the interference between the equipment. The pipes or wires of emergency equipment were easy to intertwine with other equipment or sundry things, resulting in adverse events in use. In addition, there was a lot of dust in the milieu of the ward where emergency equipment was used. During the use of emergency equipment, the dust was easy to enter the equipment through heat sink of the equipment, and the dust adheres to the circuit board, which might lead to unstable performance of the equipment.

2.2.3. Corresponding improvement measures taken

For the above fault causes, the corresponding improvement measures are also taken from the five aspects of Man, Machine, Material, Method and Milieu.

1) In terms of Method factors, clinical medical engineers and medical staff held many seminars, and extensively consulted references. The CQI team formulated the system specifications of three-level preventive maintenance of emergency equipment, the quality control and measurement management specifications of emergency equipment, the daily cleaning, disinfection and use management specifications of emergency equipment for medical staff, the code of conduct for preventing pressure ulcers and the the system specifications of transport management.

2) In terms of Man factors, the following improvement measures were proposed: (1) clinical medical engineers were required to adhere to continuing education learning, continuously improve their professional and technical level, and link the learning score of continuing education with personal year-end assessment and professional title promotion; (2) clinical medical engineers were required to strictly implement the three-level preventive maintenance system of emergency equipment, and timely conduct quality control and measurement of emergency equipment; (3) medical staff should be trained on equipment operation and maintenance, pressure ulcer prevention and patient transport process; (4) medical staff should carry out daily maintenance of emergency equipment. They should clean, disinfect and simply maintain the equipment every day, should correctly hang the status label of emergency equipment and the operation process of emergency equipment, and should locate and store the emergency equipment properly; (5) medical staff should strictly follow the code of conduct and training content for preventing pressure ulcers to reduce the possibility of pressure ulcers in patients; (6) medical staff should transport patients in strict accordance with the transport management standards and training content, so as to reduce the possibility of accidental damage to emergency equipment during the transport process.

3) In terms of Machine factors, the following improvement measures were proposed: (1) clinical medical engineers should be able to timely replace aging equipment components; (2) medical staff can correctly set parameters of emergency equipment through training and learning of equipment operation; (3) clinical medical engineers should carry out measurement and quality control of emergency equipment in time to ensure the safety and effectiveness of emergency equipment; (4) clinical medical engineers should strictly implement the three-level preventive maintenance according to the regulations and specifications to ensure that emergency equipment run in the best condition; (5) for emergency equipment that failed to be measured for many times and emergency equipment that could not be maintained, it should be scrapped in time.

4) In terms of Material factors, the damaged accessories of emergency equipment should be replaced in time, and the aged equipment consumables should be updated. For patients with a high risk of pressure ulcers, the consumables or accessories containing sensitizing materials should be replaced in time to avoid the formation of pressure ulcers.

5) In terms of Milieu factors, it is required to sort out the milieu around the emergency equipment, timely clean up the equipment and sundry things unrelated to the first aid to ensure that the first aid channel is unobstructed and the space for emergency equipment is barrier-free. At the same time, the environment of the emergency ward should be cleaned and dusted every day to ensure that the environment of the emergency equipment is dust-free.

2.3. Effect evaluation

2.3.1. Comparison of management effects of emergency equipment to be used

Before and after the implementation of quality improvement measures based on fishbone diagram

analysis, 200 sets of emergency equipment to be used were randomly selected from the whole hospital, and the management effects of the emergency equipment were compared, including the ratio of emergency equipment without stains on surfaces, the ratio of fully charged emergency equipment, the ratio of emergency equipment in the qualified measurement period.

2.3.2. Comparison of failure rates of emergency equipment in the whole hospital

Before and 2 months after the implementation of quality improvement measures, 1654 sets of emergency equipment in the hospital were inspected, and the equipment failures before and after the implementation were compared and analyzed.

2.4. Statistical analysis

SPSS software was used to process the application effect data of emergency equipment management in 2.3.1. This kind of data were count data and was analyzed by chi-square test. $P < 0.05$ indicated statistical significance. The failure rate data of emergency equipment in 2.3.2 were expressed as percentage.

3. Results

3.1. Comparison results of management effects of emergency equipment to be used

The comparison results of the use and management effect of emergency equipment to be used before and after the implementation of quality improvement measures based on fishbone diagram are shown in Table 1 below. It can be concluded that after the implementation of quality improvement measures based on fishbone diagram, the ratio of emergency equipment without stains on surfaces, the ratio of fully charged emergency equipment, the ratio of emergency equipment in the qualified measurement period increased significantly ($\chi^2=18.587$, $\chi^2=72.090$, $\chi^2=9.207$; $p < 0.05$), the quality improvement measures based on fishbone diagram method had significant improvement effect on the use and management of emergency equipment.

Table 1: Comparison of management effects of emergency equipment to be used [n (%)]

Group	n	Number of fully charged emergency equipment	Number of emergency equipment without stains on surfaces	Number of emergency equipment in the qualified measurement period
Before	200	175(87.50)	117(58.50)	191(95.50)
After	200	197(98.50)	189(94.50)	200(100)
χ^2	-	18.587	72.090	9.207
P	-	0.000	0.000	0.002

3.2. Comparison results of failure rates of emergency equipment in the whole hospital

Table 2: Comparison results of failure rates of emergency equipment in the whole hospital

Group	Total number	Failure number of emergency equipment	Failure rate of emergency equipment
Before	1654	42	2.54%
After	1654	13	0.79%

The failure statistics of emergency equipment in the whole hospital before and after the

implementation of quality improvement measures based on fishbone diagram method are shown in Table 2 below. It can be concluded that after the implementation of quality improvement measures based on fishbone diagram method, the failure rate of emergency equipment in the whole hospital decreased from 2.54% before the implementation of quality improvement measures to 0.79% after the implementation. The quality improvement measures based on fish bone diagram method had obvious effect on improving the failure rate of emergency equipment in the whole hospital.

4. Discussion

The emergency equipment of the hospital can assist doctors to rescue critically ill patients and reduce the critical condition of patients. In this process, every minute of rescue time is precious. In order to ensure the success rate of rescue, it is necessary to ensure the smooth operation of the whole rescue process, and the emergency equipment of each link and function is in the best available state. Therefore, the management and use of emergency equipment is the top priority of medical equipment management in hospitals. At present, many hospitals use emergency equipment heavily in the management of emergency equipment, but rarely carry out maintenance, resulting in equipment prone to failure, affecting medical safety. Fishbone diagram analysis is a common method in quality improvement. By using this method, the root causes of problems can be found out in time, the corresponding improvement measures can be put forward according to the root causes, the corresponding regulations and norms are formulated, and the improvement measures can be effectively implemented, so as to improve the found problems.

In this study, facing the problems in the use and management of emergency equipment in the hospital, the fishbone diagram analysis method was used to analyze the root causes of the problems from the five aspects of Man, Machine, Material, Method and Milieu, and the quality improvement measures based on fishbone diagram analysis method were made. In terms of the comparison of the use and management effects of emergency equipment to be used, medical staff cleaned and maintained emergency equipment every day, checked the status of emergency equipment in time, hung the corresponding status identification card on the equipment, checked the charging status of batteries of equipment, located and stored emergency equipment properly. As a result, the ratio of emergency equipment without stains on surfaces, the ratio of fully charged emergency equipment, the ratio of emergency equipment in the qualified measurement period increased significantly ($\chi^2=18.587$, $\chi^2=72.090$, $\chi^2=9.207$; $p<0.05$). The quality improvement measures based on fish bone diagram method can significantly improve the use and management effect of emergency equipment to be used. In addition, medical staff carry out simple maintenance of first-aid equipment every day, and clinical medical engineers strictly implemented three-level preventive maintenance of emergency equipment, timely replaced aged consumables of emergency equipment, and timely carried out quality control and measurement of equipment, so as to discover potential failure risks in time. As a result, in the comparison of failure rates of emergency equipment in the whole hospital, the failure rate of emergency equipment in the whole hospital decreased from 2.54% before the implementation of quality improvement measures to 0.79% after the implementation. The quality improvement measures based on fish bone diagram method had obvious effect on improving the failure rate of emergency equipment in the whole hospital.

5. Conclusions

In the management of emergency equipment in hospital, the fishbone diagram analysis method was used to analyze the root causes of problems in the use and management of emergency equipment from five aspects of Man, Machine, Material, Method and Milieu, and the quality improvement measures based on fishbone diagram analysis method were made. It can significantly improve the use

and management effect of emergency equipment to be used, and significantly reduce the failure rate of emergency equipment in the whole hospital. The quality improvement measures based on fishbone diagram analysis method can significantly improve the management effect of emergency equipment, and has great application value in the management of emergency equipment in 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).

References

- [1] Hunter Christopher Mark, Paul Daniel, Plumb Benjamin, *Novel solutions to old problems: improving the reliability of emergency equipment provision in critical care using accessible digital solutions.* [J]. *BMJ Open Qual*, 2022, 11: undefined.
- [2] Reilly James B, Myers Jennifer S, Salvador Doug et al. *Use of a novel, modified fishbone diagram to analyze diagnostic errors.* [J]. *Diagnosis (Berl)*, 2014, 1: 167-171.
- [3] Timmermans Lotte, Huybrechts Ine, Decat Peter et al. *Recommendations for Researchers on Synchronous, Online, Nominal Group Sessions in Times of COVID-19: Fishbone Analysis.* [J]. *JMIR Form Res*, 2022, 6: e34539.
- [4] Cox Merrilee, Sandberg Kelly, *Modeling Causal Relationships in Quality Improvement.* [J]. *Curr Probl Pediatr Adolesc Health Care*, 2018, 48: 182-185.
- [5] Zhou Yusheng, Soh Ying Shan, Loh Hui Shan et al. *The key challenges and critical success factors of blockchain implementation: Policy implications for Singapore's maritime industry.* [J]. *Mar Policy*, 2020, 122: 104265.
- [6] Wang Junlin, Kan Shuling, Chen Tong et al. *Application of quality by design (QbD) to formulation and processing of naproxen pellets by extrusion-spheronization.* [J]. *Pharm Dev Technol*, 2015, 20: 246-56.