Design improvement strategy of medical waste treatment based on PDCA+5M1E perspective

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Abstract. Medical waste had become the most important waste disposal problem in the post epidemic era. Facing five major problems such as outstanding management problems, huge quantity involved, irregular management, insufficient storage, and lack of connection between hospitals and outside hospitals, it is urgent to improve the system. Based on the 5M1E methodology under the PDCA cycle, improvement measures are proposed in terms of equipment, process and material design, providing a feasible management blueprint, and refining the standard process and information management for regions that have not implemented intelligent processes. This study investigated 54 hospitals and medical waste treatment facilities in 7 provinces and 10 cities, recovered 249 valid questionnaires, analysed the current management situation and problems, and provided a scientific basis for the standardisation of medical waste management. It helps hospitals to improve efficiency, reduce risk and pollution, promote the construction of full life cycle management system, protect public health and safety, and promote the standardisation and sustainable development of the industry.

Keywords: Post-epidemic era; Medical waste; PDCA vision; 5M1E Management.

1. Introduction

SARS in 2003, avian influenza in 2017 and COVID-19 in 2019[1]have posed challenges to the safety of storage and transportation of medical waste in hospitals in China. According to data from the Ministry of Ecology and Environment, the amount of medical waste produced from 2017 to 2024 increased from 2.05 million tons to 2.74 million tons. Medical waste is highly infectious and toxic, and there are many pathogens, there is a spread and latent risk. Therefore, reasonable arrangement of patients, doctors and decontamination flow line, strict separation of medical waste, is the key to prevent cross-contamination and transmission risk.

2. Field Research

This research covers six aspects of medical waste management, including in-hospital generation, transport, temporary storage, out-hospital transport, centralized transportation, and harmless disposal, forming a complete closed loop to ensure the whole process of information collection and safety management, and supporting public health safety.

2.1 In-Hospital Medical Waste Management

China's hospitals have established a structured medical waste management system. Medical staff classify waste according to standards, and logistics personnel seal it with QR-coded ties before transporting it via designated channels to disposal rooms for collection. Regular safety training and emergency drills enhance risk control and response capabilities, laying a solid foundation for safe transportation and disposal[2].

During internal transport, staff use intelligent terminals to scan department or doctor codes to confirm responsibility, then scan waste QR codes to record weight, register data, and securely load waste onto transport vehicles. Upon arrival at the temporary storage facility, waste is linked to turnover boxes via QR codes, and RFID systems verify weight, quantity, and category. Abnormal data is corrected before the waste is transferred into designated containers for external collection.

2.2 Out-Hospital Transportation and Centralized Processing

At the hospital discharge stage, transfer vehicles weigh and confirm waste before completing the "exit" process. Large hospitals dispose of waste daily, while smaller health centers and clinics do so every 2-3 days. Centralized transportation uses two vehicle types: fully enclosed for high-risk waste and semi-enclosed for lower-risk or temperature-sensitive waste. Both feature GPS monitoring for real-time tracking, ensuring secure and efficient transport through strict regulations and regular maintenance.

2.3 Harmless Disposal and Sustainable Development

After sorting, recyclable medical waste undergoes material recovery, while non-recyclable waste is treated via incineration, high-temperature cooking, or plasma technology. Incineration effectively disinfects and reduces volume but requires strict emission control. High-temperature cooking is environmentally friendly and safe, while plasma decomposition eliminates waste without secondary pollution.[3] Emerging technologies such as microwave treatment, high-temperature plasma, and nanomaterials drive smart, green, and comprehensive medical waste treatment, supporting the vision of a healthier and more sustainable China.

3. Proposed Countermeasures

This study combined PDCA[4] model and 5M1E[5]strategy to systematically optimize medical waste management from six aspects: personnel, equipment, materials, methods, measurement and environment. PDCA promotes continuous improvement, and 5M1E provides a comprehensive perspective to improve information collection, monitoring and risk management to ensure safe, standardized, green and efficient management,as shown in Fig.1

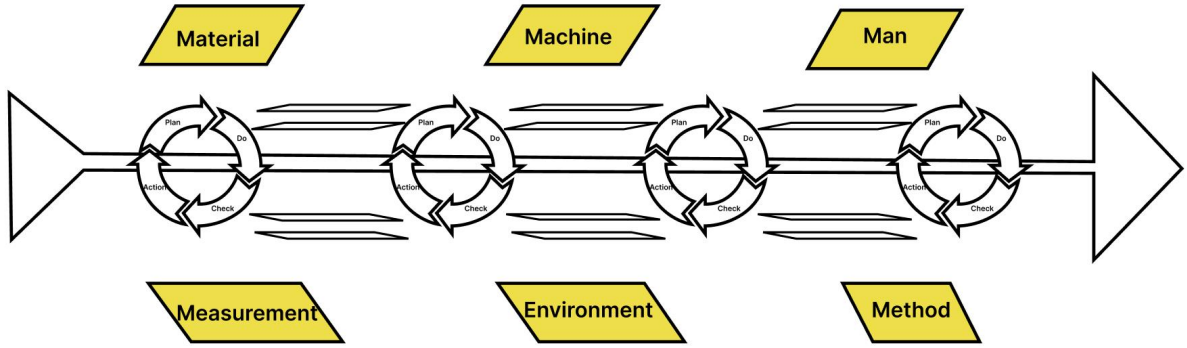

Fig.1 5M1E model diagram based on PDCA vision

3.1 Man: Establish a full-time + supervision + inspection + training management system

In terms of personnel management, it is recommended that hospitals establish full-time medical waste management teams, including full-time managers, supervisors, inspectors and training leaders. [6]At the same time, it should focus on introducing medical waste management talents with professional backgrounds, and establish an internal assessment mechanism to ensure that all departments strictly implement their responsibilities in terms of regulatory enforcement, risk control and data collection, so as to promote the continuous improvement and upgrading of the entire PDCA cycle.

3.2 Machine: Build 1+N+X integrated equipment scheme

1: Special automated transportation channels are designed for different areas of the hospital to ensure that every link from generation to disposal of medical waste can be smoothly carried out to reduce the occurrence of cross infection and management loopholes.

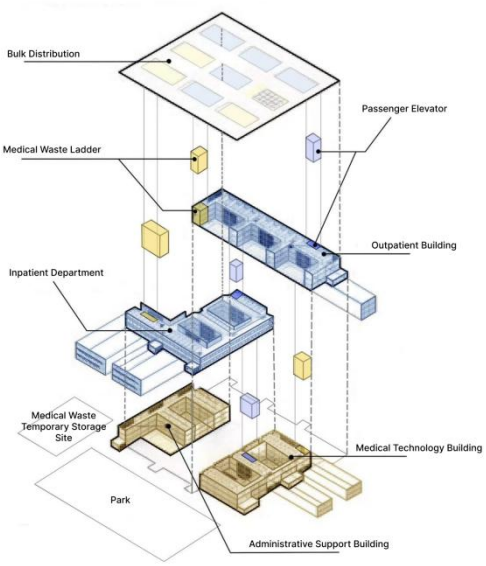

Fig.2 Transport channel diagram

N:Hospitals can optimize equipment management and improve the efficiency and safety of medical waste treatment. The current situation is that the garbage can is overflowing and the medical staff needs to call the cleaning staff. The improved program adopts a modular design, supports four categories of medical waste classification, and can be freely combined according to the needs of the department, reducing additional call steps.

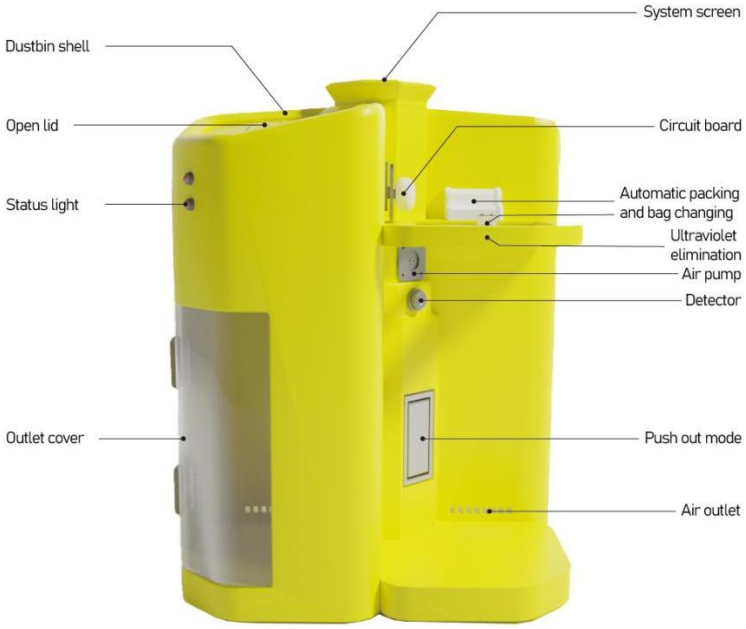

Fig.3 product diagram

Each module is equipped with automatic sealing and dressing function, and can automatically sense the filling degree of the trash can, timely packaging and preliminary disinfection, and synchronize information to the cleaning staff of the department through the system, so as to facilitate their timely collection and avoid unnecessary intervention of medical personnel.

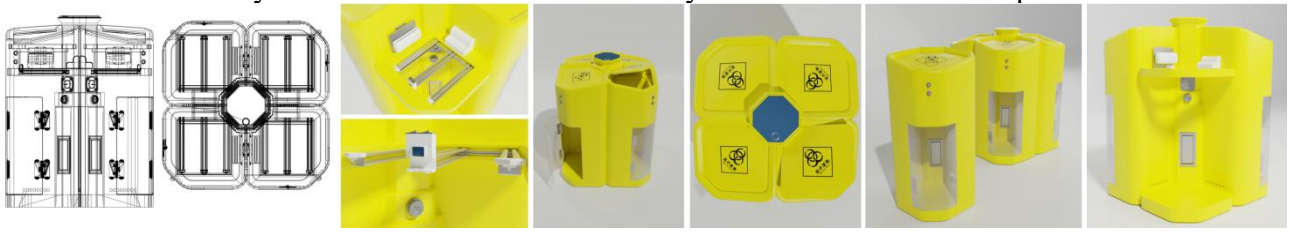

Fig.4 drawings of product design

X: For the temporary storage of medical waste, an improved anti-rodent and insect-proof floor drain design can be adopted, which not only meets the standard requirements of anti-rodent and insect-proof, but also effectively avoids the leakage and diffusion of waste.

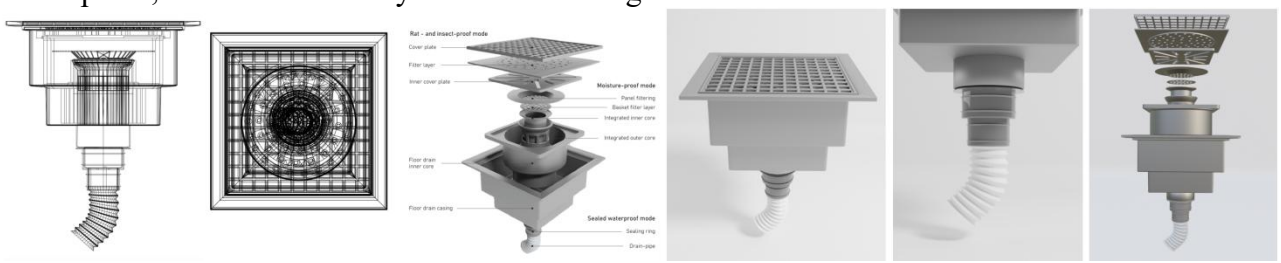

Fig.5 Parts improvement

Equipment and system upgrade to improve efficiency, reduce manual intervention, and through maintenance and technical update, in the PDCA "inspection" and "improvement" stage continuous optimization, to ensure public health safety and hospital management efficiency.

3.3 Material: Calculate the subtraction of medical supplies and the addition of building materials

Medical waste management implementation of "consumables reduction", through green procurement, standardized management to reduce disposable consumables.[7]Introduce a management system to monitor the efficiency of use, optimize the ratio, avoid waste, and explore repeatable or degradable alternatives to reduce the total amount of medical waste.[8]

The temporary storage point of medical waste is upgraded, and polymer impermeability, anti-corrosion and antibacterial materials are adopted to optimize the storage environment, improve impermeability and cleanliness, ensure safety standards, and reduce long-term storage risks.

3.4 Environment: Set up high and low risk separation of shipping lines

Environmental management Optimize the layout of the medical waste disposal room, improve safety, and ensure compliance with management requirements. As shown in Figure 4.10, adjust the sewage room close to the corridor.

Fig.6 Improvement diagram

Through these measures, we aim to improve the management environment of medical waste, enhance the management level, and ensure public health safety and environmental protection.

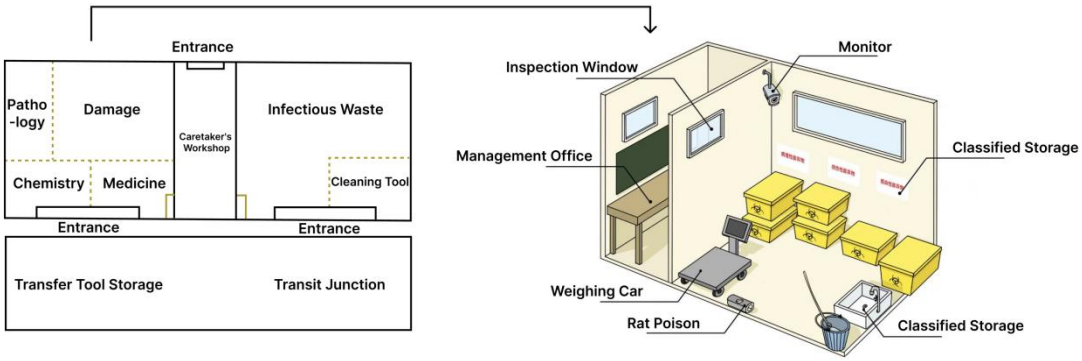

Fig.7 Schematic plan of the temporary storage of medical waste

Optimize the transport route, divide the dynamic zone and the static zone, set up a special channel to distinguish high and low infected waste, and separate the path of human flow and medical waste, so as to ensure efficient and standardized collection and transport, avoid cross-contamination and management loopholes.

These measures aim to optimize the management environment of medical waste, improve the management level, and ensure public health safety and environmental protection.

3.5 Measurement: Accurate inspection and feedback optimization

Establish a performance appraisal system to quantitatively evaluate medical waste management, including personnel assessment, space utilization, passenger elevator efficiency and emergency response time. The monitoring platform has added warning functions such as illegal handover, warehousing timeout, and abnormal weight, which automatically compare process data and issue an alarm when abnormal, helping managers quickly locate and solve problems.[9]

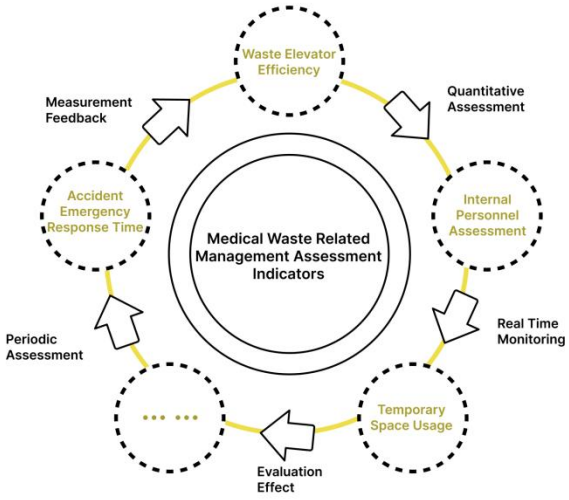

Fig.8 Measurement and assessment indication chart

Based on the above suggestions, based on the 5M1E strategy under the PDCA vision, the intelligent, standardized and closed-loop management of medical waste is promoted through continuous optimization of six key elements to provide strong support for public health safety and ecological protection.

4. Summary

This study investigated 54 hospitals and medical waste treatment institutions in 7 provinces and 10 cities, covering the whole process of medical waste generation, classification, collection, transport, temporary storage and disposal. Field observation, interview and questionnaire survey were adopted, and the influencing factors were quantitatively analyzed by AHP to propose an optimization plan. Based on PDCA cycle and 5M1E model, this paper proposes improvement measures from the aspects of equipment, process and materials to help hospitals manage medical waste efficiently and standardized.

The construction suggestions include optimizing the space layout, improving the intelligence of equipment, improving the management process, and systematically describing the application of information means in the recovery of medical waste, so as to provide references for areas that have not implemented the intelligent process. The study emphasizes on improving the efficiency of medical waste treatment, reducing risks and reducing pollution through standardized management.

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