

Original Article

The application of quality control circles to reduce the breakage rate of drugs replenished using dispensing machines

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Abstract: Objective: To explore the effect of quality control circles in reducing the breakage rate of drugs replenished using dispensing machines. Methods: Select and analyze the damage to the drugs replenished using dispensing machines, establish a quality control circle called medicine bag circle, determine the theme of reducing the breakage rate of drugs replenished using dispensing machines, effectively analyze the types of damage caused to drugs replenished using dispensing machines, and develop effective countermeasures. The damage to the drugs before and after the quality control circle activities and the success of the quality control circle activities were evaluated. Results: The breakage rate of drugs replenished using dispensing machines decreased from 0.22% to 0.09% ($P<0.01$). The target achievement rate was 108.33%, the progress rate was 59.09%, and the economic losses from the damaged drugs were decreased. The self-confidence, communication abilities, problem recognition, organization and coordination abilities, application of the quality control circle technique, responsibility and team cohesion of the quality control circle members were significantly improved (all $P<0.001$) and showed positive growth. Conclusion: The implementation of quality control circle activities can significantly reduce the breakage rate of drugs replenished using dispensing machines, reduce the economic losses in hospital pharmacies, and also promote pharmacists' individual abilities and team cohesion.

Keywords: Quality control circles, drug dispensing machines, drug breakage, quality management

Introduction

As an independent hospital department, a pharmacy plays an important role in the safe supply of drugs in the hospital. It not only provides qualified drugs to outpatients and inpatients, but it also ensures the drugs' accuracy, safety, and effectiveness [1, 2]. In recent years, automatic dispensing machines have found an increasingly wide utilization in the work of pharmacies, and can greatly improve the efficiency of dispensing drugs, promote the service level of hospital pharmacies and vastly reduce the error rate of dispensing drugs in pharmacies [3, 4]. However, there are also some problems in clinical practice, among which the more prominent one is drug breakage. The improper handling of damaged drugs not only pollutes the environment, but it also to some extent brings economic losses to the hospital and wastes social resources. At present, there are many

deficiencies in the management of drug breakage caused by dispensing machines: uneven management teams, non-standard personnel operations, non-uniform drug specifications, inconsistent replenishment methods, and no regular maintenance of the dispensing machine [5, 6]. Therefore, how to effectively reduce the breakage rate of drugs replenished using dispensing machines has become an important challenge for hospital pharmacy managers.

Quality control circles were first proposed by Dr. Ishikawa Kaoru from Japan in 1962 [7]. The circles are a group composed of grass-roots personnel doing similar work at the same work site who automatically and spontaneously carry out quality management activities and continuously solve workplace problems by inspiring individual potential, so as to improve quality and efficiency [8, 9]. As a new intervention mode, increasing attention has been paid to

Table 1. Comparison of item's scores

Thematic evaluation items	Importance (0.23)	Achievement in this period (0.30)	Circle ability (0.23)	Leadership attention (0.24)	Total scores
Shorten the waiting time to get drugs at the outpatient pharmacy	4.83	6.32	5.29	5.04	21.48
Reduce the dispensing drugs' error rates	6.21	4.53	3.91	5.04	19.69
Improve the utilization rate of the drug-receiving machine	4.37	5.12	4.83	2.16	16.48
Reduce the breakage rate of drugs being replenished using the dispensing machine	5.75	8.74	5.75	5.04	25.28
Improve patient satisfaction	3.45	3.92	3.45	5.04	15.86

quality control circles in hospital management and medical work. Studies have shown that quality control circle activities can significantly improve patients' handwashing compliance [10]. In addition, quality control circles carried out in intensive care units (ICU) and operating rooms can help improve the quality of the infection control in the department [11]. However, there has been no report on the application of the quality control circle management model in reducing the breakage rate of drugs replenished using dispensing machine. Therefore, the quality control circle management mode was implemented in this study from July to December 2017, in order to analyze and correct the main causes of drug breakage, reduce the drug breakage rate, and ensure the quality of replenished drugs.

Materials and methods

General information

The information such as the quantity of damaged drugs and the total number of drugs replenished using dispensing machines, as well as the causes of drug breakage in the outpatient pharmacy of Zibo Municipal Hospital before and after implementing the quality control circle management mode from July to December 2017 were collected to analyze the changes before and after the quality control circle activities.

Quality control circle activities

Formation of the quality control circle group: Seven pharmacists from the outpatient pharmacy were selected to set up a quality control circle activity group, in which the person in charge of the outpatient pharmacy was the cir-

cle leader, and the other 6 pharmacists were the circle members. The circle name was voted on, and "medicine bag circle" was ultimately selected using the brainstorming method [12].

Theme selection: The team conducted a thematic evaluation of the problems existing in the process of replenishing drugs using dispensing machines using an evaluation method. The theme selection was mainly scored based on four items, including importance, achievement in this period, circle ability, and leadership attention, with a total of 140 scores, with 35 scores for each item. The scores of each item were calculated using a weighted coefficient, and the themes were graded on scales of 1-5 points. On the basis of the comprehensive weight coefficient score, the theme of the quality control circle was determined to reduce the breakage rate of drugs replenished using dispensing machines. See **Table 1**.

Analysis of the reasons: The members in the quality control circle analyzed the reasons for the drug breakage in the process of replenishing drugs using dispensing machines, including frequent personnel changes, high work intensity, untimely resetting of the machines, inaccurate slot coordinates, frequent drug changes, incorrect drug placement, and damaged drug packaging, etc. The circle members determined the reasons using the brainstorming method and made a fishbone diagram. The main causes were confirmed using the Pareto Principle [13]. Finally, a truth verification was conducted to determine the real cause.

Setup of target value: According to the scoring standard of circle ability, the circle ability was set at 71.40%, and the target value was calculated according to the following formula: Target

value = current value - (current value * value of key improvement * circle ability) [14]. The current value was 0.22%, and the target value was 0.10%.

Develop and implement countermeasures: Aiming at the main causes, the circle members jointly discussed through 5W1H (who, what, whom, when, where, and how) method, and developed relevant countermeasures according to the plan-do-check-act (PDCA) cycle method [15]. The PDCA cycle method is divided into four stages: planning, design and execution, inspection, and processing [16]. Through the grading by circle members, the countermeasures were formulated as follows: regular maintenance of the slot, replacement by the stronger lever, unlocking of the slot, removal of the dispensing machine, dosing training, leaving space when storing drugs, regular placement of drugs, and so on. The specific solutions were as follows.

(1) Arrange to have engineers maintain the slot regularly and replace broken levers with stronger ones. Any deviation in the slot position of the dispensing machine should be promptly reported to the person in charge and to an engineer. The tank should be registered and regularly tested by the engineer. When the lever on the belt of the dosing mechanical arm of the dispensing machine is defective, the person in charge of the pharmacy should be informed promptly, and the engineer should be notified to replace it using a new belt as soon as possible.

(2) Have a specially-assigned person clean and unlock the slot. Regarding the unlocking of the dispensing machine slot, the engineer should be responsible for training the specially-assigned persons, and two circle members should be assigned to take charge of the unlocking work. Regular inspections should be conducted to promptly solve any mismatch issues between the slot positions and the drugs.

(3) Arrange dosing training and establish a reward and punishment system: Pre-job training was conducted on the placement and dosing of the replenishing drugs. on-machine training was conducted on the modification of

the coordinates of the mechanical arm to ensure that everyone could use it. To solve the problem of it being difficult to replenish some drugs in the blue pill box, the engineer was contacted. It was found out that the problem lay in the laser probe on the arrangement plate. Since the laser probe was not sensitive to blue, the computer could not calculate the number of drug boxes. This problem was solved by rearranging the pill boxes to recognize the non-blue parts of the pill boxes corresponding to the laser probe.

Effect evaluation: Tangible achievement: Detailed records were made on the improvement of the breakage rate of drugs replenished using the dispensing machines after carrying out the quality control circle activities. The target achievement rate, the progress rate, and additional economic benefits were calculated according to the following formula: Target achievement rate = (value after improvement - value before improvement) / (target value - value before improvement) * 100%; progress rate = (value before improvement - value after improvement) / value before improvement * 100%; additional economic benefit = (the money of drug breakage every week before improvement - the money of drug breakage every week after improvement) * the number of weeks in one year.

Intangible achievements: Before and after the quality control circle activities, the self-confidence, the communication abilities, the problem recognition, organization, and coordination abilities, the application of the quality control circle technique, and the responsibility and team cohesion of the members were scored and analyzed. The highest possible score of each item was 5, and the lowest possible score was 1. A radar chart was drawn.

Statistical analysis

All the data were analyzed using SPSS 22.00 statistical software. The quantitative data were expressed as the mean \pm standard deviation ($\bar{x} \pm sd$), and t-tests were applied. The count data were expressed as the number of cases (n, %), and chi-square (χ^2) tests were applied. $P < 0.05$ was considered statistically significant.

Using QCC to reduce the dispensing machine breakage rate

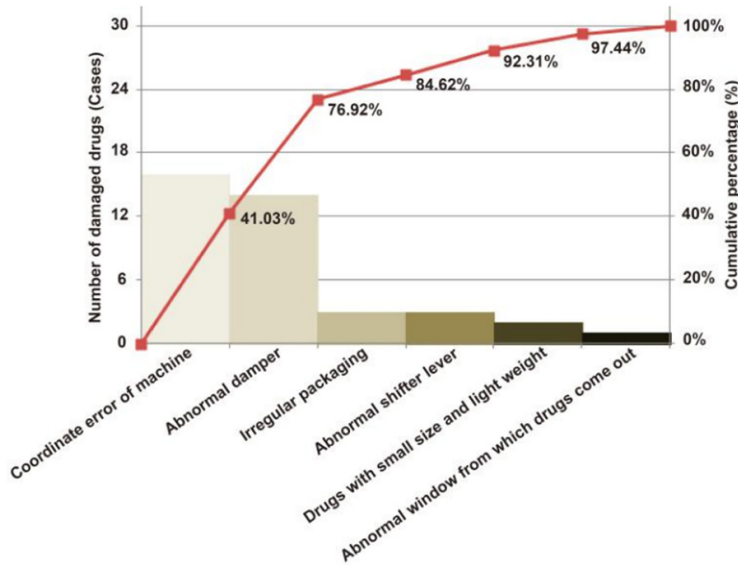


Figure 1. Plato's diagram for a cause analysis of the breakage in drugs replenished using dispensing machines.

Results

Analysis of the results of the reasons for the breakage rate of drugs replenished using dispensing machines

According to the Pareto Principle, the main causes of the breakage rate of drugs replenished using dispensing machines were deviations of the machine coordinates and the abnormal damper of machine parts. See **Figure 1**. The reasons for the deviations of the machine coordinates and the abnormal damper of machine parts were determined through the brainstorming method. Fish-bone diagrams were made from 5 aspects, including the personnel, the machine, the drug itself, the operation method, and the environment to analyze the causes of drug breakage. See **Figures 2 and 3**. After analyzing and sorting out the data of drug breakage and using the Pareto Principle, the real causes of the deviations in the machine coordinates were incapable of modification of the coordinates, inaccurate coordinates of the slot position, and reverse modification of the coordinates. See **Figure 4**. The real causes of the abnormal damper of the machine parts were defects of the belt lever, not enough drug inventory, and the placement of too many drugs. See **Figure 5**.

Tangible achievement

After carrying out the quality control circle activities, the breakage rate of the drugs replenished using dispensing machines decreased from 0.22% to 0.09% ($P < 0.01$). Target achievement rate = $(0.09\% - 0.22\%) / (0.10\% - 0.22\%) \times 100\% = 108.33\%$; progress rate = $(0.22\% - 0.09\%) / 0.22\% \times 100\% = 59.09\%$; additional economic benefit = $(1197.65 - 449.22) \times 52 = 38918.36$.

Intangible achievements

After the quality control circle activities, the self-confidence scores, the communication abilities, the problem recognition, the organization and coordination abilities, the application of quality control circle techniques, and the responsibility and team cohesion of the circle members significantly improved and showed positive growth (all $P < 0.001$). See **Table 2** and **Figure 6**.

Discussion

Quality control circle management is a breakthrough in the traditional management mode. It provides a new idea for the management of outpatient pharmacies, which can mobilize the enthusiasm and positivity of the circle members, so that each circle member can seriously discover, analyze and solve problems. By forms a virtuous circle, and circle members can create higher-quality achievement and experience the meaning and purpose of work by solving problems [17, 18]. Some studies have reported that quality control circle activities are based on the continuous improvement of detail work and exert the management effect from bottom to top, from point to surface, from part to whole. Through the establishment of a quality control circle activity group using the brainstorming method, 5W1H, etc., the existing problems in the process of medical service are proposed, and the reasons for the problems are analyzed. The targeted countermeasures are formulated and implemented to help improve the scientific soundness, refinement, and individuality of the medical management services [19]. Another

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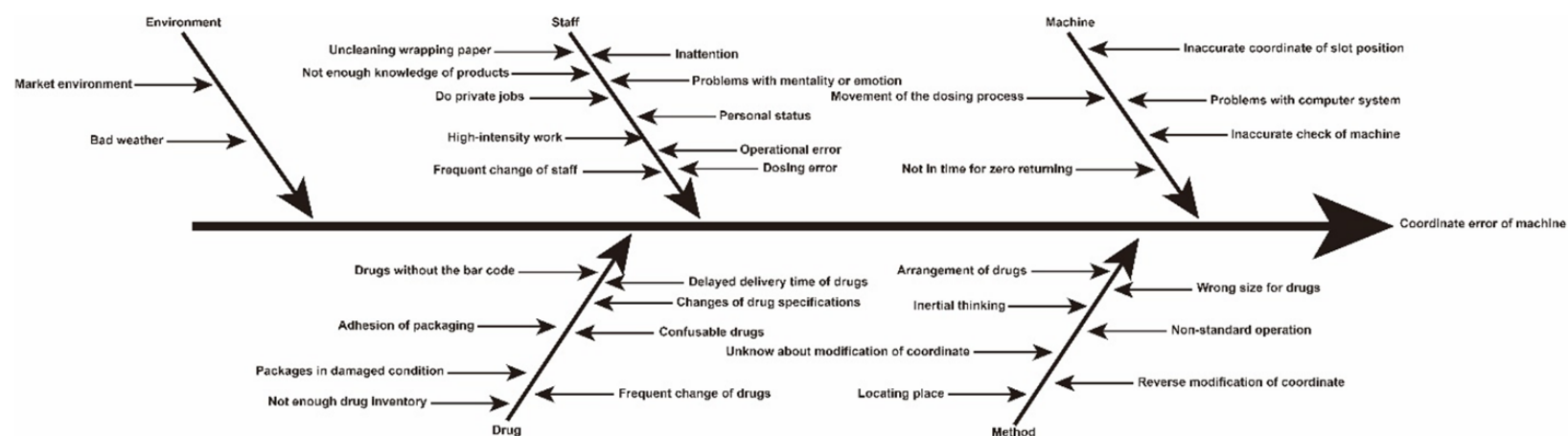


Figure 2. Fishbone diagram for the deviations of the machine coordinates.

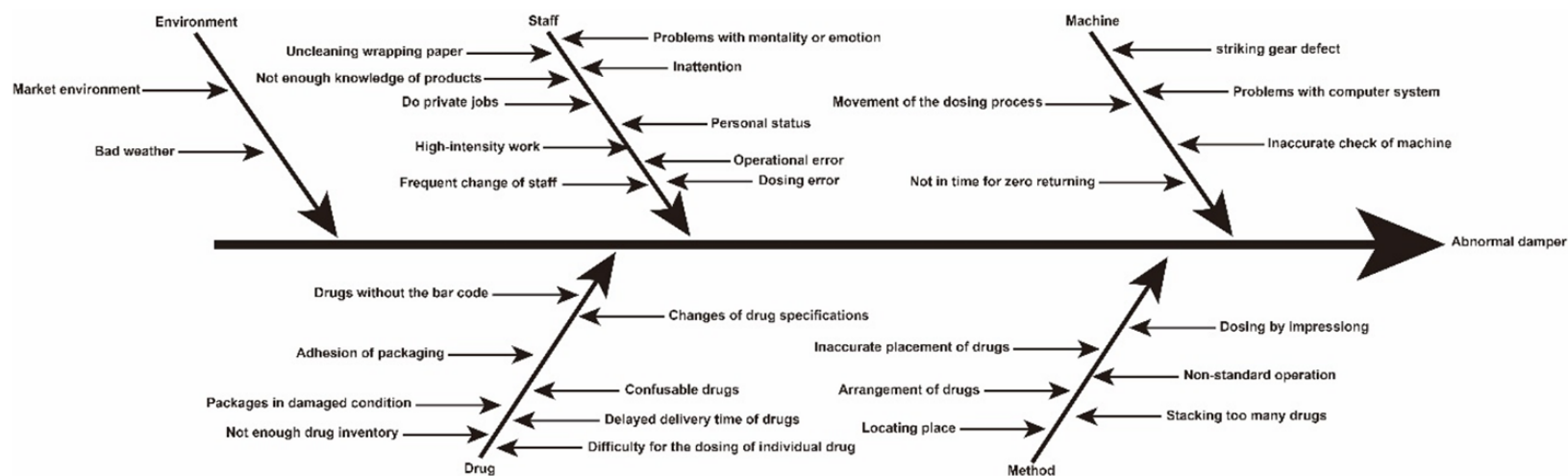


Figure 3. Fishbone diagram for the abnormal damper of machine parts.

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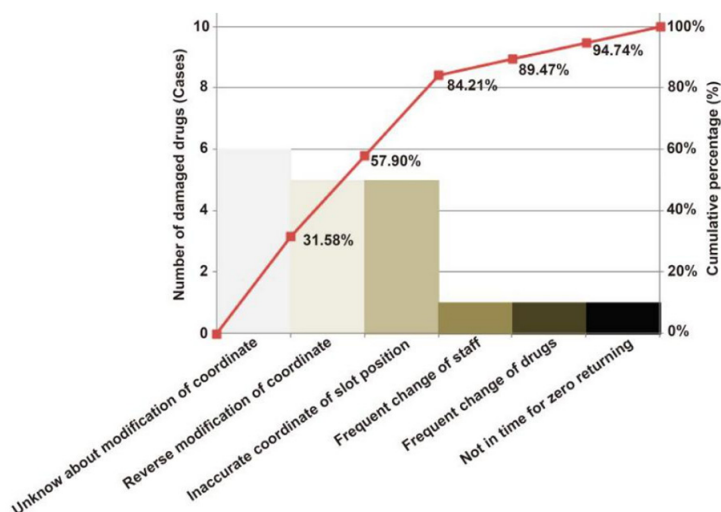


Figure 4. Plato's diagram for truth verification of deviations of the machine coordinates.

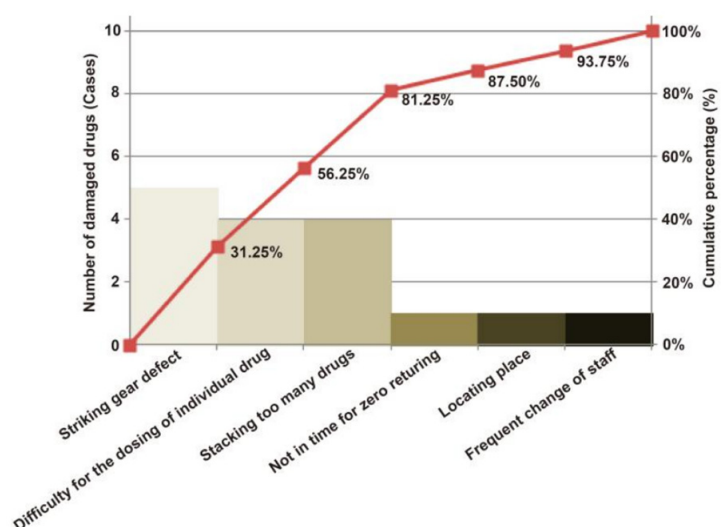


Figure 5. Plato's diagram for truth verification of the abnormal damper of the machine parts.

study found that through quality control circle activities, the causes of problems in the process of medical services are usually demonstrated from multiple dimensions of people, machine, objects and methods, so it is not only conducive to improving the quality of medical services, it also pays attention to the cultivation of the individual abilities of the circle members [20].

In recent years, as the application of dispensing machines in hospital pharmacies has

become more and more widespread, the occurrence of drug breakage caused by dispensing machines has become increasingly common. In order to effectively reduce the number of damaged drugs in hospital pharmacies, and to avoid the wasting of medical and health resources and reduce economic losses, quality control circle activities were adopted in this study according to the detailed process, such as theme determination, status analysis, countermeasure formulation, organization and implementation, etc., which effectively strengthened the drug management in outpatient pharmacies and significantly improved the quality of drug services [19, 21]. The study showed that the main causes of drug breakage when replenishing using dispensing machines in Zibo Municipal Hospital were deviations in the machine coordinates and the abnormal damper of the machine parts. Among which, the real causes of the deviations of machine coordinates were incapable of modification of coordinate, inaccurate coordinates of slot position and reverse modification of coordinates. The real causes of the abnormal damper of the machine parts were defects of the belt levers, not enough drug inventory, and the placement of too many drugs.

The inaccurate coordinates of the slot position affected the smoothness of the dosing. During the dosing, the drugs could easily move to the edge of the slot or even between the two slots, so they could not enter the slot smoothly and got stuck in the mechanical arm, with the addition of force of the lever, the drugs were easily crushed. Defective or asymmetric levers were also likely to cause some drugs to be unevenly stressed, resulting in an inability to enter the tank smoothly, thereby damaging the drugs. The replacement of drug specifications and

Using QCC to reduce the dispensing machine breakage rate

Table 2. Score list of the intangible achievements after the quality control circle activities

Items	Before quality control circle activities	After quality control circle activities	t	P
Self-confidence	2.17±0.12	3.89±0.45	9.046	<0.001
Communication abilities	2.31±0.09	4.15±0.53	8.384	<0.001
Recognition of the problem	2.27±0.15	3.83±0.48	7.598	<0.001
Organization and coordination abilities	2.06±0.10	3.91±0.51	8.719	<0.001
Application of quality control circle technique	1.14±0.08	3.88±0.42	15.700	<0.001
Responsibility	2.61±0.32	4.59±0.37	9.914	<0.001
Team cohesion	2.03±0.13	4.35±0.40	13.510	<0.001

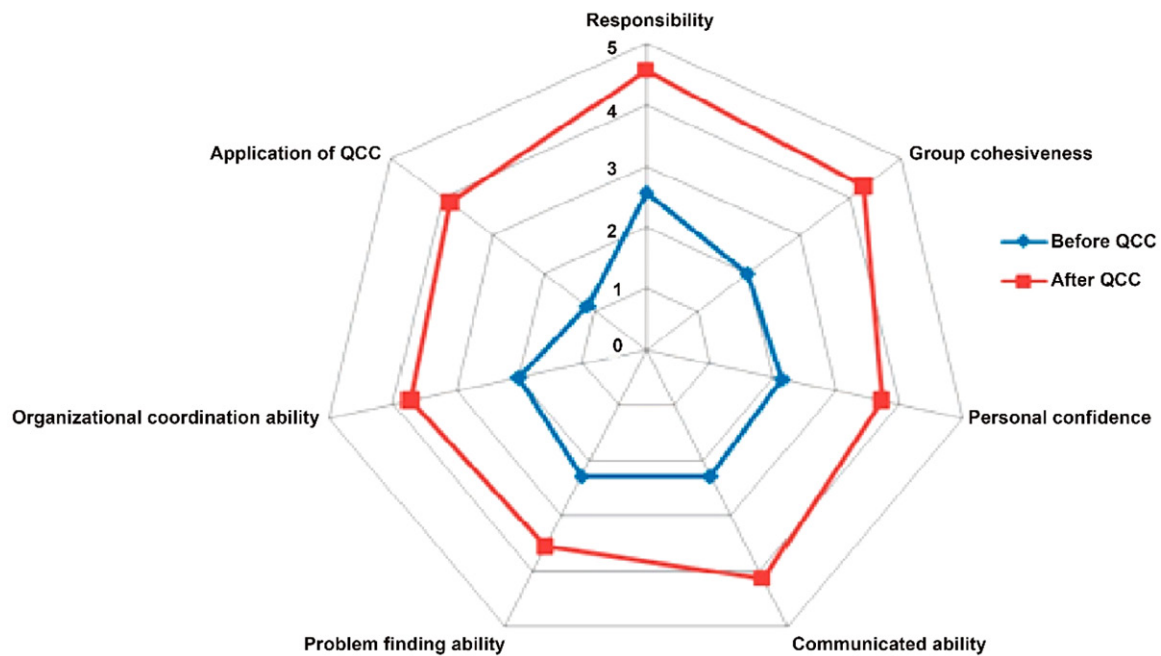


Figure 6. The radar map for intangible achievement. QCC: quality control circle.

packaging prevented the drugs from fully adapting to the size of the tank, resulting in the drugs not being able to smoothly enter the tank. In addition, some drugs were too small in size and were likely to stay in the tank, plus the repetitive movement of the lever, which eventually damaged the drugs. Drugs were added at will on the mechanical arm of the dispensing machine, and an irregular order of the drugs might cause an abnormal alarm of the damper or affect the laser probe scanning, leading to a miscalculation of the drug boxes, and finally causing the drugs to get stuck at the outlet and damaged. It was difficult to replenish some drugs in the blue pill box, causing the drugs to get stuck at the dosing port and damaged; the initial position of the mechanical arm and the

coordinates of slot were not exactly matched, so the pharmacist didn't know how to modify coordinates or even modify them reversely, so the dosing operation was not performed correctly. Hence, the drugs got stuck between the outlet and the tank, causing damage. This is basically similar to the McCarthy's findings [22].

In response to these problems, the PDCA cycle method was applied in this study to develop and implement corresponding countermeasures [23]. The analysis showed that the target achievement rate of reducing the breakage rate of drugs replenished by the dispensing machine was 108.33%, and the progress rate was 59.09%. The breakage rate was significantly lower compared with its level before the quality

control circle activity, and the difference was statistically significant. The hospital pharmacy's economic losses decreased. The research by Prasad also showed that the quality control circle activities not only improves the service quality of hospital pharmacies, but it also reduces their economic costs [24]. It has been reported that quality control circle activities have a certain promotion effect on the improvement of individual ability and team building for circle members [25]. This study indicated that after quality control circle activities, the self-confidence, communication ability, problem recognition, organization and coordination ability, application of quality control circle technique, responsibility, and team cohesion scores of the circle members significantly improved and showed positive growth, which is consistent with Zhang's results [26].

Based on the results of this study, a new process was formulated and standardized for replenishing drugs using dispensing machines: 1) when preparing drugs, the staff should ensure the drugs are clean and tidy, and there is no adhesion; 2) drugs with damaged packaging cannot be used for replenishment; 3) when drugs get stuck due to inaccurate coordinates, they should be replenished after correcting and saving the coordinates; 4) the inaccurate drug slots and slots with incorrect coordinates should be registered and counted promptly, and engineers should be contacted to deal with them; 5) a specially-assigned person shall inspect the slot of each dispensing machine for the presence of stuck or superimposed drugs and handle the issue right away; 6) according to the prompts for the number of replenishing drugs on the computer, place the drugs in the mechanical arm and stack them layer by layer neatly. Adjust the direction of drugs in the blue pill boxes (hydroxychloroquine sulfate, clopidogrel bisulfate tablets, Feilike capsules, etc.) to avoid letting the blue part have contact with the laser probe; 7) when the mechanical arm of the automatic dispensing machine stops at a certain position due to a fault, the fault needs to be located and eliminated before pressing the return key; 8) after the mechanical arm replenishes the drugs automatically and returns to the original start, the next specification of drugs can be added; 9) the X-axis and Y-axis of the mechanical arm need to be reset back to zero after every two hours of the drug replenishing process. These are of great practical and

theoretical significance for the smooth development of replenishing drugs using dispensing machines in hospital pharmacies. In the future clinical practice, continuous perfection and improvement are still required.

In summary, the implementation of quality control circle activities can effectively reduce the amount of drug breakage caused by dispensing machines and at the same time can strengthen the team cohesion of pharmacists, improve their individual abilities, and ultimately improve the quality of service in the hospital pharmacy, so it is worthy of promotion and application in clinical practice.

Disclosure of conflict of interest

None.

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